A review of conservation project selection criteria in the Midlands Biodiversity Hotspot Tender, Tasmania:

sensitivity to project duration and auction budget

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Purpose of Report

The purpose of the report is to provide a summary of how a biodiversity conservation tender operated, including a sensitivity analysis based on submitted offers. The report focuses on the Midlands Biodiversity Hotspot Tender program in Tasmanian and briefly outlines other environmental tender processes as context. The detailed description of the Midlands Biodiversity Hotspot Tender process includes the metrics used to evaluate the bids, a summary of the auction outcomes and the outcomes of the sensitivity analysis. The report informs the Landscapes and Policy Research Hub's development of tools, techniques and policy options to integrate biodiversity into regional scale planning. It is a background report in support of the Economic Futures research conducted in the hub. The report was produced by the Economics Futures Project in collaboration with the Tasmanian Land Conservancy. The report is an output of the Landscapes and Policy Research Hub.

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Frequently Used Abbreviations

ALR	Auctions for Landscape Recovery
ALRUU	Auction for Landscape Recovery Under Uncertainty
CBI	Cost Benefit Index
CVI	Conservation Value Index
FCF	Forest Conservation Fund
MBHT	Midlands Biodiversity Hotspot Tender
MBI	Market Based Instruments
TLC	Tasmanian Land Conservancy

1. Introduction

The Midlands Biodiversity Hotspot Tender (MBHT) was a voluntary biodiversity conservation program for landholders in the Northern Midlands Bioregion of Tasmania (Figure 1). The bioregion has significant biodiversity conservation values including: 10 endemic plant species (including 7 endemic orchids); two endemic freshwater mussels, plus endemic freshwater snails and caddisflies; 32 nationally threatened taxa; more than 180 plant and animal species listed by the *Tasmanian Threatened Species Protection Act 1995*; 24 nationally threatened plant species; and 12 wetlands listed on the Directory of Important Wetlands in Australia, and 10 wetlands of regional significance (Sattler & Creighton 2002).

The natural environment and vegetation of the bioregion has undergone severe modification and conversion, and was one of the first areas of Australia cleared for agriculture. As a consequence less than 30% of the original vegetation remains. The remaining natural vegetation is scattered and exists only in small patches in poor condition (Sattler & Creighton 2002). Much of the clearance in the 1980s was concentrated on vegetation types which are rare, and in the most cases, exist only in secure reserves (Kirkpatrick 1991). Moreover, in the past two decades natural and man-made threats such as vegetation loss and degradation, soil erosion, degraded river systems, dryland salinity, rural tree decline, denuded north-facing slopes and weed invasion have intensified (Davidson et al. 2007).

The Tasmanian Natural Resource Management Strategy set in place a platform for a Midlands network of protected areas (Mendel & Kirkpatrick 2002). However, according to McQuillan et al. (2009) less than 5% of the bioregion has been brought under the protected area network and earlier reserves mostly covered commercially less important vegetation types and areas. Due to continuous clearing and degradation, there are no large contiguous areas of native vegetation spanning the full range in elevation. It has been estimated that there are more than 5900 patches of remnant native vegetation less than 10 ha in size and 1895 patches, 10 ha to 50 ha in size. While these patches provide valuable habitat for threatened and priority species and communities, most of them are located on private lands (Michaels et al. 2010).

In the absence of significant amount of land to expand public reserve networks Mendel and Kirkpatrick (2002) argue that '*conservation may need to rely largely on integration with the pastoral economy through covenants and management agreements, rather than traditional reservation*' (page 1527). Responding to this call, the Australian Government conducted a Midlands Biodiversity Hotspot Tender (MBHT) to conserve biodiversity on private lands (Figure 1). This report provides a summary of how the tender operated and its performance.

Midlands Biodiversity Hotspot Tender Project Area

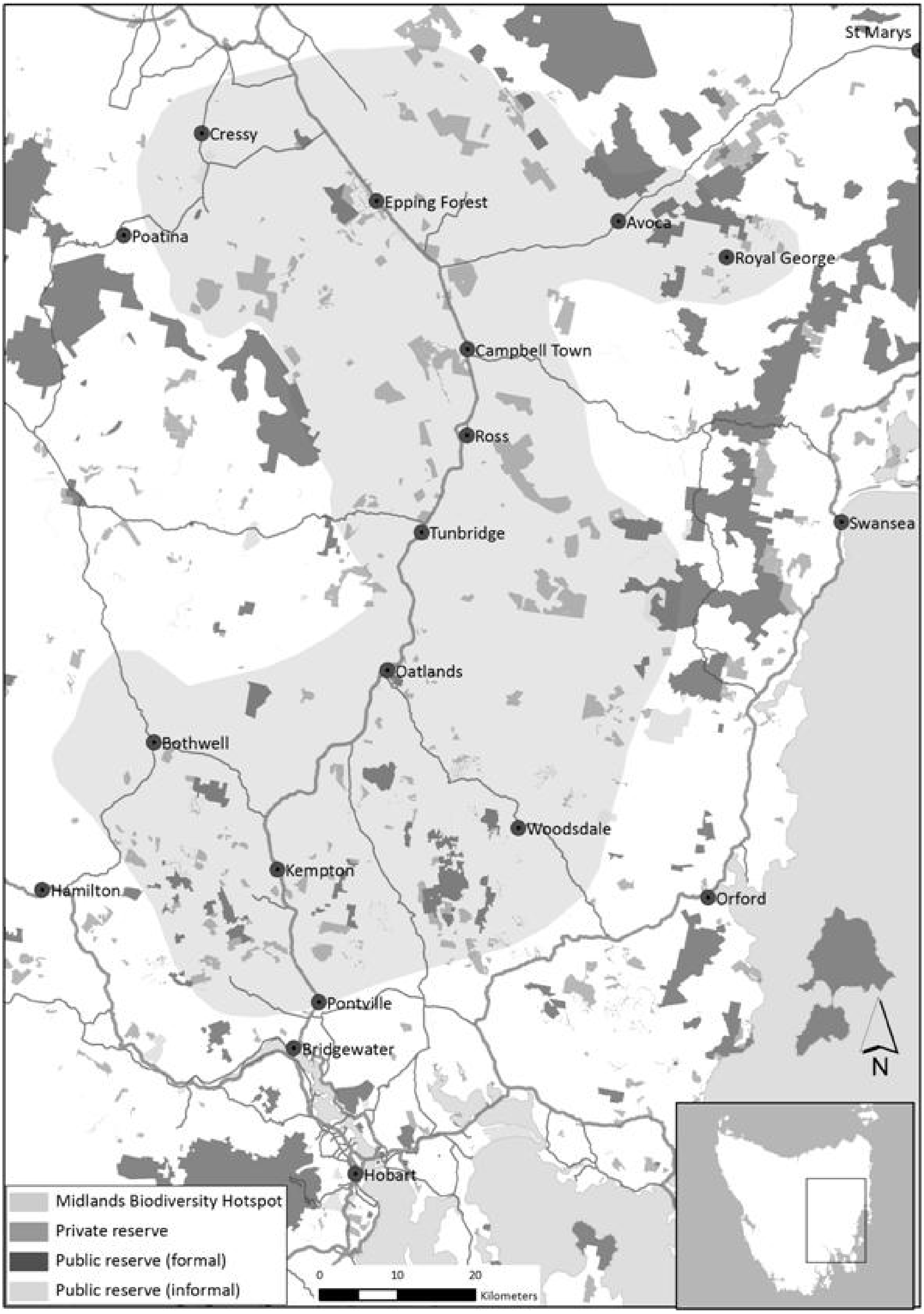

Figure 1: Map of the Midlands Biodiversity Hotspot Tender project area

2. Previous Tender Schemes

The following section provides a brief history of previous tender based schemes in Australia. A description of the 'Midlands Biodiversity Hotspot Tender' (MBHT) follows, with the results of a sensitivity analysis.

Auctions are used to allocate resources based on the submitted bids by the market participants (McAfee & McMillan 1987). An explicit set of rules determine the types and nature of bids submitted in the market (Krishna 2002). Auctions are useful for conservation payment as they can, under appropriate conditions, result in efficient and cost effective outcomes (Latacz-Lohmann & Hamsvoort 1997; Latacz-Lohmann & Hamsvoort 1998). As a result, auction based conservation incentive payments are gradually gaining popularity. Examples include 'BushTender', 'EcoTender' and 'Auction for Landscape Recovery', as well as series of pilot programs funded under a national market based instruments program.

BushTender

The 'BushTender' scheme was the first formal government environmental tender in Australia. The objective of the tender was to enhance biodiversity value of remnant or bush in the North-east and North Central regions of Victoria[1]. Later from 2003-2005, under the National Market-Based Instruments Program initiative, eleven market based instrument designs were trialled across Australia in the first round (Grafton 2005).

EcoTender

The 'EcoTender' pilot scheme was one of these implemented by the Victorian Department of Primary Industries. Similar to BushTender, EcoTender[2] also used a first-price sealed-bid tender system with multiple environmental objectives: terrestrial biodiversity; aquatic function which incorporates changes in water quality and quantity; saline land area change; and carbon sequestration. Considering pre-1750 as the 'natural benchmark' a set of indicators were assessed using a Catchment Management Framework[3].

Auctions for Landscape Recovery

In the 'Auctions for Landscape Recovery' (ALR) scheme conducted in Western Australia a sealed-bid, price-discriminating auction format was used to allocate funds to landholders for on-ground works focusing on biodiversity conservation measures[4]. Management actions included fencing of biodiversity assets, re-vegetation, rabbit and fox control, and corridor construction. A systematic conservation planning approach was used to evaluate bids (Gole et al. 2005).

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[1] A sealed bid discriminatory price tender format was used. A total of 126 expressions of interest were received from landholders, which resulted in 98 bids in the actual auction. Bids were ranked according to a Biodiversity Benefit Index (BBI) and in total 73 contracts were allocated (Stoneham *et al.* 2003)

[2] Funded by the Victorian Department of Primary Industries.

[3] In the actual tender, a total of 50 bids from 21 farms were submitted, of which 31 bids were accepted. Payment to successful bidders consisted of half at the commencement of the contract and the balance paid during intermediate periods (Eigenraam et al. 2006).

[4] A total of 55 bids were received from 38 landholders in Round One and 33 tenders from 21 landholders in Round Two.

National Market Based Instruments Pilot Program

The second round of the National Market Based Instruments (MBI) Pilot Program started mid-2006 and concluded in June 2008. A total of nine projects were funded to develop and test a new set of policy instruments[5]. For example, under the Auction for Landscape Recovery Under Uncertainty (ALRUU) project, implication of conservation outcome uncertainty on bid selection and project performances was tested using GIS analysis and choice modelling exercises. Under the project selection mechanism, rare vegetation types in moderate condition were prioritised as they had higher probability of positive response to conservation measures (White et al. 2011). On the other hand, under the 'Environmental Auctions and Beyond' trial outcomes from bi-lateral negotiations between landholders and the agency were compared with outcomes from a traditional conservation auction design. In both cases, environmental benefits of the submitted projects were similar. They observed that cost-effectiveness was the highest for a discriminatory price auction with a fixed budget, where projects with connectivity benefits were prioritised (Bryan et al. 2008). Under the 'Designing auctions with outcome bonuses' trial, performances of an outcome based payment scheme 'NestEgg' was studied where payment to landholders was related to the number and condition of the nests of ground-nesting birds in the Murray catchment. It was observed that the use of an outcome based auction could be more cost effective (at least 33%) than an input based contract (Gorddard et al. 2008).

Tasmanian Tender Programs

There have also been a number of successful conservation tenders in Tasmania. Department of Environment, Water, Heritage and the Arts, under the Forest Conservation Fund (FCF), conducted a tender during 2007 to 2009 to secure 40,000 ha of old growth and under-reserved forest communities of forest under management agreements. To evaluate submitted bids, a conservation value index was prepared. The index included assessment of several criteria, including the relative preferences for different forest types; the structural form of the forest; current condition; regional threat index from surrounding land uses and conditions; the current level of reservation for each specific forest type; maintenance status of current condition; voluntary management actions and the impacts they are likely to have; and duration of the project. Along with a tender based mechanism, direct approaches, such as negotiated price agreements, were used to achieve conservation targets (Binney & Whiteoak 2010).

This report focuses on the Midlands Biodiversity Hotspot Tender (MBHT) - a prominent tender based scheme in Tasmania.

[5] Source: http://www.marketbasedinstruments.gov.au/MBIsinaction/tabid/62/Default.aspx

3. Nature of the Midlands Tender Process

In 2007, the Tasmanian Land Conservancy was contracted by the *Maintaining Australia's Biodiversity Hotspots Program* – an Australian Government initiative, to conduct a locally-competitive tender for biodiversity stewardship contracts (Tasmanian Land Conservancy 2008). The purpose of the tender was to maximise conservation outcomes with the funds available, test the cost efficiency of a tender approach, and set market values for the various conservation values and services. The Midlands Biodiversity Hotspot Tender auction was conducted as a sealed-bid, discriminative price auction. Offers were developed with the assistance of field officers who evaluated and then assigned a biodiversity metric to each proposal.

Metrics for Tender Selection

In order to conduct the tender it was first necessary to develop a common metric to evaluate alternative bids. This was a specific metric developed to reflect the conservation values of the area being considered and designed to be applied in that area. The Midlands Biodiversity Hotspot Tender Cost Benefit Index (CBI) considered:

a) the conservation value of the parcel of land being offered,
b) the duration of conservation management services, and
c) the financial payment requested by the landholder.

The conservation value was made up of three elements (Equation 1):

Element 1 Biological values (made up of scores for floristic vegetation community (Table 1), presence of threatened species, presence of old growth trees and physical location in terms of connectivity within the region).

Element 2 A condition rating (expert assessment relative to an undisturbed site (Table 2) and weediness).

Element 3 Stewardship services – changes to management that favoured conservation (Table 3 - both positive rights in terms of level of grazing and level of firewood collection; and across all contracts, negative rights in terms of the loss of choices to not control weed and feral animals).

The Conservation Value Index (CVI) was calculated in a stepwise fashion. The innate biological values of each mapped polygon (vegetation community, threatened species, old growth and connectivity scores) are summed and multiplied by the health score and the polygon's area to give a set of polygon scores. The scores for all polygons for each bid are summed and then multiplied by the conservation service modifier (management actions to promote conservation) and a temporal weighing score to reflect the duration of conservation management. Formally:

Conservation Value Index =	((Vegetation community score + Threatened species score + Old growth score + Connectivity score) × Vegetation Health Condition × Area × Conservation Service Modifier) × Temporal Weighting Score	**(Equation 1)**

The method of calculating the conservation value for each potential offer was made transparent to each interested landholder prior to posting a bid. Although the relative scores for these elements were not disclosed, knowledge that all participants were playing under the same rules, and that (for instance) firewood collection degraded the score, led to a degree of satisfaction that the tender was 'fair'.

Vegetation Community Score

The vegetation community score and threatened species score assigned under the MBHT are summarised in Table 1. Communities were prioritised and given a 1-5 score for community and threatened species.

Table 1: Community score and threatened species score assigned under the Midlands Biodiversity Hotspot Tender (Tasmanian Land Conservancy 2008)

	Ecological Vegetation Subregion (*TASVEG codes*)			Communities		
Priority	**Northern Midlands**	**South East**	**Ben Lomond**	**Description**	**Community Score**	**Threatened Species Score**
1	GTL (end)	GTL (end)	GTL (end)	*Themeda* lowland grassland	7	5
	NBA ass. GTL	NBA ass. GTL	NBA ass. GTL	*Bursaria spinosa* &/or *Acacia mearnsii* near GTL	7	4
	GPL flats (end)	GPL flats (end)	GPL flats (end)	*Poa labillardieri* lowland grassland	7	3
2	SRI (vuln)	SRI (vuln)	SRI (vuln)	Riparian scrub	6	5
	DOV (end)	DOV (end)	DOV (end)	*Eucalyptus ovata* forest & woodland	6	4
	DMW			Midlands woodland complex	6	4
	AWU (vuln)	AWU (vuln)	AWU (vuln)	Wetland undifferentiated	6	4
	WVI (end)	WVI (end)	WVI (end)	*Eucalyptus viminalis* wet forest	6	3
	NME (vuln)	NME (vuln)	NME (vuln)	*Melaleuca ericifolia*	6	1
		WBR (vuln)	WBR (vuln)	*Eucalyptus brookeriana* forest	6	1
	NNP (rare)		NNP (rare)	*Notelaea, Pomaderris, Beyeria*	6	1
3	DAZ (vuln)	DAZ (vuln)	DAZ (vuln)	*Eucalyptus amygdalina* on cainozoic deposits	5	5
	GRP	GRP	GRP	Rockplate grassland	5	4
	GCL	GCL	GCL	Lowland grassland complex	5	4
	DAS (vuln)	DAS (vuln)	DAS (vuln)	*Eucalyptus amygdalina* on sandstone	5	3
	DVS	DVS	DVS	*Eucalyptus viminalis* healthy forest	5	3
		DGL (vuln)		*Eucalyptus globulus* dry forest	5	3
	DPO	DPO	DPO	*Eucalyptus pauciflora* not on dolerite	5	3
		DTO (vuln)		*Eucalyptus tenuiramis* not on dolerite	5	3
4	DAD			*Eucalyptus amygdalina* on dolerite	4	3
	DRO		DRO	Eucalyptus *rodwayi*	4	3
	DVG	DVG	DVG	*Eucalyptus viminalis* grassy forest	4	2

Ecological Vegetation Subregion (*TASVEG codes*)				Communities		
Priority	**Northern Midlands**	**South East**	**Ben Lomond**	**Description**	**Community Score**	**Threatened Species Score**
4	DAM			*Eucalyptus amygdalina* on mudstone	4	2
	DPD			*Eucalyptus pauciflora* on dolerite	4	2
	GPL slopes	GPL slopes	GPL slopes	*Poa labillardieri* lowland grassland	4	2
	GCL derived	GCL derived	GCL derived	Lowland grassland complex (derived)	4	2
	SHW	SHW	SHW	Wet heathland	4	2
	SLW	SLW	SLW	*Leptospermum* scrub	4	2
	Significant Outlier Community			not listed above or below	4	2
5		DAM	DAM	*Eucalyptus amygdalina* on mudstone	3	2
	DSC		DSC	*Eucalyptus amygdalina/Eucalyptus obliqua* damp forest	3	2
			NAR	*Acacia melanoxylon* on rises	3	2
	NBA (dieback)	NBA (dieback)	NBA (dieback)	*Bursaria spinosa* &/or *Acacia mearnsii* in dieback	3	2
	GSL	GSL	GSL	Lowland sedgey grassland	3	2
	NAV		NAV	*Allocasuarina verticillata* forest	3	1
6			DAD	*Eucalyptus amygdalina* on dolerite	2	2
		DRO		Eucalyptus *rodwayi*	2	1
		WOU	WOU	*Eucalyptus obliqua* wet	2	1
7		DAD		*Eucalyptus amygdalina* on dolerite	1	3
		DPU		Eucalyptus *pulchella*	1	3
		DDE	DDE	*Eucalyptus delegatensis* dry	1	1
		DOB	DOB	*Eucalyptus obliqua* dry	1	1
		DPD		*Eucalyptus pauciflora* on dolerite	1	1
	NAD	NAD	NAD	*Acacia dealbata* forest	1	1
		NAV		*Allocasuarina verticillata* forest	1	1
		WDU	WDU	*Eucalyptus delegatensis* wet	1	1
		WRE	WRE	*Eucalyptus regnans* wet	1	1
	Low Significance Outlier Community			not listed above or below	1	1

Table notes:

TASVEG codes	as described in the *Tasmanian Vegetation Monitoring and Mapping Program TASVEG V2.0 Metadata* handbook (2009)
(end)	endangered;
(vuln)	vulnerable
ass.	associated with (rare) rare

The vegetation health score consisted of three categories based on attributes of individual polygons (as shown in Table 2).

Category 1 included diversity attributes; both structural and species diversity, as well as flora health.

Category 2 included community level attributes in terms of disturbance. Disturbance could be in the form of grazing or fire as well as the infestation of weeds.

Category 3 included measures of lack of diversity in terms of species and structural diversity. There were clear overlays in the various categories.

Table 2: Vegetation community health scores criteria for polygon assessment used in Midlands Biodiversity Hotspot Tender (Tasmanian Land Conservancy 2008)

Category	Attributes	Score
1	At least three of the following attributes to qualify for Category 1 Appropriate structural diversity Appropriate species diversity Flora in good health Soil surface appropriate for community Co-occurrence of lots of 'rare' species Unique or unusual plant assemblages for the site Occurrence of habitat features, for example tree hollows/caves/fallen logs	1.3
2	Community in good condition as demonstrated by the presence of the indicators above however some biological disturbance or degradation obvious, for example from: Grazing Physical disturbance Firewood collection Frequent fire Naturalised weeds, for example clovers, flatweeds	1
3	Three or more of the following attributes Lack of structural diversity Lack of species diversity High level of physical disturbance High grazing pressure Tree dieback present Phytophthora symptoms evident High level of high threat weeds	0.7

To account for the positive impact that management can have on the condition of the conservation values, a conservation service (threat reduction) scoring approach was developed. A summary is presented in Table 3.

Table 3: Generalised conservation service (threat reduction) scoring approach (Tasmanian Land Conservancy 2008)

Possible extent of amelioration of threatening process	Range of amelioration scores
Potential impact of threat is major loss of values, no agreement to monitor and guard against threat.	0% (reject bid)
Agree to reduce threat or maintain at level of moderate impact	50%
Agree to reduce threat or to maintain at minor impact	75%
Manage threat to maintain conservation value at optimum level	100%

Landholders could choose from five time periods (Table 4) to deliver the conservation services and these were mediated by two different legal instruments. Contracts with the Tasmanian Land Conservancy, under common law agreements, were issued for a duration of 6 or 12 years. Contracts issued by the Tasmanian Government under the conservation covenant were for beyond 24 years and in to perpetuity.

Table 4: Types and durations of contracts (Tasmanian Land Conservancy 2008)

Type of contract	Agency	Duration
Common law agreement	Tasmanian Land Conservancy	6 or 12 years
Conservation covenant	Tasmanian Government	24, 48 years or in perpetuity

Tender Process

The tender was advertised and expressions of interest received from 89 potential bidders. Rapid field assessment of 80 of these sites was conducted by experienced biological field officers, who also explained the tender to landholders in greater detail. Fifty-four sealed bids were submitted to the tender administrator. Field data (measured areas, biological values and condition assessment) were determined by the field officers. Landholders determined the size and shape of the land in the bid, the level of conservation service they were offering, the duration of the agreement and the amount of money they were asking to deliver the defined conservation services.

Bids were checked for accuracy, the metric calculated for each bid, and each Cost Benefit Index (CBI) was plotted as a mechanism to compare the bids. Probity required that the nature and details of the bids were not disclosed to anyone apart from the administrator, thus ensuring that each bid was assessed on the objective merits of the bid as expressed by the metric and its component scores. An expert panel was assembled to assess and interpret the results, and to form a recommendation to submit to the funding body as an investment package up to the amount of funds available within the program. Various qualitative assessments of the bids were made by the expert panel to check that the metric was performing as expected in ranking bids in approximate cost order.

Once accepted, individual contracts were drawn up with each successful landholder. The contracts included agreed responsibilities for on-ground monitoring and reporting of conservation services. Successful contracts totalled 8,089 hectares from 32 bids, using money drawn not only from Maintaining Australia's Biodiversity Hotspots, but also money drawn from two other funding programs that existed concurrently, the Forest Conservation Fund, and the Non-Forest Vegetation Program.

In this study, we examined the consequences of varying the project duration, weight and auction budget. The study uses the original bid data, recognising that offers may have varied under different rules and conditions.

Sensitivity of Auction Outcomes

The results of all of our sensitivity analysis depend on the assumption that bidder behaviour would not change between the different scenarios tested, even though standard auction literature indicates that individual landholders are likely to respond differently to auction rules. Without a formal survey or conducting the auctions again, we do not have any prior empirical knowledge about how our particular group of landholders would respond to changed auction rules. Therefore, following Stoneham et al. (2003), we assumed that bidders would submit the same bid under different scheme.

Using the original tender data this study explored the consequences of project duration and auction budget on auction outcomes.

Sensitivity to Project Duration

The total conservation value or score generated for a polygon was multiplied by the temporal weighting to generate an overall conservation benefit score. In the original project selection, different project lengths (6 years, 12 years, 24 years, 48 years and in perpetuity) were given different weights. Projects with longer duration received higher weights (Scenario 5 in Table 5). In order to test the sensitivity around the weighting scheme, an additional four scenarios have been generated for this report.

In Scenario 1 projects of all durations are given an equal weight of 1. This is the baseline scenario used to assess the impact of temporal weighting. Scenarios 2 - 4 are intermediate variations gradually giving higher weights to projects with longer durations. In order to compare across the scenarios, we have calculated raw ecological values without any temporal weighting modifications. For example, under Scenario 5 the conservation value of a project with 12 years duration was estimated as 50. Using Equation 2, the raw conservation value of the project would be estimated as 25, which is equal to the conservation value divided by the temporal weighting score.

Raw Conservation Value Index = CVI / Temporal Weighting Score **(Equation 2)**

In order to compare different scenarios, we use the following steps:

Step 1: Under different temporal weighting scenarios, projects of different durations were multiplied by their respective Temporal Weighting Score.

Step 2: Projects were selected based on their total CVI subject to budget constraints.

Step 3: The raw conservation value index was calculated for individual successful projects using Equation 2.

Step 4: The total raw conservation value score and total payment were calculated by summing up the raw conservation value index and bid prices of the successful projects.

Step 5: The Raw Conservation Value Index score per dollar (Raw CVI/$) was calculated by dividing the total raw conservation value score by the total payment.

Table 5: Five temporal weighting scenarios

Term	Temporal Weighting Score				
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
6 years	1	1	1	1	1
12 years	1	2	2	2	2
24 years	1	2	3.8	3.8	3.8
48 years	1	2	3.8	6.6	6.6
In perpetuity	1	2	3.8	6.6	10

Sensitivity to Auction Budget

In terms of auction design, we tested the impact of the auction budget and the cost-effectiveness of project selection. The MBHT auction was originally conceived as having a fixed budget. However, towards the end of the project, two other sources of funding were brought in and allowed the funding of further bids. This expanded the size of the available budget by a factor of 6.5 and allowed further bids to be funded.

Depending on the shape of the supply curve, the price would change. An elastic supply curve would allow the agency to secure more conservation benefits within a fixed budget, whereas an inelastic supply curve would make it prohibitively expensive to purchase additional conservation benefits with an increased budget. The impact of increasing the budget on cost effectiveness of auctions could be explained by using Figure 2. Given a budget constraint (M_1), the total cumulative CVI is J_1 and the total cost of the auction, the area under the supply curve (S) is given by oaM_1J_1. If the budget is expanded to M_2 the total cost of procuring J_2 is oaM_2J_2. Inclusion of more expensive projects with additional budget drives the price up. On the contrary, lowering of budget would select only the cheaper projects.

Conservation Value Index

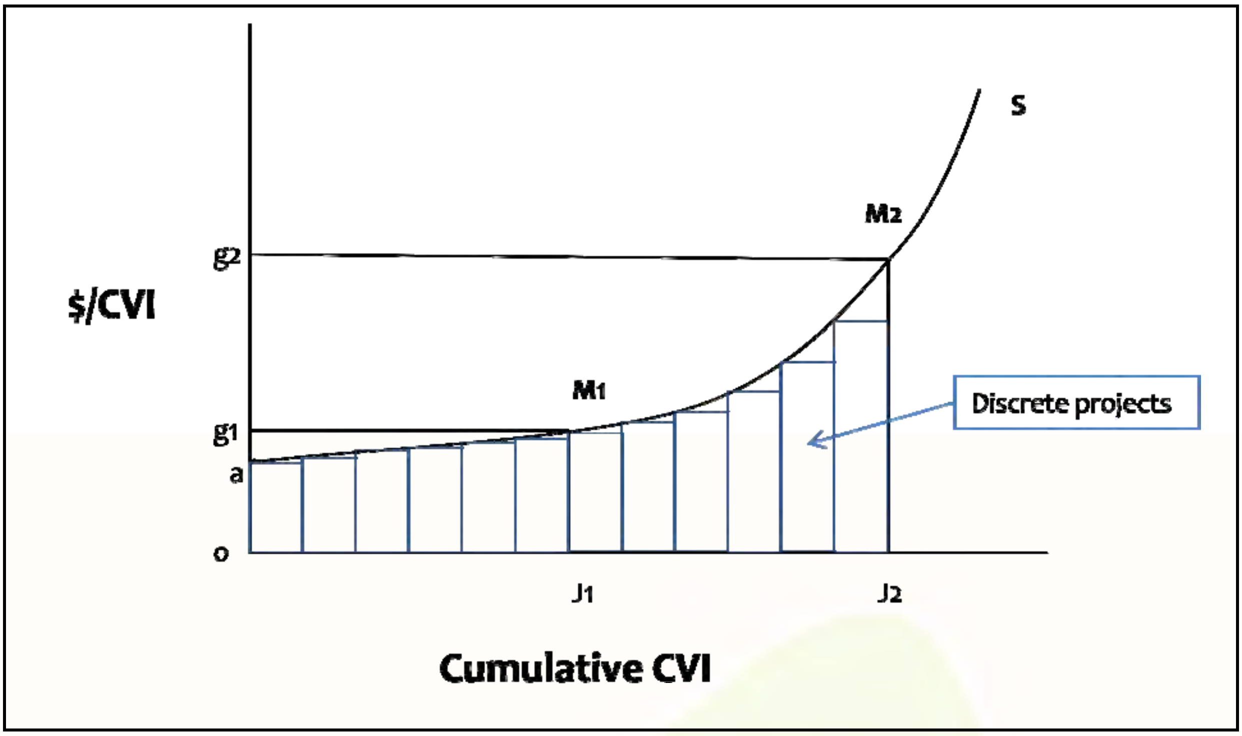

Figure 2: The supply curve for conservation value for a hypothetical conservation auction (Source: Latacz-Lohmann & Hamsvoort 1997)

In the current design, each bidder submits an offer to fund a project. Their bid consists of the price and the attributes of the proposed conservation activity. Offers are selected on the basis of maximising the environmental benefits, subject to the condition that the total procurement cost does not exceed the agency's budget. In order to test the sensitivity of the supply curve derived under the MBHT budgetary constraints, we varied the budget from $0.01 million to $11 million in $100,000 increments in our simulations[6]. This allowed us to infer supply responses to budgetary constraints under the program.

[6] The original budget was $1.2 million, but the final funds applied to the bids was $7.9 million

To calculate the influence of budgetary constraint in the optimisation model[7], we started with the lowest budget constraint (that is, \$0.01 million). For a fixed budget, projects were selected based on their total CVI (calculated from Equation 1; Scenario 5 in Table 5) subject to budget constraints. The total conservation value score and total payment was calculated by summing the conservation value index and the bid prices of the successful projects. To estimate the effect of budget constraint, the Conservation Value Index score per dollar (CVI/\$) was calculated by dividing the total conservation value score by total payment. To estimate cost-effectiveness of the discriminatory price auction, dollar per Conservation Value Index score (\$/CVI) was calculated by dividing the total payment by the total conservation value score. Finally, the dollar per Conservation Value Index score (\$/CVI) of the most expensive project among the selected projects was calculated and used to determine the uniform payment level. These steps were repeated for an increased budget constraint using the original set of bids.

It is a common practice to measure relative cost-efficiency of auctions by comparing them with a uniform payment scheme (Stoneham et al. 2003; White& Burton 2010). In Figure 2, for a budget M_1 a uniform payment, g_1 is paid per unit of the CVI. The total cost of the uniform payment is og_1M1J_1, while the area ag_1M1 gives the efficiency gain from the discriminative price auction. With an increased budget the benefit is substantially higher, ag_2M_2. Following White and Burton (2010), we also compared the auction performance with a counter-factual uniform payment scheme, where a uniform payment per CVI was calculated. The uniform payment per ecological score is calculated in such a way that winning bidders receive no less than their successful bids. Therefore, winning bidders receive payments equal to their CVI score multiplied by the uniform payment per CVI. In the above figure for example, with a budget of M_1 all the winning bids would receive a uniform payment g_1 per CVI, whereas with an auction budget of M_2 all winning bids would receive a payment equal to g_2 per CVI.

4. Results and Discussion

In this section we present and discuss the results from the simulation experiments. First, the sensitivity of the results to project duration, then to the size of the budget.

Sensitivity to Project Duration

The raw CVI scores per dollar against budget are plotted in Figure 3. While the benefit (score) per dollar declined as the budget increased as expected, we also observe that raw CVI score per dollar is quite sensitive to the weight attached to different project durations. For example, the median raw CVI score per dollar is 6.45% lower in Scenario 5 (with different weighting for different durations) than in Scenario 1, where projects of different durations were given equal weight (Table 6). This trend indicates that there is a trade-off involved in weighting project selection between projects of longer duration but smaller conservation scores, versus projects with shorter length and higher conservation scores.

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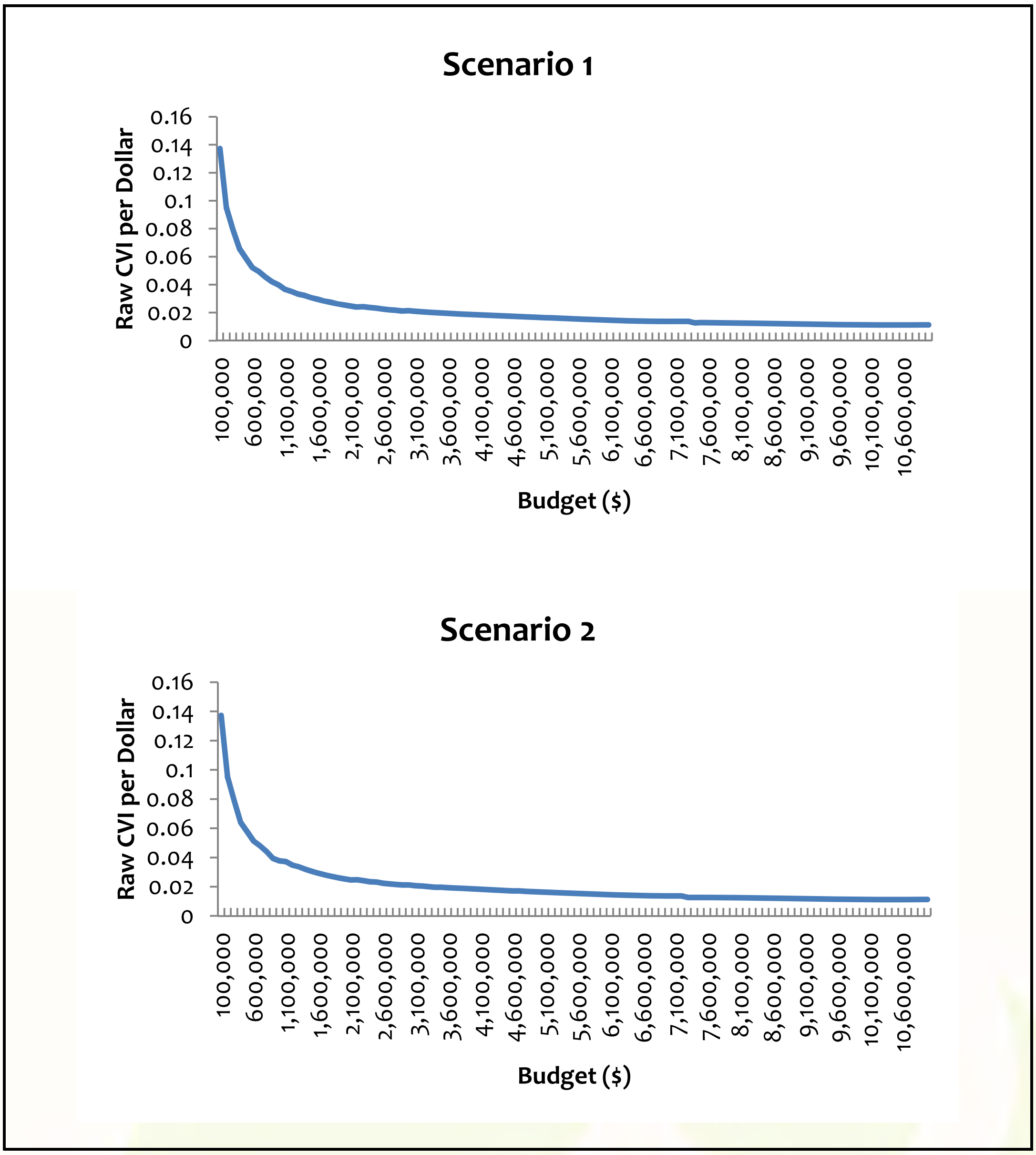
[7] Solved using General Algebraic Modeling System (GAMS©)

Short duration, high value projects could be seen as 'buying time' to allow other policy instruments, such as regulation, to catch up to the increasing loss of ecological values. This is in fact what happened in Tasmania, with the very rare lowland native grasslands being listed under the national *Environmental Protection and Biodiversity Conservation Act 1999* within two years of the auction being held.

Raw CVI score per dollar for different ecological weight scenarios



Raw CVI score per dollar for different ecological weight scenarios

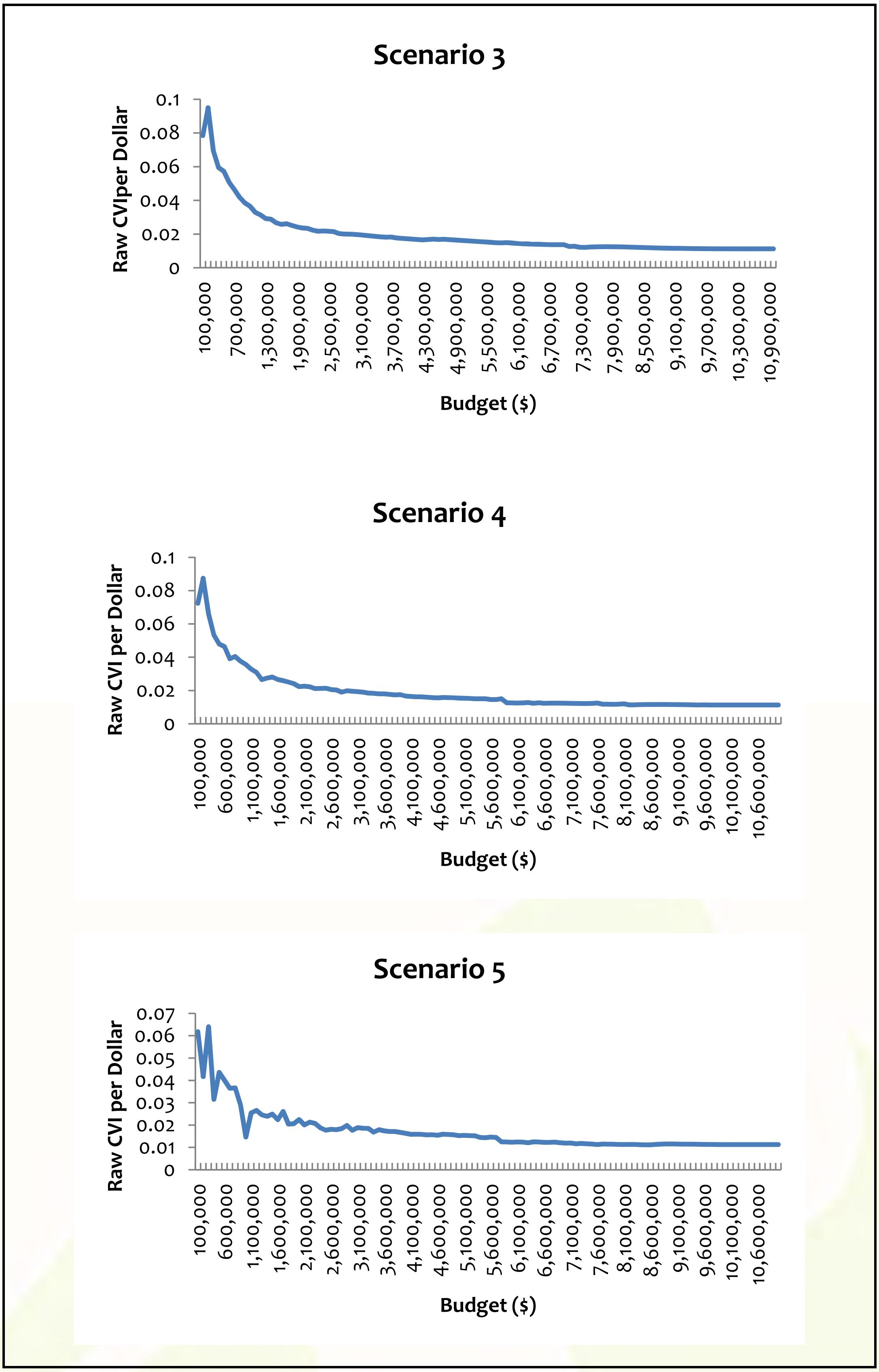


Figure 3: Raw CVI score per dollar for different ecological weight scenarios

Table 6: Raw CVI score per dollar for different ecological weight scenarios

Scenario	Mean	N	Standard Deviation	Median	Minimum	Maximum
Scenario 1	0.0213	110	0.01773	0.0155	0.01	0.14
Scenario 2	0.0212	110	0.01758	0.0154	0.01	0.14
Scenario 3	0.0198	110	0.01397	0.0153	0.01	0.09
Scenario 4	0.0189	110	0.01276	0.0150	0.01	0.09
Scenario 5	0.0171	110	0.00927	0.0145	0.01	0.06
Total	**0.0196**	**550**	**0.01464**	**0.0151**	**0.01**	**0.14**

Sensitivity to Auction Budget

The tender process is sensitive to the raw conservation value, temporal weighting and auction budget. Figure 4 shows the conservation value score per dollar. We can observe that changing the budget has a moderate effect on the performance of the auction. For example, increasing the auction budget from $0.01 million to $11 million reduced CVI/$ from 0.20 to 0.07[8]. Changes in CVI/$ come from the fact that with additional budget, more expensive projects (with relatively lower CVI score) are included in the portfolio. The non-linear trends in CVI/$ (Figure 4) indicate that it would be proportionately more expensive to purchase environmental benefits with a higher budget. The results are similar to the observations made by Hailu et al. (2011) from their modelling of the Burdekin water quality tender. They observed that the environmental benefit to cost ratios were more than 50% higher when the budget for the auction was reduced from $600,000 to $300,000, although as the budget went up more environmental benefit could be accrued.

[8] It should be noted that with a budget of $9.8 million all submitted bids are selected. Therefore, we do not see any changes in CVI/$ after this point.

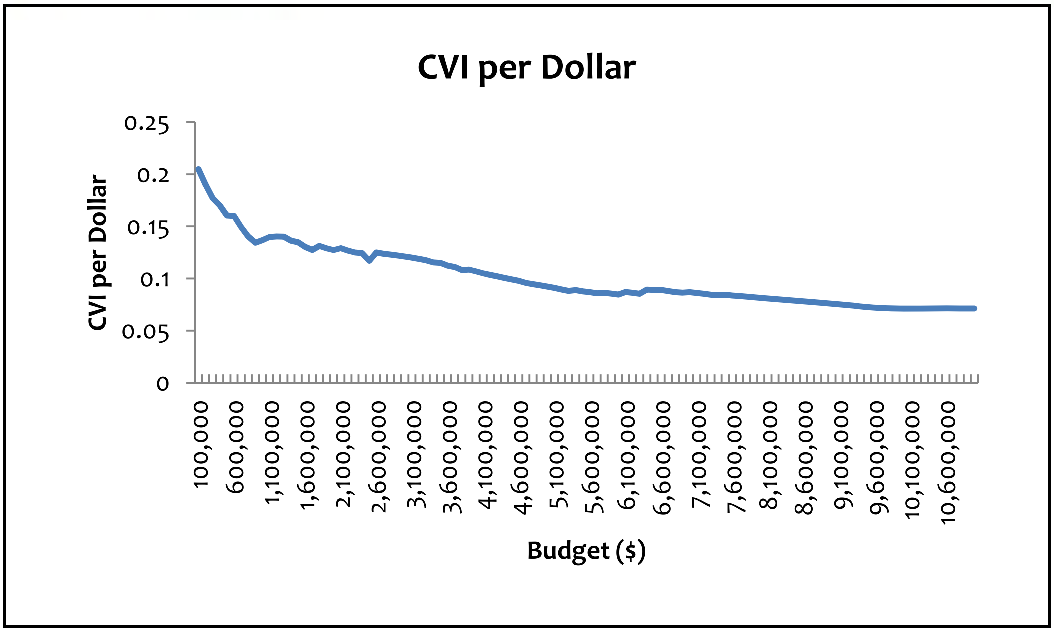


Figure 4: CVI score per dollar

Relative Benefits of a Discriminatory Price Auction Mechanism

It is possible to calculate the benefits of the auction mechanisms by comparing it with an environmental benefit-based uniform payment scheme. Following Stoneham et al. (2003), we plotted dollar per CVI score ($/CVI) for the adopted discriminatory price scheme and a hypothetical uniform payment scheme (Figure 5). Under the uniform payment scheme, each successful landholder would receive the same price, which is equal to the price of the marginal offer.

To clarify the analysis, consider the results for a budget scenario where the budget constraint is equal to $100,000. Based on the optimisation results with this amount of budget, 19,878 units of CVI could be purchased for a total expenditure of $97,000. The dollar per CVI for the marginal project9 is $5.31, which is the price that an agency would need to pay under a uniform payment scheme to generate the same amount of CVI score. As a consequence, the total payment under a uniform payment scheme would be approximately $105,000, which is $8,000 higher than the estimated expenditure under the discriminatory price scheme. We observed that this trend continues for higher budget scenarios as the $/CVI score are always higher with the uniform payment scheme compared to the discriminatory price scheme (Figure 5). Similar types of benefits have been observed by White and Burton (2010) for Auctions for Landscape Recovery (ALR) Project and Stoneham et al. (2003) for BushTender Project.

[9] That is, the most expensive project selected under this budget constraint.

Figure 5: Dollar per CVI score for discriminatory and uniform price schemes

5. Concluding Remarks

This report gives an overview of conservation project selection criteria used in the Midlands Biodiversity Hotspot Tender in Tasmania and the sensitivity of the scheme to the changes in project duration weight and budget. In summary, results from our sensitivity analysis indicate that the Conservation Value Index Score per dollar (CVI/$) is sensitive to duration of projects and conservation benefits. The current weighting scheme has the tendency to select longer-term projects at the expense of current conservation values. They are also highly sensitive to auction scope in terms of auction budget with higher auction budget, with the CVI/$ declining with a higher auction budget. Compared to a hypothetical uniform payment schemes, the current project selection mechanism was more cost effective.

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