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Land managers' willingness-to-sell defines conservation opportunity for protected area expansion

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ABSTRACT

Spatial prioritization techniques are increasingly applied in the design of protected area networks, which are regarded as the cornerstone of nature conservation efforts. These techniques are becoming ever more sophisticated, but are still founded primarily upon biological data. A common assumption made in most spatial prioritizations is that land throughout a planning region is available for acquisition. We interviewed land managers in the Eastern Cape province, South Africa, and mapped their willingness-to-sell their land using a psychometric analytical technique. We examined the, (i) degree to which vegetation type targets are achieved across a planning region, (ii) areal and cost efficiency, and (iii) spatial configuration, of candidate protected areas identified as important for achieving conservation targets. We found that only 10 out of 48 land managers were willing-to-sell their land. Only seven, five and one of the 19 vegetation types, respectively, could achieve their conservation targets of 10%, 30% and 50% when unwilling land managers were removed from the analysis. Assuming unwilling land managers could be convinced to sell if offered a premium price, the cost of acquiring all lands was between 6.20% and 30.67% more expensive than 2006 land prices. Accounting for implementation opportunities and constraints, such as land manager willingness-to-sell, not simply identifying biological priorities, is of fundamental importance for ensuring spatial prioritizations deliver maps with the potential to usefully guide expansion of protected area networks which can be feasibly implemented.

1. Introduction

The resources available for conservation action are woefully inadequate compared to the resources invested in activities that degrade or destroy nature (Balmford et al., 2002). Formally protected areas (i.e., IUCN protected area categories I–IV) are widely regarded as the cornerstone of nature conservation efforts defying this destruction (Margules and Sarkar, 2007). Substantial research has focused upon developing spatially-explicit, computer-based decision-support tools, notably area-selection algorithms, to identify locations for candidate protected areas which efficiently achieve conservation targets (i.e., numbers or extents of valued natural features) (Moilanen et al., 2009). These spatial prioritizations have become standard procedures for identifying candidate networks of terrestrial protected areas at local (e.g., Pence et al., 2003), regional (e.g., Noss et al., 2002; Rouget et al., 2006; Smith et al., 2006) and continental scales (e.g., Klein et al., 2009), and for prioritizing global conservation investment (Brooks et al., 2006) and marine protected areas (e.g., Fernandes et al., 2005).

Historically, conservation planners applying algorithms used biological data when selecting protected areas. Spatial prioritizations have typically applied species (Kirkpatrick, 1983; Brooks et al., 2001; Polasky et al., 2001) and/or habitat types (Noss et al., 2002; Smith et al., 2006; Rouget et al., 2006) alone, although recently these are being complemented with vulnerability (Wilson et al., 2005) and cost (Naidoo et al., 2006) data. Conservation planners have lamented the apparent inadequacy of existing biological datasets, and have consistently called for greater resources for biological inventory (Balmford and Gaston, 1999; Margules and Pressey, 2000; Brooks et al., 2001; Meir et al., 2004).

However, the effectiveness of land acquisition initiatives depends fundamentally upon two constraints to which biological data provides no answers: availability of (1) funds for purchase of protected areas, and (2) lands for acquisition. These two factors perhaps explain why documented examples of spatial

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prioritizations being translated into protected areas appear to often occur on public land, which minimizes land acquisition costs and the difficulties of convincing multiple stakeholders to sell their land (Pressey, 1998; Fernandes et al., 2005).

Whilst there has been a recent flurry of research incorporating economic costs into spatial prioritizations (Naidoo et al., 2006) to improve the cost-effectiveness of expanding protected area networks (Polasky et al., 2001; Wilson et al., 2006), most spatial prioritizations in the peer-reviewed literature, including our own, assume most, if not all, land is available for acquisition. Land availability is a fundamental consideration if areas are to be purchased (Tans, 1974; Margules and Usher, 1981; Pressey et al., 1994; Willis et al., 1996; Costello and Polasky, 2004; Meir et al., 2004; Wilson et al., 2006; McDonald-Madden et al., 2008), as it is known, generally, to be heterogeneous across most regions (Meir et al., 2004). This is primarily because it is fundamentally a function of individual peoples idiosyncratic values and choices (Cowling and Pressey, 2003).

Increasingly, it is recognized that the willingness of private land managers to engage conservation initiatives is crucial to them being effective (Curtis et al., 2001; Cowling and Pressey, 2003; Meir et al., 2004; Winter et al., 2005; Knight and Cowling, 2007; Nelson et al., 2008; Knight et al., 2010). Willingness-to-sell will likely be of fundamental importance in countries with significant extents of privately-owned land. However, the effects of including data on the willingness of land managers to sell their land in a spatial prioritization is yet to be assessed. Why has so little effort been directed towards understanding and mapping land manager willingness-to-sell for the expansion of protected area networks when it is a fundamental factor determining the effectiveness of protected area expansion initiatives?

Government conservation organizations in South Africa have funds for land acquisition, specifically, the Eastern Cape Parks Board is considering expansion of the Great Fish River Reserve. We interviewed private land managers in a production landscape of the Makana Municipality, Eastern Cape province, and mapped and analyzed their willingness-to-sell, to assess how inclusion of data on land manager willingness influences spatial prioritizations. Specifically, we assessed: (i) whether conservation targets can be achieved when unwilling land managers preclude their land from sale, (ii) the cost-efficiency of achieving conservation targets given variable degrees of land manager willingness, and (iii) the variability in the spatial configuration of candidate protected area networks when willingness-to-sell is measured in different ways. This research is conceptually founded within the emerging conservation opportunity paradigm that includes data on implementation opportunities and constraints (e.g., willingness-to-sell) in spatial prioritizations (Cowling et al., 2004; Knight and Cowling, 2007; Knight et al., 2010).

2. Methods

2.1. Study Area

The planning region was chosen for its proximity to the proposed Fish-Kowie Megaconservancy Network, a conservation priority in the Subtropical Thicket Ecosystem Planning project (Rouget et al., 2006; Knight et al., 2010), its high level of plant endemism, the negligible rates of habitat destruction, and with a view to supporting Eastern Cape Parks land acquisition programme. It lies within the Makana Municipality, Eastern Cape province, South Africa, and forms part of the south-western portion of the Maputaland–Pondoland–Albany hotspot (Steenkamp et al., 2004), a global conservation priority.

2.2. Data

We adopted vegetation types as a surrogate for valued nature (Vlok et al., 2003), which are widely regarded as useful for spatial prioritizations (Cowling et al., 2004; Higgins et al., 2004). Cadastral data from the Chief Surveyor-General (2001) denote the legally-recognized parcels of land for management and transfer of ownership (Pressey and Logan, 1998; Pierce et al., 2005), and were used as planning units ($n = 301$).

We applied a psychometric analytical technique to map willingness-to-sell, and not a contingent valuation or choice experiment approach, as typically adopted in economic studies. Accordingly, we did not use a monetary measure for willingness-to-sell, as complementary research (see Knight et al., 2010) suggested land managers valued non-monetary factors equally, if not more, when considering whether or not to sell. Willingness-to-sell data was collected from June to November 2006 through face-to-face interviews with 48 land managers responsible for the 301 cadastres comprising the planning region. Draft questionnaires, comprising Likert statements and open-ended questions, were reviewed by experienced social researchers, piloted with land managers, and refined. Land managers were identified from the telephone directory or by other land managers during interviews ('snowballing'; Babbie, 1989). We monitored the spatial location of cadastres as interviews proceeded, targeting land managers whose cadastres improved the contiguity of the final sample. Contiguous sampling was impossible due to land manager illness, death, or anonymity. The semi-structured interviews lasted one to 6 h, were typically conducted in the land managers residence, and addressed diverse topics beyond willingness-to-sell, including conservation knowledge and behavior, burnout, presence of local champions, social capital, and other willingness characteristics (Knight et al., 2010). Only willingness-to-sell results are presented here derived from the Likert statements in Table 1. Responses to these statements were tested for internal consistency using McDonald's $\acute{\omega}_h$ (Zinbarg et al., 2005) and reliability using the RV co-efficient (Robert and Escoufier, 1976), and those demonstrating acceptable coefficient thresholds were combined into a scale. Acceptable thresholds of internal consistency depend on whether applications of the research are theoretical or applied (Nunnally, 1978). We are unaware of published thresholds for $\acute{\omega}_h$, but suggest values of 0.60 are acceptable. We conducted analyses with the R open-source environment for statistical computation and graphics (R core, 2007).

Land acquisition cost data was sourced from the 2006 South African Property Transfer Guide (SAPTG). Acquisition costs were estimated from land sales records within a ten kilometer radius of interviewed land managers and adjoining protected areas, first, as property prices have increased by at least an order of magnitude

Table 1
Likert statements used to gather data on land managers' willingness-to-sell their land to conservation organizations. Following tests of internal consistency and reliability, two questions (1 and 5) were used to build a willingness-to-sell scale (see Knight et al., 2010).

	Likert statement	Internal consistency
1	I am currently thinking of selling my property	Strong
2	I would never sell my property, but intend to pass it onto my immediate family or relatives	Poor
3	My family has made arrangements (e.g., a succession plan) for the transfer of my property to the next generation	Poor
4	I would preferentially sell my property to a nature conservation organization (e.g., SANP, ECPB) than any other private buyer	Poor
5	I am thinking of selling my property... (*time categories listed*)	Strong

between 2000 and 2006, apparently driven by overseas buyers (Armsworth et al., 2006), and second, veld grazing capacity can be highly heterogeneous and affects land values. Records in communal lands east of the Great Fish River were excluded as these lands prices are strongly influenced by the history of Apartheid. Cadastres less than 10 hectares were also excluded from acquisition cost calculations, as these were typically housing blocks whose acquisition costs are inflated relative to farming land due to, for example, additional infrastructure. Land sale records that did not match cadastres in the spatial data were excluded.

Typically, land is managed and transferred not as single cadastres, but as sets of cadastres managed by one land manager as a single property. Acquisition costs were calculated in Rands per hectare (R/Ha) for individual cadastres using cadastral areal extents calculated from the Chief Surveyor-General (2001) spatial data matched to sale price data from the SAPTG, as areal extents of cadastres in the SAPTG are known to be unreliable (M. Powell, pers. comm.). The median cadastre sales price of R4700/ha was adopted, and was cross-referenced against, and found to match, anecdotal evidence for acquisition costs. Property area from the spatial data was multiplied by the R4700/ha value. These values were weighted for individual land managers across the five response categories (Table 2) to examine three different willingness-to-sell scenarios, so as to estimate a cost for individual cadastres.

Three willingness-to-sell scenarios were developed (Table 2). Context 1 reflects conditions where returns on agriculture and land cost are both average, there being little incentive for land managers to sell. Context 2 reflects conditions prevalent in 2006, where land managers experienced varying financial returns (i.e., private game farming lucrative, stock farming not), with some land managers more willing-to-sell than others. This scenario may also reflect a situation where land redistribution (a current government initiative) is proactively underway. Context 3 applies uniformly distributed weightings centered around the 'Unsure' questionnaire category, providing an 'objective' weighting structure. Our experience suggests that a significant number of land managers who 'Definitely will not sell' would sell their land if offered a premium price.

2.3. Targets

We applied three conservation targets (10%, 30% and 50%) expressed as a percentage of the extent of each vegetation type. The 10 percent target was chosen for its generally accepted (though widely criticized) status (McNeely, 1993; Soulé and Sanjayan, 1998). The 30% target was chosen being a recent international recommendation (IUCN, 2003). The 50% target was chosen as an estimate of the minimum proportion of a region required to ensure the persistence of all species (Soulé and Sanjayan, 1998).

Table 2
Willingness-to-sell weightings applied to mean property acquisition costs (i.e., 4700 Rands/hectare) across the five response classes of the land manager survey. Context 1 represents 'average' land conditions where returns on agriculture and land cost are both modest, offering little incentive for land managers to sell. Context 2 represents conditions in 2006: some stock farmers are keen to sell because financial returns are poor, whilst most private reserve owners are not willing-to-sell as returns are good. Context 3 represents weightings with even breaks for 'objective' comparison.

	Land manager response weightings				
	1	2	3	4	5
	Very keen to sell	Keen to sell	Unsure	Will not sell	Definitely will not sell
Context 1	0.9	1	1.05	1.1	1.2
Context 2	0.75	1	1.1	1.25	1.5
Context 3	0.8	0.9	1	1.1	1.2

2.4. Marxan spatial prioritization software

We used Marxan software to select near-optimal minimum sets of cadastres which cost-effectively achieve targets and which incorporate spatial design principles (Ball et al., 2009). The objective function can be stated as:

$$\text{Minimize} \sum_{i=1}^{m} c_i x_i + b \sum_{i1=1}^{m} \sum_{i2=1}^{m} x_{i1}(1 - x_{i2}) cv_{i1,i2} \quad (1)$$

$$\text{Subject to} \sum_{i=1}^{m} a_{ij} x_i \geqslant t_j \quad \forall j \quad (2)$$

where there are m cadastres and n features considered. Term one of Eq. (1) represents the sum of the selected cadastres costs, where the control variable $x_i = 1$ if cadastre i is selected and 0 if not selected. The cost of selecting cadastre i is the cadastre dependent parameter c_i. Term two of Eq. (1) is the weighted connectivity cost of the candidate protected area network, where b is the connectivity weighting factor to control its relative importance in the objective function and $cv_{i1,i2}$ is the connectivity value associated with having cadastre i_1 selected and cadastre i_2 not selected. The Boundary Length Modifier (BLM), b, is adjustable for enforcing greater or lesser connectedness within a protected area network. In Eq. (2), a_{ij} is the amount of each feature j held in each cadastre i, and t_j is the amount of each feature j that must be selected. The algorithm seeks to identify sets of planning units (from M different units) that meet the targets for all N features while minimizing the objective function (Ball et al., 2009).

All analyses applied the simulated annealing algorithm complemented with heuristic summed irreplaceability and normal iterative improvement to ensure target achievement for all vegetation types. As simulated annealing provides multiple near-optimal solutions, we ran each analysis 10,000 times per scenario to find the best solution. The species penalty factor was set at 10, after initial experimentation to ensure all conservation targets would be achieved.

2.5. Scenarios

Table 3 details the 81 analyses conducted, arranged across 11 scenarios, which can be classed broadly by (1) manual selection of cadastres (replicating non-systematic approaches traditionally adopted by conservation organizations), and (2) computer-based Marxan analyses. Of the three manual scenarios, Scenario 1 randomly selected cadastres, whilst Scenario 2 randomly selected cadastres by willingness classes, to emulate the way some land acquisition programmes prioritize areas by purchasing only those lands that are opportunistically available (Willis et al., 1996). Scenario 3 selected cadastres by largest area per willingness class, as large areas are favoured by politicians and bureaucrats who tend to measure conservation effectiveness in hectares. Each scenario comprised three analyses that differed by the 10%, 30% and 50% targets.

Of the eight scenarios (72 analyses) conducted using Marxan (Table 3), four scenarios (4–7) weighted land managers willingness-to-sell (to estimate implementation costs), and four scenarios (8–11) excluded unwilling land managers from the analyses (to replicate the real-world willingness-to-sell constraint facing land acquisition initiatives). Scenarios 4 and 8 provided near-optimal solutions, neither being constrained by cost weightings (Willingness Cost; Table 2). The remaining six scenarios (5–7, 9–11) were weighted by cost (Willingness Cost; Table 2). All Marxan scenarios applied combinations of three variable Boundary Length Modifier (BLM) weightings of 0, 10 and 100 to assess the influence of compactness on selected cadastres, against the three targets (10%, 30%, 50%).

Table 3
A total of 81 analyses and were conducted across 11 scenarios. 1 denotes targets expressed as a proportion of the planning region, not as a proportion of individual vegetation types. 2 denotes application of the Boundary Length Modifier (BLM) in Marxan. 3 denotes willingness cost weightings as detailed in Table 2. 4 denotes willingness constrained minimum sets analyses which have excluded cadastres owned by land managers unwilling-to-sell. All analyses were conducted for three targets of 10%, 30% and 50%.

	Scenario	Description	BLM weightings[2]	Willingness cost[3]	Willingness constrained[4]	No. of analyses
Manual selections[1]						
1.	Random	Areas ranked randomly to assess if (i) minsets are more effective than random selections, (ii) region-wide% targets achieve representation	None	Average	No	3
2.	Random availability	Areas ranked randomly by willingness classes. Reflects the way some land acquisition programmes prioritize land	None	Average	No	3
3.	Willingness-to-sell weighted by cadastre area	Areas ranked by willingness class and then largest area. Reflects (ineffective) approach where greater area = greater effectiveness	None	Average	No	3
Marxan analyses – Land managers' willingness weighted						
4.	'Best' near-optimal	Identifies the near-optimal solution for comparison to willingness constrained minsets	0, 10, 100	None	No	9
5.	Context 1	'Average' conditions. Returns on agriculture and land cost both moderate, therefore no incentive for land managers to sell	0, 10, 100	Context 1	No	9
6.	Context 2	2006 conditions. Some stock farmers keen to sell as returns poor. Land managers in eco-tourism not keen to sell as returns good.	0, 10, 100	Context 2	No	9
7.	Context 3	'Objective' willingness weightings which apply zero as the value for the 'unsure' response for land managers, and even weightings	0, 10, 100	Context 3	No	9
Marxan analyses – Unwilling land managers excluded						
8.	'Best' near-optimal	Identifies the near-optimal solution for comparison to willingness constrained minsets	0, 10, 100	None	Yes	9
9.	Context 1	'Average' conditions. Returns on agriculture and land cost both moderate, therefore no incentive for land managers to sell	0, 10, 100	Context 1	Yes	9
10.	Context 2	2006 conditions. Some stock farmers keen to sell as returns poor. Land managers in eco-tourism not keen to sell as returns good.	0, 10, 100	Context 2	Yes	9
11.	Context 3	'Objective' willingness weightings which apply zero as the value for the 'unsure' response for land managers, and even weightings	0, 10, 100	Context 3	Yes	9
	Totals		72	63	36	81

We compared the scenarios by (i) the number of targets achieved, (ii) estimated acquisition costs, (iii) the sum of individual land manager willingness weightings, and (iv) the spatial patterns of willingness-to-sell. Marxan provides a "summed solution" which is a measure of the importance of a cadastre for achieving conservation objectives. The summed solution is the number of times a cadastre was selected across 10,000 runs. We also investigated the similarity of scenarios by examining the spatial patterns of candidate protected area networks, applying a Spearman rank correlation analysis to the summed solutions for each pair of analyses (i.e., same target and BLM, but one including willingness-to-sell and one not).

3. Results

3.1. Target achievement

All nine near-optimal Marxan analyses unconstrained by land manager willingness-to-sell, achieved representation of 19 vegetation types to targets levels. However, land manager willingness-to-sell was low throughout the planning region, with only 10 out of 48 land managers (20.8%) willing to sell their land, leaving only 23.1% of the planning region available for acquisition. When planning units managed by unwilling land managers were removed from the analysis, the achievement of targets was substantially compromised. Only seven, five and one of the 19 vegetation types were represented, respectively, to 10%, 30% and 50% target levels. The level of target achievement for each Marxan analysis was uniform across each target level, regardless of varying the BLM weighting and cost constraints.

3.2. Cost efficiency

The most cost-efficient scenarios across all three targets (10%, 30% and 50%) for all nine near-optimal Marxan analyses unconstrained by land manager willingness-to-sell were consistently those without the BLM weighting. Land acquisition costs were homogenous across all BLM weightings for both the 30% and 50% targets for Context 1, with a maximum cost of R117, 555, 910. The 30% and 50% targets were homogenous for both Contexts 2 and 3. Interestingly, Context 1 was significantly more costly to purchase than either Context 2 or Context 3, despite the lower land purchase costs. The analyses comprising the Contexts 1–3 (Scenarios 5–7) were variously between 6.20% and 30.67% more expensive than estimated 2006 land prices. Notably, costs varied little for the three 50% target analyses.

3.3. Spatial configuration

The most area-efficient scenarios across all three targets (10%, 30% and 50%) for all nine near-optimal Marxan analyses unconstrained by land manager willingness-to-sell were consistently those without the BLM weighting. Application of the BLM weighting significantly reduced the number of cadastres selected, with the total area of all selected cadastres increasing only marginally (Fig. 1). The number of cadastres selected by the nine near-optimal Marxan analyses unconstrained by land manager willingness-to-sell typically decreased with increasing BLM weighting, the exception being for the 10% target. The Spearman rank correlation showed there was little spatial similarity between the near-optimal minimum sets, the BLM weighted minimum sets, and the willingness constrained minimum sets (Table 4). No predictable patterns were observable in the spatial distribution of land manager willingness-to-sell. Values were spatially heterogeneous, with land managers adjacent to existing protected areas being no-more willing-to-sell than land managers remote from existing protected areas. No spatially-contiguous groups of land managers with either high or low willingness-to-sell emerged from the analysis.

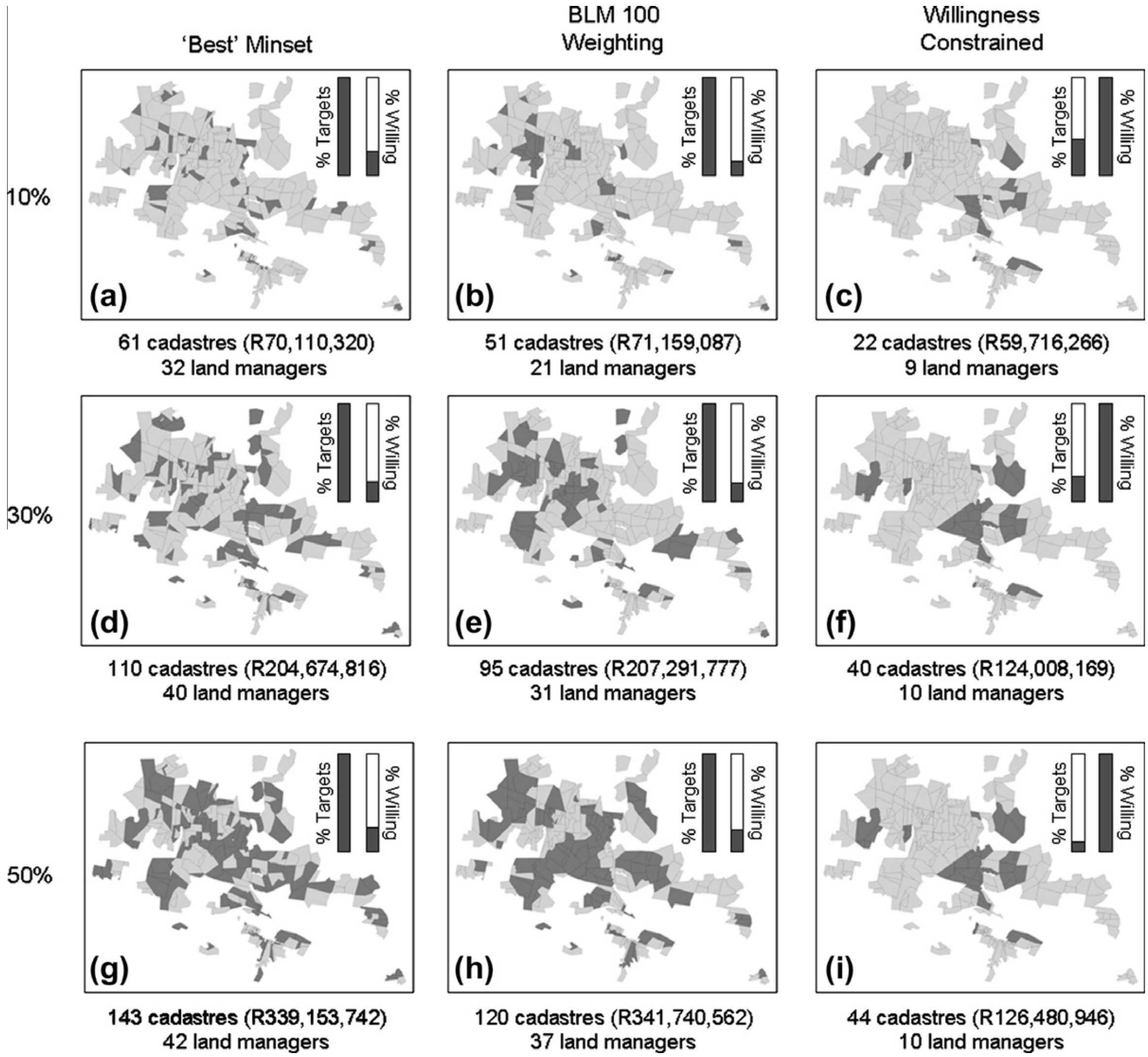

Fig. 1. Near-minimum sets of cadastres vary markedly in spatial configuration depending upon the BLM weighting and the willingness-to-sell constraint. Rows represent minimum sets with the same targets, whilst columns represent minimum sets with the same constraints. The BLM weighting produced a substantial reduction in the number of cadastres required to achieve targets and in the number of land managers potentially involved in a private land conservation initiative. A trade-off exists between target achievement and the proportion of land managers willing to sell their land to conservation interests.

3.4. Manual selections

Random selection of areas securing 10%, 30% and 50% of the planning region represented, respectively, only three, nine and eight of the 19 vegetation types to target levels. In comparison to the three analyses unconstrained by BLM weighting, the area, cost and number of cadastres were all lower for the 10% and 30% targets, but higher for the 50% target. Random sampling of cadastres by willingness ("Random availability"; Table 3) classes (constrained to the total area selected in the near-optimal analyses) selected significantly fewer cadastres than the purely random selections, though their total area was similar. Random selections of cadastres performed better than solutions constrained by land manager willingness-to-sell. Sampling of cadastres by willingness classes that preferentially selected the largest available cadastres first (similar to how some conservation agencies purchase lands), chose significantly fewer sites than either of the random selections.

4. Discussion

Most spatial prioritizations published in the peer-reviewed literature make a fundamental assumption – that most, if not all, land in a planning region is available for acquisition. However, we found low levels of land manager willingness-to-sell throughout the planning region, which substantially compromises attempts to achieve conservation targets. Furthermore, land manager willingness-to-sell was spatially heterogeneous, with land managers adjacent to existing protected areas being no-more willing-to-sell than land managers remote from existing protected areas, meaning compact options for acquisition are limited. There appears to be no likely easily mapped spatial surrogate for

Table 4
Spearman rank correlation coefficients between the different willingness-to-sell weightings (i.e., None, Context 1, Context 3, and Context 2) per conservation target. Minimum sets identified using a compactness (BLM) weighting of 100 were used.

Willingness weightings	Target		
	10%	30%	50%
None vs. Context 1	0.948	0.860	0.909
None vs. Context 3	0.881	0.719	0.824
None vs. Context 2	0.748	0.499	0.678
Context 1 vs. Context 3	0.983	0.964	0.979
Context 1 vs. Context 2	0.912	0.860	0.918
Context 3 vs. Context 2	0.965	0.948	0.965

willingness-to-sell. Interestingly, applying the BLM weighting produced only a marginally higher total acquisition cost. However, it should be noted that, given our conservative weightings of land acquisition costs based on land managers' willingness-to-sell, the expansion of the protected area network could prove very costly. We suggest our results are probably typical for production landscapes that provide their inhabitants healthy economic returns, and regions with urban development pressure. In economically marginal regions, land availability may, in fact, be high, and land acquisition costs correspondingly low, with land managers seeking to exit economically marginal businesses.

Interestingly, the trade-off between cost and the number of cadastres selected when all sites are available is small (Fig. 1). It is therefore useful to apply compactness and cost constraints when identifying cadastres for acquisition (or establishing private land agreements) in areas where land availability is high and properties comprise multiple cadastres. The significant reduction in the number of cadastres required to achieve targets for relatively little additional cost will prove beneficial for implementers – significantly fewer sales to negotiate, and increased time- and cost-effectiveness, which reduces protracted negotiations with land managers. Management costs, such as fencing, for conservation agencies could also be reduced.

This study was specifically designed to assess, in a simple way, the hypothesis that land manager willingness-to-sell compromises the implementation of recommendations from spatial prioritizations. However, the simplicity of the study has limitations. Firstly, minimum set analysis provides only a temporal 'snap-shot' of the region, which is potentially limiting for practical planning because willingness-to-sell may be highly dynamic over time. For example, since this data was collected, several land managers have sold their properties, meaning land availability has probably changed. Willingness-to-sell is likely influenced by a wide range of human, social and economic factors, some of which can be easily identified from available data (e.g., time a land manager has lived on a property), some of which the data can be gathered (e.g., burnout), and still others which are probably unpredictable (e.g., global market shifts) (Guerrero et al., 2010). Understanding rates of land manager turnover will be important for long-term conservation planning. Conceptually and practically situating spatial prioritizations within an "informed opportunism" approach (Noss et al., 2002; Knight and Cowling, 2007) is another technique for addressing the temporal change in land manager willingness-to-sell (Game et al., 2011).

Secondly, gathering land manager willingness-to-sell data can be time consuming, but is a worthwhile investment as the returns-on-investment when gathering biological data diminish rapidly (Grantham et al., 2008), and the often greater variability of non-biological data produces more significant influences upon spatial prioritization outputs (Perhans et al., 2008). Data gathering activities can double as opportunities for liaising meaningfully with land managers so as to build trust in, and support for, conservation initiatives. Data on land manager's willingness to engage other management instruments and institutions should be collected in addition to their willingness-to-sell (Knight et al., 2010) to enable the development of a landscape management model (Rouget et al., 2006) comprising an optimal mix of conservation instruments (Young et al., 1996).

Thirdly, we note that our vegetation and willingness-to-sell data is of finer resolution than is typically applied to spatial prioritizations, and that this will make achieving representation more difficult. However, fine-scale data should be utilized wherever possible, especially for scheduling action in regions exhibiting high species turnover or fragmentation (Rouget, 2003; Knight et al., 2006). We suggest that conservation planners wishing to replicate our study apply Context 1 willingness-to-sell weightings where returns on land-use and land cost are both modest, and the Context 2 scenario where land-use is dominated by two major activities with one significantly more lucrative.

Our finding that available land comprises such a small proportion of the planning region has implications generally for how the principle of flexibility is addressed in conservation planning. Flexibility manifests both as (1) the range of alternative site configurations achieving targets to form a representative protected area network, and (2) the ability to respond to opportunities dynamically as they arise (i.e., informed opportunism; Noss et al., 2002; Knight and Cowling, 2007) (Pressey et al., 1993; Margules and Pressey, 2000). Many regions are likely to have lower numbers of alternative protected area configurations than perhaps expected without willingness-to-sell data, with targets unachievable for some or many natural features. Options for avoiding land-use conflicts may therefore be few, especially when targets are high. In this context, the adoption of a long-term informed opportunism approach to land acquisition (e.g., Game et al., 2011) may prove effective. Data on the human and social factors that define implementation opportunities and constraints will facilitate such an approach (Knight and Cowling, 2007). In regions where willingness-to-sell is low, establishing private land conservation initiatives should be considered (e.g., Knight et al., 2010).

Our qualitative observations suggests land managers have low willingness-to-sell for economic reasons, or because they are culturally and historically attached to the region, and define their identity, at least partially, from their geographical context. If land is to be purchased, it may be necessary to pay premium prices to provide an incentive for land managers to sell, and so increase the availability of land (Meir et al., 2004). Several land managers who were unwilling-to-sell indicated they would consider selling if offered substantially (i.e., 2–3 times) more than market value. Paying premium land prices increases the funds required to establish protected area networks, and may inadvertently increase land prices (Armsworth et al., 2006). The degree to which purchases for conservation increase land acquisition costs will relate to the amount of land purchased, and the degree of development pressure (Armsworth et al., 2006). We have witnessed this phenomenon throughout the planning region between 2001 and 2006, where land prices increased from roughly 500 to over 6500 Rands per hectare, as large tracts of land were purchased by wealthy foreigners for private reserves. Knowing that land purchases for conservation have the potential to increase costs (Armsworth et al., 2006) and that increased cadastre availability is better than increased funding when selecting protected areas over the medium-term (Meir et al., 2004), an alternative strategy to land acquisition is required – private land conservation initiatives. Although many land managers may be unwilling-to-sell, they may be interested in committing to some form of covenant or voluntary conservation agreement (Langholz, 1996; Thackway and Olsson, 1999; Langholz and Lassoie, 2001; Chacon, 2005; Winter et al., 2005). This has the advantage of costing significantly less in both the short- and long-term (Pence et al., 2003), although security of these landscapes may be less certain. A parallel study indicates that the majority of land managers are potentially interested to join private land conservation initiatives in the planning region (Knight et al., 2010).

There has been considerable discussion of the merits of integrating the natural and social sciences for conservation planning (Soulé, 1986; Meine and Knight, 1999; Meffe, 2001; Balmford and Cowling, 2006; Hunter and Gibbs, 2007), however few practical recommendations have emerged. We know, however, that conservation planning products (e.g., maps) must be both user-useful and user-friendly (Pierce et al., 2005). Mapping conservation opportunity (Knight and Cowling, 2007), rather than priority conservation areas based on biological data alone, addresses implementers need to understand implementation opportunities and constraints. Biological and vulnerability data should be complemented with data on economic costs, human capital and social capital to reflect the feasibility and probable effectiveness of conservation actions on-the-ground (Cowling et al., 2004; Knight and Cowling, 2007; Knight et al., 2010). As an example, the inclusion of land managers' willingness-to-sell in spatial prioritizations informing land acquisition initiatives means implementers receive conservation planning products which detail land availability. This reduces the likelihood that conservation planners will have to repeat their analyses when selected areas are found to be unavailable (Margules and Pressey, 2000; Knight et al., 2010). It also better ensures that conservation planners and the staff of implementing agencies appear professional and capable to stakeholders, which promotes confidence and trust, saves time and money, and better promotes the usefulness of spatial prioritizations for solving real-world problems for both implementers and stakeholders. We strongly encourage conservation planners to invest equal time and resources in gathering and analyzing human and social data to complement biological, vulnerability and economic data. This can be most effectively achieved by sourcing human and social data from the people making major daily decisions that affect landscapes (Smith et al., 2009) – land managers.

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