From: [redacted]
Sent: Tuesday, October 8, 2024 5:20 PM
To: Rhea Rachel <rhea.rachel@ipart.nsw.gov.au>
Cc: Ineke Ogilvy <ineke.ogilvy@ipart.nsw.gov.au>; Thomas Banuelos <tom.banuelos@ipart.nsw.gov.au>; Kira van Os <kira.vanos@ipart.nsw.gov.au>
Subject: IPART Submission- 8 October 2024

Dear Rhea,

Following our meeting last week, I would like to express my gratitude to IPART for the opportunity to submit this written submission.

As I mentioned during our discussion, a significant contributing factor to the discrepancies in credit pricing was the malfunctioning of the BCT BOPC calculator.

Upon the introduction of the BOPC, I was actively engaged with multiple departments, including OEH, BCT, and the DPE Economics Department, in a related case study.

By way of background, I have been involved in the Biodiversity Offset Scheme since 2012. Over the years, I have facilitated the creation of five Biobanking Agreements, notably from the historic Fernhill Estate at Mulgoa and one on behalf of Twin Creeks Golf and Country Club at Luddenham.

In 2015, I personally purchased credits from the Fernhill Estate as an investment and am currently a credit holder (Credit Holder ID 225).

Throughout my engagement with the various departments, I maintained correspondence with senior management. To provide context without overwhelming you with information, I have attached selected correspondence relevant to my complaints regarding the BOPC calculator.

I received assistance in preparing these submissions from former department senior managers who were aware of the issues with the scheme at the time. Additionally, I have attached discussion papers that encapsulate the concerns I raised in last week's meeting. One notable attachment is an email from my account at Twin Creeks Golf and Country Club dated 19 April 2021, which summarizes the essence of my complaints at that time.

The key recipients of this email include:

[redacted]

It is important to highlight that [redacted] and [redacted], both from the DPE Economics Department, were the architects of the BOPC calculator. I recommend that IPART reach out to them, as they were well aware of the incorrect pricing issues and the numerous complaints from credit holders at the outset, yet did not rectify the BOPC.

As you may know, I am also a director of Thesium, and my partner, Greg Steenbeeke, is a senior ecologist/BOS assessor. I have attached 2 presentations regarding a seminar he attended back on 6 November 2019 led by Mladen Kovac. These presentations have valuable insights, particularly Greg's comments noted on them at the time.

The BOPC effectively halved the values of BBAM credits, whereas, in most cases, it should have reflected nearly double the BAM values, as fewer credits are generated under BAM. Additionally, a further complication arose from the introduction of new trading groups permitted under BAM, which were not previously allowed under BBAM. For instance, under BBAM, HN 528 (PCT 849) could not be inter-traded with HN 529 (PCT 850), resulting in historic price differences.

With the allowance for trading between these groups under BAM, the pricing has become blended, distorting the market and causing confusion when justifying the discrepancies to developers regarding the old and new schemes.

Lastly, I would like to note that when the BOPC was made available for public use, it was not possible to save copies of credit price searches. I took the initiative to screenshot some credit pricing at that time. I particularly draw your attention to the attached screenshot of a “Blue Chip” credit HN 528 under BBAM, now known as PCT 849.

Furthermore, I have included a copy of the OEH Public Register dated August 2018, highlighting trade information from 20 August 2018, and comparing it to the BCT screenshot from 6 November 2018 for PCT 849. You will observe that the credit pricing remained virtually the same per credit when, according to the statement of Reasonable Equivalence, it should have been nearly double.

I have multiple screenshots of BOPC prices for various credits, and it is evident that since 2018, the calculator has been significantly flawed. The various departments were aware of these issues but allowed developers to continue purchasing credits based on incorrect BOPC pricing.

As a result, the BCT is now obligated to acquire credits from the market at prices significantly below realistic values. This situation may explain the BCT/CST's reverse action process, as they lack sufficient funds to meet their obligations and appear to be attempting to suppress pricing.

I would be pleased to provide IPART with additional credit case examples, should that be necessary.

Thank you for your attention to this matter.

Regards

Paul Cubelic

Director

Cubelic Holdings Pty Ltd (OEH Credit Holder Id 225)

DISCUSSION PAPER MAY 2021

The conditions required for market-based conservation mechanisms to deliver economic growth for NSW

The Government's Intent

The government has been clear, it wants to establish market-based conservation mechanisms to facilitate sustainable development in urban and rural environments. Section 1.3, the purpose of the Biodiversity Conservation Act 2016, is specific on this matter:

(m) to establish market-based conservation mechanisms through which the biodiversity impacts of development and land use change can be offset at landscape and site scales

The Biobanking Scheme

The purpose of the Biodiversity Conservation Act and the provisions that follow build logically on the Biodiversity Banking and Offsets Scheme, 'BioBanking' mechanism that has been operational over the past six years. Biobanking has had its successes in facilitating development and protecting biodiversity with 20 Statements and 59 Agreements established. The scheme has been particularly successful in securing financial return on environmentally constrained land for private land

owners and has facilitated the streamlined assessment of some challenging development sites. In addition, an early economic assessment of the scheme's performance delivered a clear positive result with the conclusion that Biobanking is twice as cost effective as the EP&A Act, delivering 30% greater area of offset land at two thirds of the total cost to development proponents[1].

The natural question to now be asked is, *'with such a positive economic outcome and the ability to facilitate development and deliver returns to private land holders why hasn't the scheme been a runaway success?'* The answer lies primarily in a failure to make the policy, regulatory and operational adjustments to actively manage the scheme and therefore optimise results.

Opportunities for reform

In 2013 Heagney noted the that developers underestimate the time costs associated with biodiversity approvals (where Biobanking performs well) and place the highest importance on upfront financial costs payable in the first year of development (where Biobanking performs poorly). Scenario testing of deferred Biobanking payment options undertaken as part of the report indicated that allowing equal annual Biobanking payments over a period of 3-5 years makes upfront financial costs of Biobanking comparable to those of the EP&A Act and allowing equal annual Biobanking payments over a period of 10 years reduces upfront financial costs associated with Biobanking to less than half of those of the EP&A Act.

The 2014 review of the scheme by the NSW Office of Environment and Heritage[2] identified the following limitations of BioBanking that were found to act as either disincentives or barriers to participation for landowners and developers, specifically:

---

[1] Heagney, E. 2013, Cost-Effectiveness of Biodiversity Offsetting Mechanisms in NSW:
A Comparative Analysis of Biobanking and the EP&A ACT, Final Report. (HEAGNEY ALLMAN P/L CONSULTING)

[2] http://www.environment.nsw.gov.au/biobanking/bbfindings.htm

- concerns about the uncertainty of offset supply
- landowner concerns about the high costs of establishing biobank sites, combined with uncertainty that biodiversity credits, once created, would be sold
- length of time taken to review and process biobanking statements and agreements
- uncertainty around red flag decisions
- expectations about higher transaction costs compared to alternative assessment and offsetting pathways.

Action on these well documented reforms will increase scheme participation and as a result accelerate the delivery of land for development

The Market Potential

Given the right policy, regulatory and operational conditions the market is poised to deliver significant efficiencies in the supply of land for development, the distribution of financial returns to private land holders with land constrained by either land use planning, heritage or environmental considerations as well as biodiversity conservation outcomes.

Improving the supply of land for development

Developers and investors are looking for yield and real estate in Sydney (in particular) is providing attractive returns as long as the risk associated with the assessment process is minimised. The Biodiversity Banking Assessment Methodology (BBAM) if universally and consistently applied is an extremely efficient means of minimising assessment risk. Unfortunately, neither the development sector or the regulatory agency has been consistent in the quality of the application of the BBAM and the processing of biobanking statements and agreements.

The result of this failure to provide services in a consistent and timely manner is an erosion of confidence in the market and low participation rates. To address these issues the administrating agency must:

1. Clearly identify the responsible person for each biobanking transaction. This person must case manage the transaction from start to finish working with the customer to resolve issues and maintain quality standards
2. The agency must meet its guarantee of service by adopting a customer centric, problem-solving attitude
3. The up-front costs of Biobanking need to be addressed. The ability to stage payments along development milestones (with severe penalties for a failure to meet obligations) is required to improve market participation (this applies whether a Biodiversity Conservation Trust operates or not)
4. The government must be willing to make the necessary regulatory changes to the scheme that will improve efficiencies on a regular basis based on the body of operational evidence and market performance gained each year

Stimulating supply and distributing financial returns to all private landowners

Significant pressure is exerted on planning schemes when the benefits of the uplift in value on some lands is not shared across all landowners. While there is much debate about reducing the scale of the benefits won by some developers through better benefits realisation (or value capture) another mechanism that deserves greater attention is the redistribution of benefits between landowners without the involvement of government. Biodiversity trading is one such market mechanism. Biodiversity trading will allow landowners whose land is constrained by planning, heritage and environmental constraints to benefit from proximate development and therefore reduce the pressure on the planning system to allow for costly and 'unplanned' development.

Excellent examples of the distribution of benefits are found under the Growth Centres Biodiversity Offset Program.

The benefits of offset supply are not well understood by the market and effective, trustworthy and tailored advice to the market through the agency and more importantly private service providers (ecological and development consultants) is critical if the issues of uncertainty of supply are to be addressed. The development sector operates on short timelines that don't align well with government information programs.

Similar information gaps and asymmetry exist in the investment sector, and this is hampering the supply of credits through specific investment vehicles. There are some examples of individuals and groups making strategic investments in land and credits with a view to sell offset credits in the future. This is uncommon at present, and the government has the opportunity to increase the level of investor participation, improve supply and stabilise prices (through greater numbers of transactions and the revealing of prices) if it were to address the information gaps that exist in the market at present.

Another issue affecting supply is the cost of biobanking agreement assessments. It was originally thought that prospective credit buyers would take options and/or finance preliminary investigations into credit availability at potential agreement sites. This hasn't come about at the scale desired. A lack of information about the scheme, its benefits and the credits desired is hampering this element of the market functioning.

The key strategy for success here is to more clearly present the information the market requires to operate to the market in a way that they are used to. The existing agreement and statement registers and expression of interest tables do not meet the needs of the market. Government should make all data on the scheme and its performance open to the public so that market operators can exploit the opportunity to present information to the market for commercial gain. This is analogous to the open government principles that have seen private operators present transport timetables to the public

One long standing concern of offsetting is that offsets will be in the wrong location and hamper future development. The government can influence the location of offsets away from future development centres/corridors and to areas of high conservation value through credit generation bonuses, publicly funded price bonuses, policies to direct government infrastructure offset to these areas and subsidised agreement assessments. This approach has the benefits of improved supply, increased conservation outcomes and the creation of areas of higher investor interest through reduced risk associated with the value of the investment.

Market participation

In order to stimulate the market to operate the government does need to provide policy certainty and ensure that the scheme rules are clear, transparent and stable. Key threats to the market's operation are the devaluing of credits through allowing for extremely wide trading rules and overly simplistic translation of credit requirements into payments into the Biodiversity Conservation Fund

Biodiversity outcomes

The government is undertaking some of the largest investments in biodiversity conservation ever and yet it is known that these investments fall far short of what is required to protect our biodiversity resources into the future. Recruitment of the private sector through offsetting is a logical and necessary strategy, consistent with the user pays principle, for biodiversity conservation.

Arguments that offsetting is a net environmental loss are wrong in that they are based on assumptions that unmanaged areas of land will retain their biodiversity values. There is overwhelming evidence that the threats to biodiversity from weeds, pests, habitat destruction from human activities such as trail bike riding and illegal dumping require considered and active management for these values to be retained. In urban and peri-urban environments where these costs are high offsetting is the most efficient means to deliver biodiversity conservation outcomes.

Conclusion

There are a number of investors ready to exploit the biodiversity market. Several have made strategic investments in either land, credits, or both and a growing number of consultancies are developing specific expertise to advise and guide investors and developers alike.

The government is on the right track with its reforms. A step change in development and conservation outcomes can be achieved if a more market driven approach to biodiversity offsetting is adopted. The guiding principles for government should be:

- How can we facilitate this market?
- What information can we make available to inform the market?
- How do we remove barriers to market participation?
- How do we ensure the Biodiversity Conservation Trust is the port of last resort rather than an intrusive participant in the marketplace?

Just a thought bubble at present…

Obstacles	Solutions
Information gaps and asymmetry	Effective, trustworthy and tailored advice
Lack of skills and time to identify and implement offsetting measures	High quality, low cost planning and delivery of offsetting products and services
High upfront costs and lack of funds to pay for biodiversity offsets and the creation of offset supply	Financial incentives and structures to reduce upfront costs and financing mechanisms to spread costs over time

Discussion Paper – BOPC Calculator – March 2021:

Here are some points:

1. Statement of reasonable credit equivalence – these statements transfer credits from BBAM to BAM. There is no explanation as to the process at each site – there is no transparency to this process. There can be large changes in the credit numbers. Whilst credits generally decrease (up to 50%), in a few limited instances they have increased. Overall, however, based on what I have seen to date credits usually decrease to ~70% of the prior amount generated or required.

2. The BOPC modelling appears to ignore that many trades have been based on management costs only, wherein the amount paid for credits is based on the only the part A (TFD) credit costs. That is, many trades have not incorporated the Part B component of credit prices (opportunity cost and any profit). These trades have occurred where development has occurred on part of the lands owned, and a Biobanking site was established on other (usually adjoining) lands. In these instances, the payment was only based on the minimum TFD price. These trades do NOT reflect the "market" in operation, as no commercial sale has occurred. Creating a Biobanking or Stewardship site has significant risks – in particular in being able to actually sell credits (i.e. sometimes credits are created but there is not market demand for the credits created). This needs to be recognised.

3. The BOPC pricing was set up using Biobanking credit prices. However, as identified above the number of credits is not directly comparable. In effect, just as if a product was purchased overseas a credit 'exchange rate' is needed within the BOPC to allow for the two different credit types. This should either be done for individual credit types, or if done on a generic basis for all credit types should give the higher most generous exchange rate such that the BOPC price is lifted <u>above</u> the market price.
    - As an example, most threatened flora species changed from being based on a count to area based. This has meant that the number of credits required have dropped by orders of magnitude for these species. This has not been reflected in BOPC pricing.
    - As a further example, for where threatened flora species have remained based on count, there have been key changes in the equations. As identified below, although the key difference is that a scaling factor of multiplying by 10 the number of credits required at a development site was removed from the BAM equation. This should mean that the modelled BOPC prices should have increased by at least 10 x to account for this change in the equations. *Epacris purpurascens* var. *purpurascens* is an example of such a species.
        - BBAM 2014 (Equation 6) – Number of species credits required at a development site = Number of individuals impacted X threatened species offset multiple X 10
        - BAM 2020 (Equation 3) - Number of species credits required at a development site = Number of individuals impacted X biodiversity risk weighting

4. There are multiple technical changes which have been occurring through the BBAM to BAM transition process. These changes will cumulatively impact on the amount of TFD, all lifting the TFD requirement. These changes have not, as yet, flowed through to the market. The BOPC has suppressed the ability for the market prices to respond, as if it is cheaper to meet a credit obligation using the BCF (using the BOPC price), then this is what will occur.
    - The 'discount rate' applied when calculating the expected future returns from fund invested in the TFD was reduced from 3.5% to 2.6% on 20 November 2018: https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-offsets-scheme/total-fund-deposit-discount-rate . The implication of this change is that, on average, the TFD will need to be increased by approximately 30% to account for the lower expected rate of return.
    - The "base" credits awarded under the BAM are less, though it may be possible to generate extra credits through additional management actions.
    - The BCT has recently brough in the Ecological Monitoring Module for Stewardship sites (webinar link: https://vimeo.com/510966539). They have stated that based on their test cases that this will add ~5% to the TFD. However, their presentation had very large variation in the additional cost (1 – 14%). The additional monitoring has not yet been implemented on sites, and thus this has not, as yet, flowed through to credit prices.

5. There are a number of issues specific to species credits prices – a number of points are below:
    - Many species credits have never actually traded, and thus there is a massive deficit of data to inform any BOPC pricing.
    - A high bar is set for "proving" that a relevant threatened species is present at a Stewardship site. It may be prohibitively costly to create species on a Stewardship site, especially when a site is initially established, and the high costs incurred.
    - BBAM did not penalise landowners for not generating threatened species credits initially. However, BAM (Section 11.9.3) will apply discounts if credits for threatened species are generated ~12 months after the establishment of the Stewardship site. This will either increase the initial cost and risk for landowners, OR lead to fewer credits being generated in the future.
    - The cost of ecological monitoring (as per the new Ecological Monitoring Module) may be quite high and may make the new credits uncompetitive versus BOPC pricing.
    - Below is an extract from the BOPC (12-3-2021). This compares credit prices for various different types of Koala credits under the BOPC. The Koala is listed as a Vulnerable threatened species throughout NSW and is listed as an endangered population in Hawks Nest / Tea Gardens, Pittwater, and Tweed. I note there is no BOPC price available for the Tweed endangered population. The credit prices for the Koala endangered populations that are available, are approximately 38% cheaper than the Koala as a whole. This does not make sense, as endangered populations will be limited in their extent, and thus it is reasonable to expect that fewer credits will be available, and thus the prices will be higher. The only situation in which this may make sense, would be if Koala credits could be generated for BOTH the Koala (in general) AND the endangered population. It is not clear whether this is the intent.

Biodiversity Offset Payment Calculator

Version: 2.1
Last updated: 22/10/202

Credit Offset Payment Calculator | Payments

Species credits for threatened species

Species profile ID	Species	Threat Status	Price per credit	Risk premium	Administrative cost	No. of species credits	Final credits price
10616	***Phascolarctos cinereus*** (Koala)	Vulnerable	$495.24	20.6900%	$80.00	1	$677.71
10614	***Phascolarctos cinereus - endangered population*** (Koala in the Pittwater Local Government Area)	Endangered Population	$309.97	20.6900%	$80.00	1	$454.10
10615	***Phascolarctos cinereus - endangered population*** (Koala, Hawks Nest and Tea Gardens population)	Endangered Population	$309.97	20.6900%	$80.00	1	$454.10

List of acronyms

1. Biobanking Assessment Method (BBAM) – under the previous *Threatened Species Conservation Act 1995*
2. Biodiversity Assessment Method (BAM) – under the *Biodiversity Conservation Act 2016*
3. Total fund deposit (TFD)

From: [redacted]
To: [redacted]
Subject: FW: Biodiversity Conservation Trust BOPC Revision - Submission Comments
Date: Tuesday, 8 October 2024 3:12:56 PM
Attachments: [redacted]

From: Paul Cubelic
Sent: Monday, 19 April 2021 7:25 PM
To: BCT Info Mailbox [redacted]
Cc: [redacted]
Subject: Biodiversity Conservation Trust BOPC Revision - Submission Comments

Dear BCT,

We thank you for the opportunity to further submit our view (as credit holders) to the current problems with the BOPC. As you may be aware, over the last 8 months, Twin Creeks Golf and Country Club have been engaged with OEH/BCT and DPIE economics department as a case study, RE the issues around the BOPC problems and we rely on our past correspondence to the matter past raised forwith.

It is our view the original market set up by OEH and how it was to function is crucial to the changes suggested by the BCT has material and commercial implications for the market going forward. We have consulted with various ecologists in the marketplace overtime and we think that the economists within DPIE Economic department don't understand the BAM/BBAM system and how changes affect (or should affect) the Biobanking credit pricing.

Biobanking (Biodiversity Stewardship Scheme) is a sensible approach to balance between the urban development pressure and Biodiversity Conservation we applied is a sensible scheme, though the BCT BOPC continues to be the problem in the schemes success. We note that OEH and BCT and DPIE economics division has been aware of the many problems within the scheme for quite some time, we hope now they can truly iron out the bugs within the system.

We reaffirm on our past comments towards our case study and we hope those comments add weight to the Departments future decisions. We draw your attention to the early OEH Biobanking overview document (attached) which shows the in principle way the scheme was to function, we draw your attention to clause 9 (page 12), which describes the way the Biobanking credit market pricing was to function. We note that some current BBAM holders engaged into the OEH scheme as presented. Whist we understand the need for refinement and possible changes we do not agree with the BCT approach RE "Developers" , the original Biobanking Scheme was always intended as a market driven scheme (see OEH document attached).

In addition to our previous comments about the current schemes issues, we wish to make further comment as follows :

1. The Statement of Reasonable Credit Equivalence - these statements transfer credits from BBAM to BAM. There is no explanation as to the process at each site - there is no transparency to this process. There can be large changes in the credit numbers. Whilst credits generally decrease (up to 50%), in a few limited instances they have increased. Overall, however, based on what we have seen to date credits usually decrease to ~70% of the prior amount generated or required.

2. The BOPC modelling appears to ignore that many trades have been based on management costs only, wherein the amount paid for credits is based on the only the part A (TFD) credit costs. That is, many trades have not incorporated the Part B component of credit prices (opportunity cost and any profit). These trades have occurred where development has occurred on part of the lands owned, and a Biobanking site was established on other (usually adjoining) lands. In these instances the payment was only based on the minimum TFD price. These trades do NOT reflect the "market" in operation, as no commercial sale has occurred. Creating a Biobanking or Stewardship site has significant risks - in particular in being able to actually sell credits (i.e. sometimes credits are created but there is not market demand for the credits created). This needs to be recognised.

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* As an example, most threatened flora species changed from being based on a count to area based. This has meant that the number of credits required have dropped by orders of magnitude for these species. This has not been reflected in BOPC pricing.
* As a further example, for where threatened flora species have remain based on count, there have been key changes in the equations. As identified below, although the key difference is that a scaling factor of multiplying by 10 the number of credits required at a development site was removed from the BAM equation. This should mean that the modelled BOPC prices should have increased by at least 10 x to account for this change in the equations. Epacris purpurascens var. purpurascens is an example of such a species.

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4. There are multiple technical changes which have been occurring through the BBAM to BAM transition process. These changes will cumulatively impact on the amount of TFD, all lifting the TFD requirement. These changes have not, as yet, flowed through to the market. The BOPC has suppressed the ability for the market prices to respond, as if it is cheaper to meet a credit obligation using the BCF (using the BOPC price), then this is what will occur.

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credits through additional management actions.

* The BCT has recently brough in the Ecological Monitoring Module for Stewardship sites (webinar link: https://vimeo.com/510966539). They have stated that based on their test cases that this will add ~5% to the TFD. However, their presentation had very large variation in the additional cost (1 - 14%). The additional monitoring has not yet been implemented on sites, and thus this has not, as yet, flowed through to credit prices.

5. There are a number of issues specific to species credits prices - a number of points are below:

* Many species credits have never actually traded, and thus there is a massive deficit of data to inform any BOPC pricing.
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* BBAM did not penalise landowners for not generating threatened species credits initially. However BAM (Section 11.9.3) will apply discounts if credits for threatened species are generated ~12 months after the establishment of the Stewardship site. This will either increase the initial cost and risk for landowners, OR lead to fewer credits being generated in the future.
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List of acronyms

6. Biobanking Assessment Method (BBAM) - under the previous Threatened Species Conservation Act 1995
7. Biodiversity Assessment Method (BAM) - under the Biodiversity Conservation Act 2016
8. Total fund deposit (TFD)

We further find your comment in you submission, Point 2, page 2 perplexing :

" This mechanism gives developers a choice for offsetting that did not exist before 2016. It is often used for developers with smaller offset obligations where the transaction costs of seeking offsets in the market or establishing new BSAs may be more expensive than paying into the Fund. It is also used by developers where the offsets needed are not readily available in the market, which is likely to lead to project delays. As of 3 March 2021, 169 developers have paid $30 million into the Fund, transferring 384 offset obligations to the BCT. "

We say, apart from Sydney Metro as a large potential purchaser for our credits and a few small developer inquires, we ask generally , why 169 developers paid $30 million into the BCT. We have not been contacted by the majority of those developers (we understand they not all be Cumberland Palin based). The OEH public sales register has been indicative of a distorted market representation, this is representing an incorrect marketplace. Sales regardless of their frequency need to be input into the BOPC in Real Time and not have the slow BOPC updates, first Quarterly (cancelled), now six monthly (still not updated) or even stalled due to low trade, this is incorrect. The BCT has stated 169 developers have paid into the BCT, equating to $ 30 mil dollars was placed into the fund, where is disclosed in a public register, in real time ?

As previously stated, Twin Creeks Golf and Country Club have material concerns for its ecosystem credit devaluation due to the ongoing BOPC pricing issues.

We continue to be available to assist the department as a case study and look forward to your reply.

Regards

Paul Cubelic

[redacted]

Twin Creeks Golf & Country Club

[redacted]

[redacted]

[redacted]

BioBanking
Biodiversity Banking and Offsets Scheme

Scheme Overview

Department of **Environment & Climate Change** NSW

This information booklet has been prepared to provide an overview of the Biodiversity Banking and Offsets Scheme.

The scheme is implemented through:

- Part 7A of the *Threatened Species Conservation Act 1995*
- Threatened Species Conservation (Biodiversity Banking) Regulation
- BioBanking Assessment Methodology

The legislation can be downloaded from: www.legislation.nsw.gov.au.

More information on the scheme is available on the website of the Department of Environment and Climate Change at: www.environment.nsw.gov.au/threatspec/biobankscheme.htm

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Contents

1. Addressing biodiversity loss

The conservation of our endangered animals, plants and ecosystems is one of the greatest environmental challenges facing Australia today. The key reason for our historically high extinction rates is habitat degradation and loss, initially from over-grazing and clearing for agriculture, and more recently from the clearing of native vegetation for urban development.

Innovative approaches are needed to tackle the challenge of balancing development needs (to provide the community with new housing, jobs and amenities), while also conserving biodiversity for the future.

The Biodiversity Banking and Offsets Scheme (BioBanking) has been established by the New South Wales Department of Environment and Climate Change (DECC) to help address the loss of biodiversity and threatened species.

Creating a market in biodiversity credits gives incentives to protect biodiversity values.

BioBanking will:

- provide a transparent, consistent and robust framework for the assessment and management of biodiversity offsets
- create new opportunities for conservation on privately owned land
- provide permanent security and management for biodiversity offsets
- provide a secure mechanism for investment in biodiversity conservation.

BioBanking provides new opportunities for conservation on privately-owned land. Photo: A. Remnant/DECC

2. Biodiversity offsets

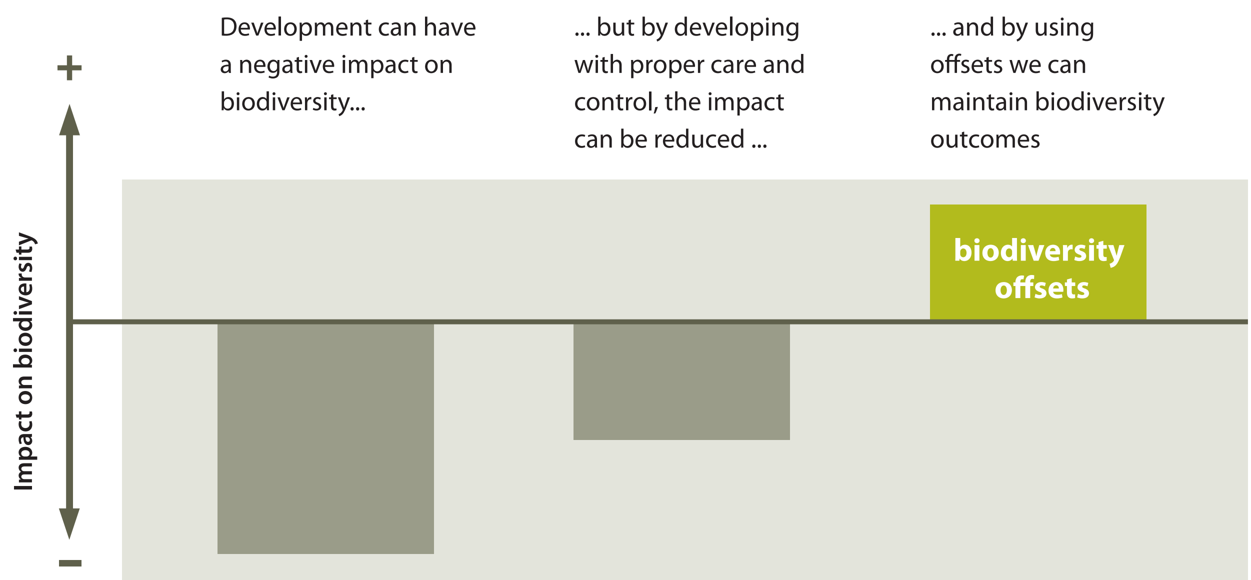
Biodiversity offsets have commonly been used to counterbalance the impact of development on biodiversity, but they have been organised on a case-by-case basis until now.

While this flexibility has resulted in some good biodiversity outcomes, there is generally no guarantee that the offset will be managed for conservation or that there will not be pressure to develop the land in the future. BioBanking provides a consistent, robust and transparent approach for offsets. Under BioBanking, offsets will be:

- Measurable. Offset requirements will be known up-front, allowing developers to minimise the impacts of development and plan for offsets.
- Consistent. A rule-based approach determines credit requirements.
- Secure. The biodiversity offset is provided by the biobank site from which the credits are generated.
- Transparent. Biobanking statements and credit transactions are on the public register.
- Strategic. Establishing a biodiversity credit market enables offsets to be more strategically located. This encourages participants to locate offsets on large parcels of land, in areas better for conservation that can compensate for a number of developments, rather than piecemeal efforts negotiated individually.

Without a market framework, offset sites must be negotiated and established separately for each development. There is no incentive for the offset area to be better than the minimum required, and there are few options for ensuring the long-term management of such areas.

Figure 1 Using offsets to help address biodiversity loss



3. How does BioBanking work?

The Biodiversity Banking and Offsets Scheme helps to address the loss of biodiversity in NSW. It achieves this by enabling landowners in NSW to establish biobank sites to secure conservation outcomes and offset impacts on biodiversity values.

BioBanking establishes an 'improve or maintain' test for biodiversity values. Improving or maintaining biodiversity values means avoiding important areas for conservation of biodiversity values, and offsetting impacts on other areas. The offsets are measured in terms of credits, using the BioBanking Assessment Methodology. The scheme requires participating developers to meet this improve or maintain test based on the impact of their proposed development.

Credits are created by the landowner, who establishes a biobank site and commits to enhancing and protecting biodiversity values. The credits represent an improvement in the condition of biodiversity values such as an improvement in the habitat or an increase in the habitat or population of a threatened species.

The scheme creates a market for the credits. Landowners can sell the credits to provide income and fund the future management of the site. Developers can buy the credits to offset impacts from their development and to meet the improve or maintain test.

Developers will need to source particular types of credits in accordance with the offset rules in the methodology:

- Ecosystem credits can only be used to offset biodiversity impacts in the same ecological community, or in another community of the same formation that has an equal or greater percentage of land cleared and the same predicted threatened species.
- Species credits can only be used to offset biodiversity impacts on the same threatened species.

There may also be demand for the credits from organisations seeking to secure conservation outcomes. Those buying credits are securing the conservation of biodiversity in perpetuity.

If participants fail to meet their commitments under the scheme, penalties can be applied. The performance of participants is monitored by DECC.

Scheme administration

BioBanking will be managed by DECC.

The core functions of DECC will be to:

- register biobank agreements
- issue biobanking statements
- manage the public registers
- audit biobank sites
- enforce biobanking agreements and statements
- prepare annual reports on the scheme.

Catchment management authorities will be able to help landowners establish biobank sites where appropriate. Local government and other NSW State Government agencies will be involved in the scheme administration in accordance with the legislation:

- Local government will incorporate biobanking statements into the development consent.
- Department of Planning will be consulted before biobanking statements are issued (where required).
- Department of Primary Industries will be consulted on biobanking agreements.
- Department of Lands will register biobanking agreements on land title.

The scope of the scheme

BioBanking will commence in 2008.

The scheme will only address biodiversity values including threatened species listed under the *Threatened Species Conservation Act 1995*.

BioBanking does not affect local government's role in land use planning and development control. It provides a systematic mechanism for assessing and offsetting impacts on biodiversity.

The scheme applies to:

- developments under Part 4 and activities under Part 5 of the *Environmental Planning and Assessment Act 1979* that are required to undertake the threatened species assessment of significance
- development projects under Part 3A of the *Environmental Planning and Assessment Act 1979* (the Minister for Planning may require that Part 3A developments offset impacts in accordance with the biobanking assessment methodology)
- the establishment of biobank sites on both private and public land including land to which the *Native Vegetation Act 2003 applies*.

A scheme review will be conducted after the first two years of operation.

4. Biobank sites

Landowners are able to generate biodiversity credits by agreeing to carry out a set of management actions which, over time, are expected to improve biodiversity values. Management actions are set out in the biobanking agreement and may include the management of grazing, fire, weeds, human disturbance and other actions, depending on the threatened species present at the site.

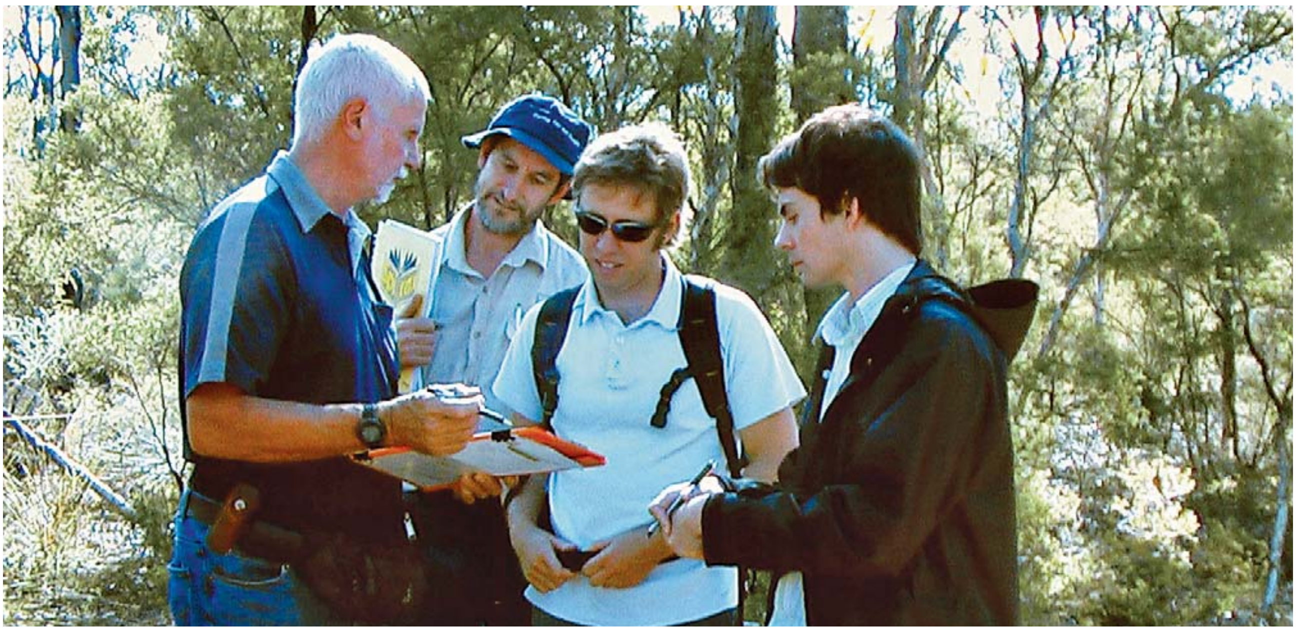
Biodiversity credits are issued once a biobanking agreement has been approved; the number and type are calculated using the BioBanking Assessment Methodology and the Credit Calculator.

These biodiversity credits can then be sold on the open market, generating an alternative income source for the landowner to help manage the land for conservation. In order to generate credits, landholders need to establish a biobank site by signing up to a biobanking agreement.

Landholders anywhere across NSW can voluntarily establish a biobank site to generate credits, except for land that is already managed or expected to be managed for biodiversity conservation. The consent of all owners and certain parties with an interest in the land is required under the legislation.

Landowners can decide which areas of their land they will include as the biobank site, allowing different economic activities (such as primary production) to continue on other parts of their land. Landowners can also decide who they will sell their credits to, the price of their credits, and the timing of the sale.

All biobanking agreements are registered on the land title. The obligation to protect and manage the land is binding on both current and future owners of the site.



DECC and Hunter–Central Rivers CMA staff and ecologists discuss the BioBanking Assessment Methodology during the pilot program. Photo: J.Stace/DECC

5. The biodiversity credit market

Once credits have been issued to a biobank site owner, they can immediately be sold to any buyer. Each biobank site may generate a number of different ecosystem or species credits, and any of these credits may be sold separately or in groups.

Biodiversity credits may be purchased to:

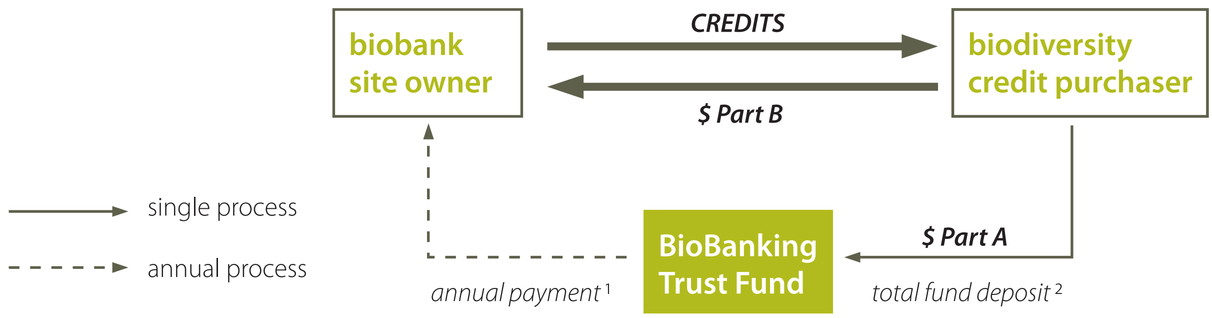
- achieve conservation goals. The sale of the credits provides funds for the ongoing management of the site.
- offset the impacts of a development on biodiversity values by purchasing credits and then retiring them in accordance with the scheme rules. Credits from one or more sites may be required to satisfy the number and type of credits needed.

In addition, credits can be:

- purchased as an investment for re-sale at a later date
- purchased in advance of project approval (which can be resold later if not used)
- acquired to build a portfolio of credits to offset future development.

Developers will seek to purchase credits available for the lowest price. Landholders will aim to get the best possible return from their credit sales.

Figure 2 Credit transactions (calculating the price of credits is detailed further on p.12)



[1] Annual payment as per schedule in biobanking agreement

[2] Based on present value of estimated management cost

6. BioBanking for developers

Developers can voluntarily use BioBanking to minimise and offset their impacts on biodiversity. The scheme provides an alternative path for developers to the current threatened species assessment of significance process.

BioBanking offers several advantages for developers:

- It can reduce costs and time associated with biodiversity assessments.
- It provides a transparent and consistent rule-based approach for determining offsets, enabling offset requirements to be assessed even in the initial stages of project design.
- It allows credit requirements to be estimated and purchased at any stage of the project proposal.
- It enables offset sites to be managed by biobank site land owners interested in conservation rather than by developers.
- It enables greater flexibility in project management and costs.

Developers must run the BioBanking Assessment Methodology to participate in the scheme. The methodology:

- determines what impacts the development will have on biodiversity values, and whether the development can meet the improve or maintain test
- assesses the number and type of credits that need to be retired in order to offset the impacts.

The types of credits that are suitable to offset a particular development will be set out in the biobanking statement, in accordance with the offset rules. Any measures that have been proposed to minimise the impact of the development onsite, or environmental contributions for conservation purposes, may be taken into consideration under the assessment.

The biobanking statement sets out the credit requirements, and is then submitted with the development application under the *Environmental Planning and Assessment Act 1979*. The statement satisfies the biodiversity assessment requirements, and exempts the developer from needing an assessment of significance or species impact statement for the proposal.

The consent authority (the council or Department of Planning) incorporates a condition in the development consent (if granted) that requires retirement of credits in accordance with the statement, before the work commences.

For Part 3A developments, the Minister for Planning may require that biodiversity credits are purchased and retired as a condition of project approvals to offset the impacts of the project. They may also require compliance with a biobanking statement that has been obtained voluntarily.

Once credits have been used to either offset development impacts or permanently secure conservation of biodiversity, they are retired so they can no longer be used for any other purpose.

7. BioBanking for conservation

The scheme aims to encourage and secure investment in conservation by providing both the legal and financial mechanisms to ensure the long-term conservation of biodiversity values at biobank sites. Organisations with conservation goals can rely on the scheme's robust nature to ensure the longevity of their investments in biodiversity outcomes.

The BioBanking legal mechanisms include the biobanking agreement, which runs with the land and is placed on title. This is backed up by the Compliance Assurance Strategy, which is DECC's commitment to ensuring participants in the scheme fulfil their obligations.

The financial mechanism is provided by the BioBanking Trust Fund. By purchasing credits, buyers are providing the upfront capital needed for the long-term funding of conservation on biobank sites. These funds are used to manage the site and improve the biodiversity values on that site, and in so doing increasing the viability of threatened species populations and improve the quality of habitat and the condition of native plant communities.

The scheme makes it easier to secure conservation outcomes. Here is an example of what those seeking to secure conservation outcomes would need to do:

1. Decide on the desired conservation outcomes. This could include conserving habitat for a particular species, conserving an endangered ecological community, or helping establish a corridor or conservation habitat within a particular area.
2. Search the public register for credits that support these outcomes. These may be credits in the ecological community or threatened species, or credits created from a biobank site in a particular area.
3. Buy those credits from the credit holder.
4. Retire the credits to ensure protection and management of the site. This means the credits cannot be sold on to a third party in the future. The retirement of credits is recorded on the public register of credits.

In addition, biobank site owners are able to choose the purchaser of their credits. This means that a biobank site owner may decide to sell their credits only to those seeking credits for conservation purposes. In this situation, the biobank site owner would need to specify this in the contract covering the sale of the credits.

8. Credit calculations using the BioBanking Assessment Methodology

The BioBanking Assessment Methodology provides a set of rules to determine the number and type of biodiversity credits that a development site will require to offset impacts, and that a biobank site can create and sell to protect biodiversity values.

The BioBanking Credit Calculator software is used to apply the methodology rules and determine credit requirements for development sites as well as the credits landowners can generate and sell.

There are two main types of biodiversity credits – species credits and ecosystem credits. It is likely that both types of credits would be required or generated for any site.

- Ecosystem credits are created for all ecological communities, as well as threatened species that can be reliably predicted as occurring on site, using the presence of vegetation that provides habitat for a given ecological community or threatened species. The number of ecosystem credits is calculated based on vegetation surveys.
- Species credits are created for threatened species that cannot be reliably predicted using habitat surrogates. The number of species credits is calculated based on targeted survey reports.

The methodology assesses all biodiversity values, including the composition, structure and function of ecosystems, and threatened species, populations and ecological communities, and their habitats (as defined in the *Threatened Species Conservation Act 1995*).

The number of credits

The number of credits calculated depends on a number of factors such as site values (e.g. the structure and function of ecosystems), and landscape context (e.g. the values for connectivity and area of vegetation). The methodology uses the scores from each of these factors to derive the change in biodiversity values as a result of either development, or protection and management over time.

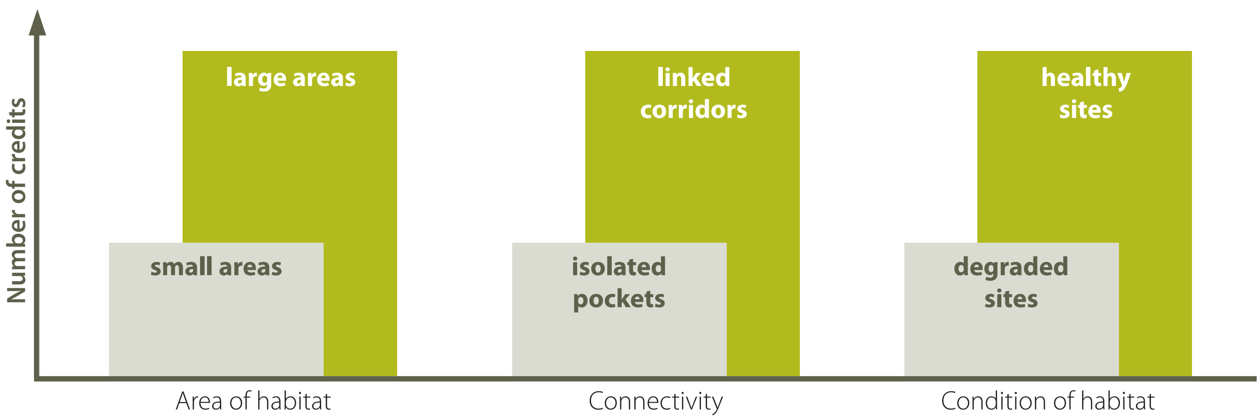
The improve or maintain test

The improve or maintain test measures the impacts of development on biodiversity values. A development is considered to improve or maintain biodiversity values if impacts on other areas are counter-balanced by the retirement of credits in accordance with the offset rules, and if red flag areas (areas that are important for biodiversity conservation and that cannot easily be replaced) are avoided, subject to the variation provisions. The development footprint may need to be modified to meet this test.

Red flag areas include over-cleared vegetation types (including endangered ecological communities) and threatened species populations or habitat which cannot withstand further loss because only a small number of populations remain and/or all viable populations are considered essential for the survival of the species.

There may be some circumstances in which developments impacting on red flag areas still meet the improve or maintain test (the variation provisions). A set of Ministerial protocols will specify the situations in which these variations could be justified. These protocols will be publicly available. The Director General of DECC must apply the protocols and must be of the opinion that avoiding red flag areas would be unnecessary and unreasonable in the particular circumstances. The Director General must publish reasons for the decision.

Figure 3 Factors important in credit calculations



9. The price of credits

The price of biodiversity credits will be based on the characteristics of the biobank site from which the credits are generated, as well as the existing supply and demand for credits by the market.

The location, condition and area of a property defined as a biobank site will affect the credit price. For example:

- Small, isolated sites may have higher management costs than larger sites adjoining other areas already managed for conservation.
- Surrounding land uses or past management behaviour may influence the presence of weeds or other biodiversity threats, which may affect the level of management required.
- The location of the property will also affect the land value, which in some cases may influence the return on credit sales expected by the landholder.

While buyers and sellers of credits are free to negotiate the price, credits will be priced to ensure the Total Fund Deposit is reached as soon as possible. Payment is made into the BioBanking Trust Fund when credits are first sold by a biobank site owner, until the Total Fund Deposit has been reached. This provides capital for future payments to the biobank site owner for the long-term management of the site. Both the Total Fund Deposit and the schedule of payments are set out in each biobanking agreement.

The price of biodiversity credits will be based on a combination of the minimum price determined by the Total Fund Deposit (Part A costs) and any additional return negotiated between the landholder and the buyer (Part B costs).

Calculating the price of credits

Total price of credits	=	**Part A** **Total Fund Deposit**	+	**Part B** **Return to landholder**
		The estimated cost of management and reporting, for the life of the agreement.		*Costs that landholders may seek to charge when setting the credit sale price, which may include:* • *establishment costs (e.g. application fee)* • *field assessment* • *preparation of management plans* • *land value* • *opportunity cost* • *return or risk margin.*

Worked example

A landholder with 200 hectares establishes a biobank site and receives 1000 credits.

Part A costs for the ongoing management costs were estimated to be $394,000 (to provide payments of $100,000 in year 1, $80,000 in year 2, $40,000 in year 3, $20,000 in year 4 and $10,000 for year 5, and onwards).

Part B costs, for establishing the agreement and the expected return to the landholder, were calculated to be $80,000.

The total price of credits would be $394,000 + 80,000 = $474,000, or $474 per credit.

If the landholder sold all 1000 credits for $600,000 (or $600 per credit), $394,000 is deposited into the BioBanking Trust Fund and the balance of $206,000 is paid directly to the landholder.

Payments into the BioBanking Trust Fund only need to occur on the first sale of credits (or if retired, before the first sale). If the credits are sold a second (or subsequent) time or the Total Fund Deposit has been met, the full credit sale price is exchanged directly between buyer and seller.

If the Part B amount were to include the land value for the biobank site at $10,000 per hectare (so totalling $2,000,000), the additional cost above the Trust Fund amount would be $2.08 million. This would increase the individual credit cost to $2,394.

A $5 million development proposal that saves six months on time to obtain their approvals could save $375,000, or 15% in interest and expenses. Even at the higher credit price example, this saving would fund over 150 credits.

10. The BioBanking Trust Fund

Some of the income generated from managing the land for conservation will be paid to the landholder through the BioBanking Trust Fund. The Fund invests funds deposited through the sale of biodiversity credits on behalf of the biobank site owners. The funds plus investment earnings are used to make payments to the biobank site owner to help cover the cost of managing the site, over time.

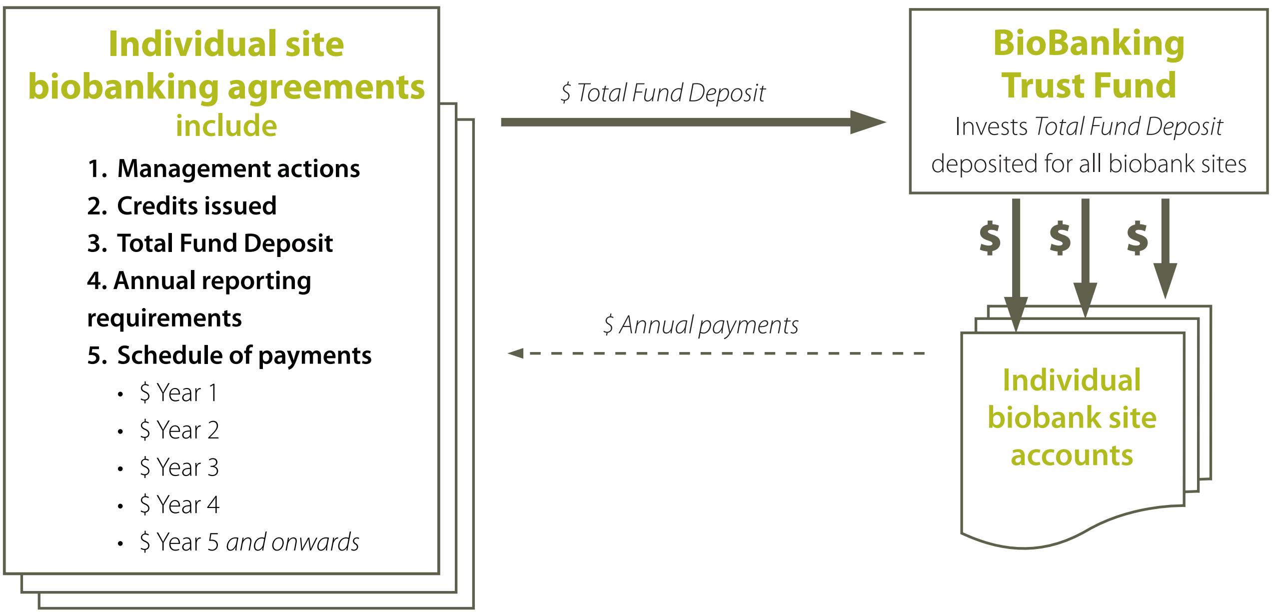
The BioBanking Trust Fund:

- provides a financial incentive to biobank site owners to continue to carry out obligations under the biobanking agreement (in addition to legal mechanisms)
- ensures that if land established as a biobank site is sold, the new owner of the site has the capacity to continue to manage the site.

The amount deposited into the BioBanking Trust Fund from credit sales is called the Total Fund Deposit, and is the estimated cost of carrying out the management actions on a biobank site. The Fund Manager will keep separate accounts for each biobank site and will publish public annual reports .

The Total Fund Deposit and future schedule of payments to the landholder are set out in each biobanking agreement. These payments are made each year after the landholder submits a report showing compliance with the agreement. If the future investment return is lower than expected for an extended period, discussions with the landholder would determine possible future payments.

Figure 4 The relationship between a biobanking agreement and the BioBanking Trust Fund



11. What will make this scheme a success?

The latest science

The BioBanking Assessment Methodology is based on ecological principles, current threatened species, and native vegetation data. This methodology will be reviewed and updated on a regular basis to ensure that it incorporates the latest scientific knowledge. The methodology is publicly available, providing full access to the rules applied in the scheme.

Public registers

The BioBanking public register will provide details of all biobanking agreements, statements and credits. It will also provide an expression of interest facility to enable interested landholders to promote their possible interest to generate credits given appropriate interest from a credit buyer.

Reporting

Biobank site annual returns

Biobank site owners are required to submit an annual return detailing their performance in fulfilling the conditions of the biobanking agreement. Failure to submit a satisfactory report could result in annual payments being withheld.

Annual reports

DECC will publicly release an annual report on the scheme's performance on its website. This report will provide the community with information about the number and type of credits issued, the biobanking agreements signed, and the biobanking statements issued. It will also report on the financial aspects of the scheme.

Compliance and enforcement

Compliance ensures that there is accountability for the commitments made under the scheme. DECC will undertake a comprehensive compliance assurance program to:

- ensure the integrity of the BioBanking Scheme
- ensure compliance with legislative requirements (to ensure biobank sites are managed properly)
- ensure that offences are detected and appropriate action is taken.

Ecosystem credit transaction report

Transaction date from - 1/08/2018 to 31/08/2018

Transaction date	Transaction type	Plant community type	CMA subregion	Surrounding vegetation	Patch size	Number of credits	Price per credit (ex-GST)
15-Aug-2018	Credits Retired	HN556/Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	>100 ha	28	
17-Aug-2018	Credits Retired	SR545/Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin Bioregion	Illawarra	>70%	>100 ha	31	
		SR652/Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion	Illawarra	>70%	>100 ha	54	
20-Aug-2018	Credits Transferred	HN529/Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	>100 ha	948	$16,000.00
		HN528/Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	>100 ha	439	$25,000.00
		HN526/Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	>100 ha	95	$17,500.00
		HN526/Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	<5 ha	16	$17,500.00
		HN528/Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	<5 ha	101	$25,000.00

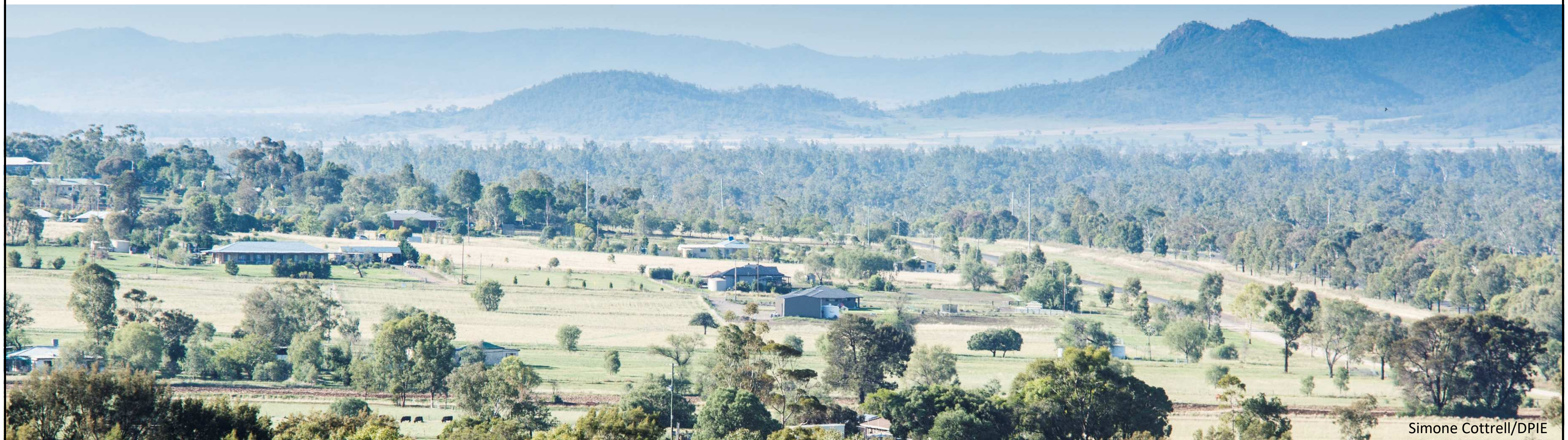
Transaction date	Transaction type	Plant community type	CMA subregion	Surrounding vegetation	Patch size	Number of credits	Price per credit (ex-GST)
20-Aug-2018	Credits Transferred	HN529/Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	>70%	<5 ha	15	$16,000.00
31-Aug-2018	Credits Retired	HN528/Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland - Hawkesbury/Nepean	31-70%	>100 ha	44	

- End -

DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

BAM Support for Accredited Assessors

A series of webinars to support the role of accredited BAM assessors in the Biodiversity Offset scheme (BOS)



Simone Cottrell/DPIE

For more information, go to the BAM Support Webinar webpage or contact us via the BOS Online Enquiry Form

Department of Planning, Industry and Environment

BAM SUPPORT WEBINAR 5

The Biodiversity Offsets Payment Calculator and the Spot Price Index

[redacted]

Wednesday 6th November 2019
2:00 – 3:00 pm

For more information, go to the assessor resource page www.environment.nsw.gov.au/biodiversity/assessors or contact us at www.environment.nsw.gov.au/biodiversity/bos-help-advice

NSW GOVERNMENT

Overview

TIME	ITEM	DESCRIPTION	DURATION
2:00	Introduction	Acknowledgment of Country Introduction and house keeping	10 mins
2:10	Content Presentation	1. Overview of the latest update to the Biodiversity Offsets Payment Calculator (BOPC) 2. Update on the public release of the offsets market Spot Price Index	25 mins
2:35	Q & A session	Presenter and SME panel address participants' questions	20 mins
2:55	Wrap-up and Close	Closing remarks Upcoming sessions Post-webinar feedback	5 mins

Biodiversity Offsets Scheme

Biodiversity Offsets Payment Calculator (BOPC) and

Spot Price Index (SPI)

November 2019

The Biodiversity Offsets Payment Calculator was upgraded on 31 October 2019. The new calculator came into effect on 1 November 2019.

This change coincided with the launch of the **Spot Price Index**.

Biodiversity Offsets Payment Calculator

NSW GOVERNMENT

The BOPC is used to determine how much a developer must pay into the Biodiversity Conservation Fund instead of purchasing and retiring credits from the market (or an alternate offsetting pathway)

Using the BOPC is a ‘premium’ pathway

NSW GOVERNMENT

The BOPC is built using sophisticated statistical and economic models that attempt to predict how market prices will evolve over time in response to changing market conditions and policy parameters.

The Biodiversity Conservation Trust will be under an obligation to later secure biodiversity offsets from the money paid into the Fund.

NSW GOVERNMENT

The BOPC uses the following data in its models:

- historical credit sales data (price and quantity)
- costs of producing biodiversity credits
  - taken from existing biodiversity stewardship or biobanking agreements
  - includes all costs associated with the BSA such as land, labour, material, etc.

Regularly scheduled BOPC updates

Updates with new data

The BOPC is regularly updated every 3 months with latest cost-of-production or credit trade data.

As more trading data is entered into the model its accuracy of prediction improves.

Updates due to other changes

The BOPC is updated for any changes likely to impact on market dynamics.

1. Change to discount rate used to estimate biodiversity stewardship total fund deposit
2. Implementation of the BAM
   - change in quantity of credits
   - introduction of trading groups

NSW GOVERNMENT

Expected market response

	Effect on market	Expected market response
Discount rate reduction Total Fund Deposit	Reduces profit margin for landholders	Landholders increase prices to retain profit margins
Change in credit quantity (Supply) Credit equivalence assumption	Reduces landholder revenue per hectare	Landholders increase prices to maintain existing revenue level
Change in credit quantity (Demand) Credit equivalence assumption	Developer cost of offsetting is reduced	Developers resist credit price increases and purchase fewer credits

NSW GOVERNMENT

Expected market response

	Effect on market	Expected market response
New trading group rules	Highly complex. Effectively broadens the types of credits that can be traded on a like-for-like basis Oversimplifying greatly – expect to see credit prices within trading groups to converge to new average weighted prices. Variable effect on landholder profit margins and developer costs	Expect landholders to attempt to increase credit prices (in a sub-set of credits) and developers to resist higher credit prices.

NSW GOVERNMENT

Uncertainties in the BOPC

The BOPC relies on data, assumptions and modelling to estimate how market prices will evolve in response to changing market conditions and market parameters.

The BOPC is sensitive to the following:

- BBAM to BAM credit equivalence
- Market supply and demand modelling
- The combining of many individual credit markets into a smaller number of trading group markets

These issues are resolved the more actual BAM trades are recorded – removing the need for complex equivalence estimation and other modelling.

NSW GOVERNMENT

Paradox of Value

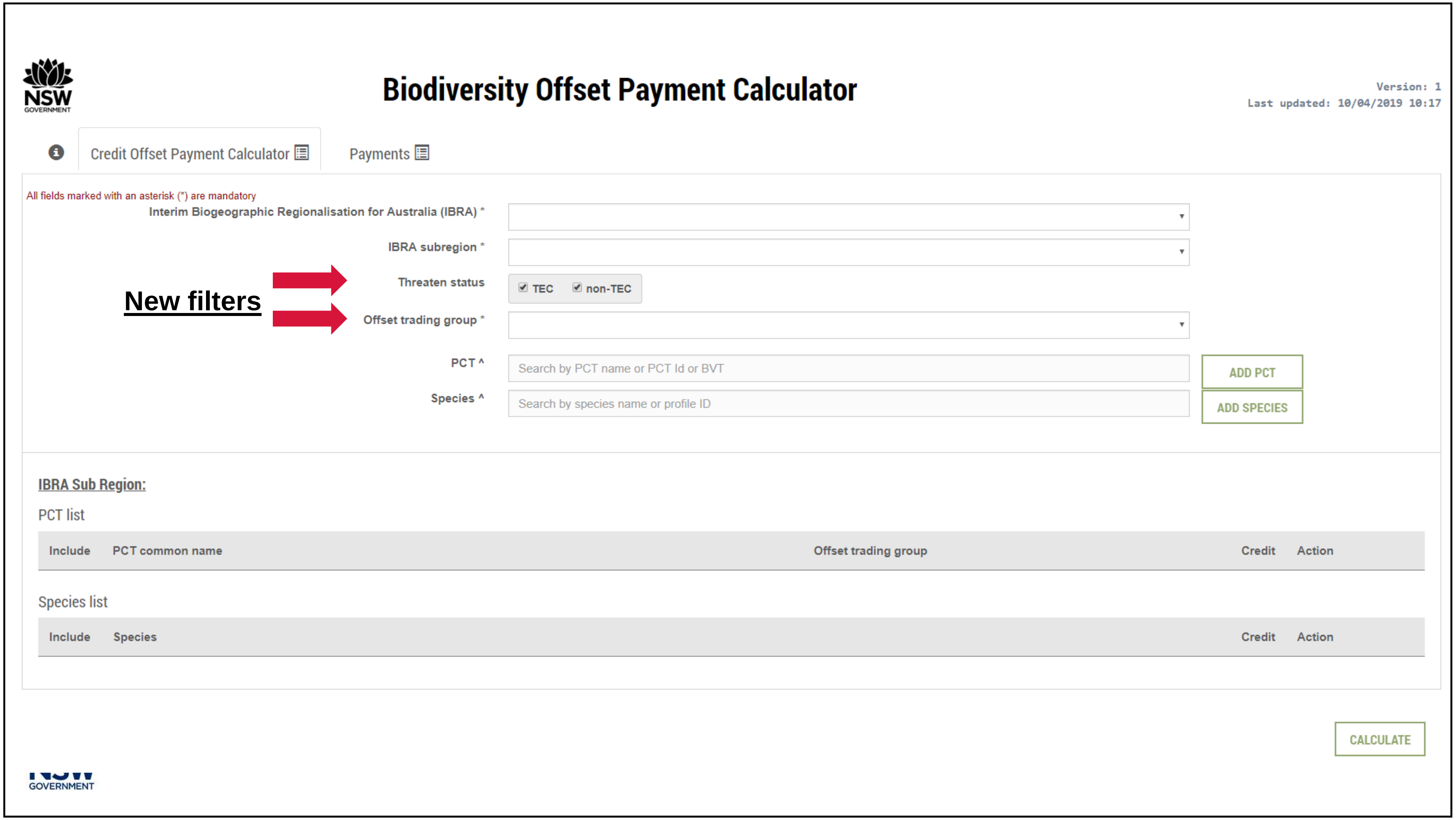
Water – Diamand Paradox

- Water is essential for human wellbeing
- Water can be purchased for $1 per bottle
- There is abundant supply of water to more than meet demand
- Diamonds are not essential for human wellbeing
- 1 carat diamonds can be purchased for up to $25,000 (depending on quality, cut, etc)
- There is a shortage of diamond supply that is less than the demand for diamonds

Ecological vs Market Scarcity

- Ecologically threatened species are considered 'more important' from an ecological value perspective
- If market supply of non-threatened species is less than their market demand then (like diamonds) their price increases
- Conversely, if there is abundant market supply of threatened species that more than meets demand, then (like water) their price decreases

NSW GOVERNMENT


NSW GOVERNMENT
Biodiversity Offset Payment Calculator
Version: 1
Last updated: 10/04/2019 10:17
Credit Offset Payment Calculator
Payments
All fields marked with an asterisk (*) are mandatory
Interim Biogeographic Regionalisation for Australia (IBRA) *
IBRA subregion *
Threaten status
TEC
non-TEC
New filters
Offset trading group *
PCT ^
Search by PCT name or PCT Id or BVT
ADD PCT
Species ^
Search by species name or profile ID
ADD SPECIES
IBRA Sub Region:
PCT list
Include
PCT common name
Offset trading group
Credit
Action
Species list
Include
Species
Credit
Action
CALCULATE
NSW GOVERNMENT

BBAM Spot Price Index

The Spot Price Index (SPI) is one of a series of economic instruments the Department of Planning, Industry and Environment has developed to improve economic efficiency in the Biodiversity Offsets Scheme.

NSW GOVERNMENT

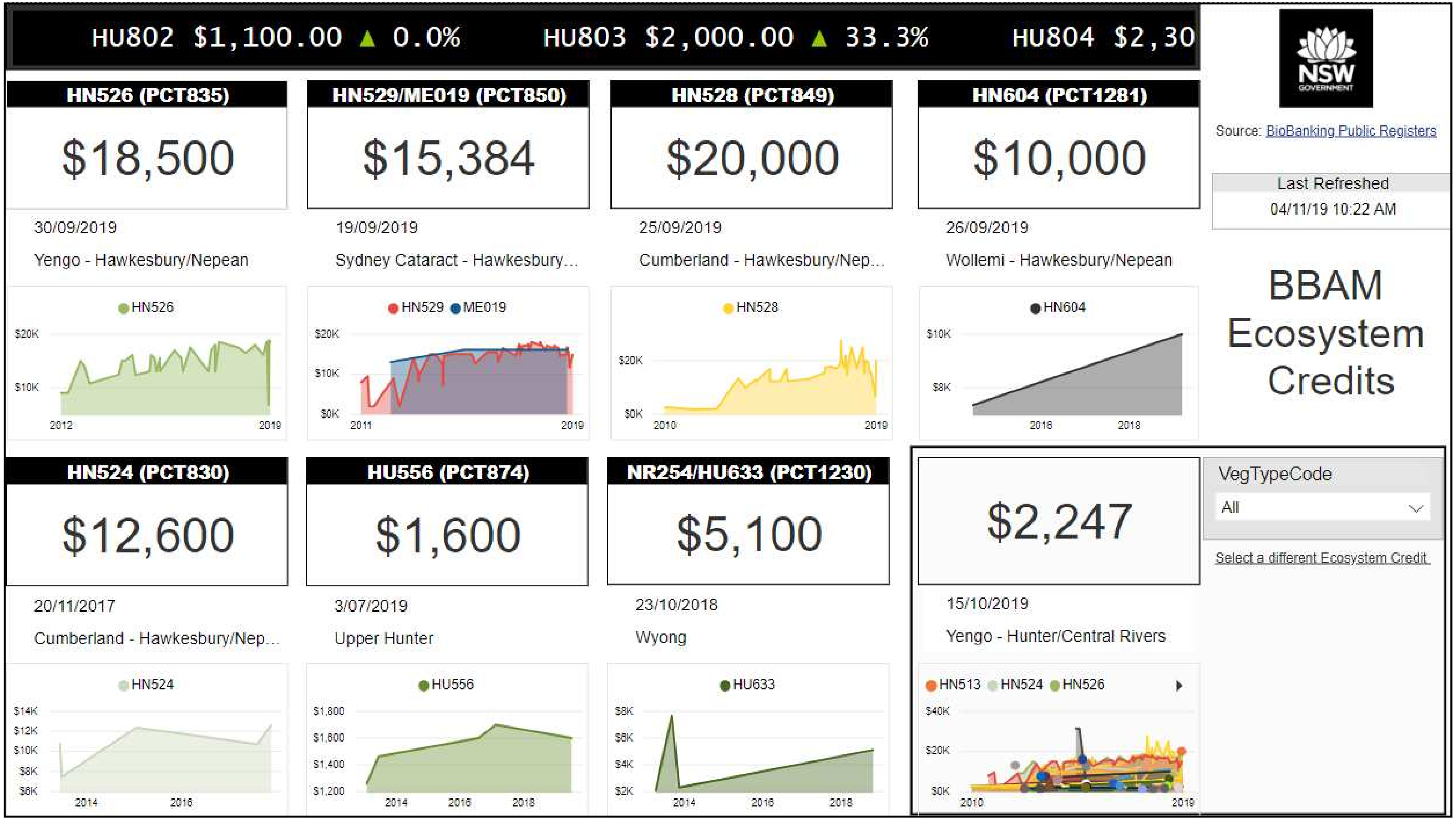
The SPI provides a much richer source of market information than can be extracted from the BOPC

- actual (raw) credit prices – not an econometric estimate
- history of credit trade prices
- spatial information on credit trades and BSAs
- market performance – at LGA, CMA region and up to State level

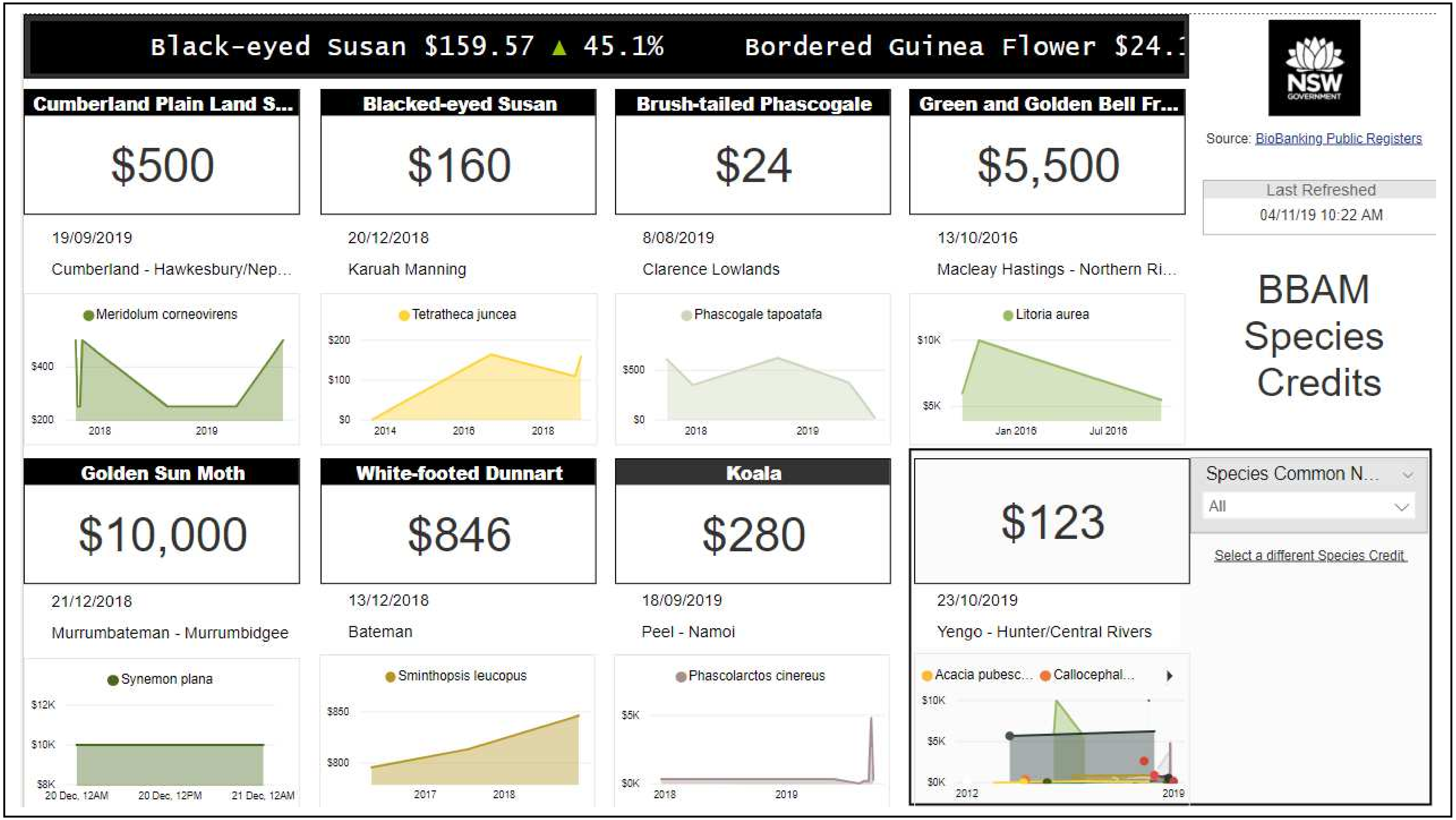
NSW GOVERNMENT

***BAM SPI is under development (there are not credits trades registered yet)**

Ecosystem credits spot price

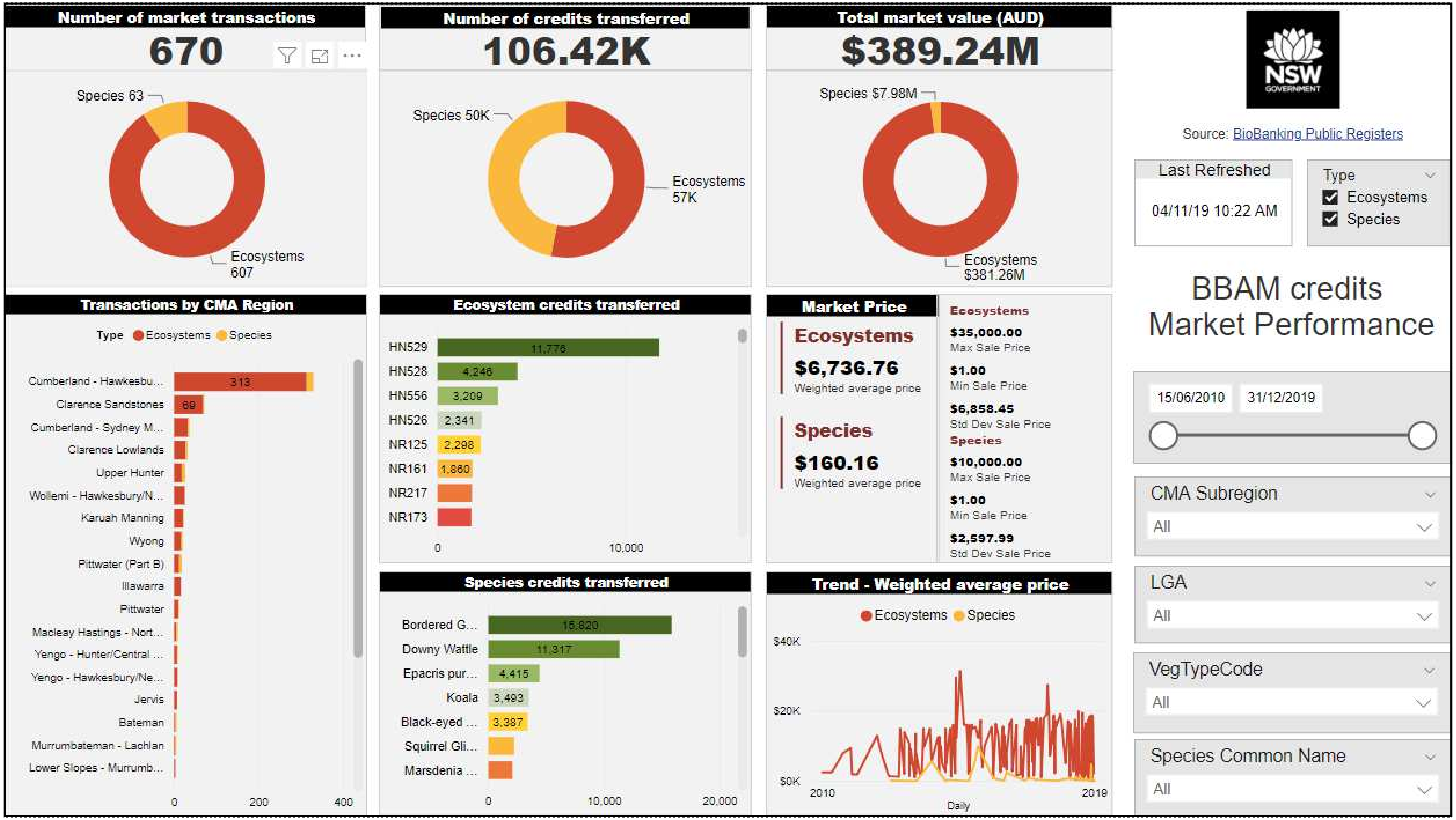

HU802 $1,100.00 ▲ 0.0% HU803 $2,000.00 ▲ 33.3% HU804 $2,30
HN526 (PCT835)
$18,500
30/09/2019
Yengo - Hawkesbury/Nepean
HN526
HN529/ME019 (PCT850)
$15,384
19/09/2019
Sydney Cataract - Hawkesbury...
HN529 ME019
HN528 (PCT849)
$20,000
25/09/2019
Cumberland - Hawkesbury/Nep...
HN528
HN604 (PCT1281)
$10,000
26/09/2019
Wollemi - Hawkesbury/Nepean
HN604
Source: BioBanking Public Registers
Last Refreshed
04/11/19 10:22 AM
BBAM Ecosystem Credits
HN524 (PCT830)
$12,600
20/11/2017
Cumberland - Hawkesbury/Nep...
HN524
HU556 (PCT874)
$1,600
3/07/2019
Upper Hunter
HU556
NR254/HU633 (PCT1230)
$5,100
23/10/2018
Wyong
HU633
$2,247
15/10/2019
Yengo - Hunter/Central Rivers
HN513 HN524 HN526
VegTypeCode
All
Select a different Ecosystem Credit

Species credits spot price


Black-eyed Susan $159.57 ▲ 45.1% Bordered Guinea Flower $24.1
Cumberland Plain Land S...
$500
19/09/2019
Cumberland - Hawkesbury/Nep...
Meridolum corneovirens
Blacked-eyed Susan
$160
20/12/2018
Karuah Manning
Tetratheca juncea
Brush-tailed Phascogale
$24
8/08/2019
Clarence Lowlands
Phascogale tapoatafa
Green and Golden Bell Fr...
$5,500
13/10/2016
Macleay Hastings - Northern Ri...
Litoria aurea
NSW GOVERNMENT
Source: BioBanking Public Registers
Last Refreshed
04/11/19 10:22 AM
BBAM Species Credits
Golden Sun Moth
$10,000
21/12/2018
Murrumbateman - Murrumbidgee
Synemon plana
White-footed Dunnart
$846
13/12/2018
Bateman
Sminthopsis leucopus
Koala
$280
18/09/2019
Peel - Namoi
Phascolarctos cinereus
$123
23/10/2019
Yengo - Hunter/Central Rivers
Acacia pubesc... Callocephal...
Species Common N...
All
Select a different Species Credit

Biodiversity Offset Market performance

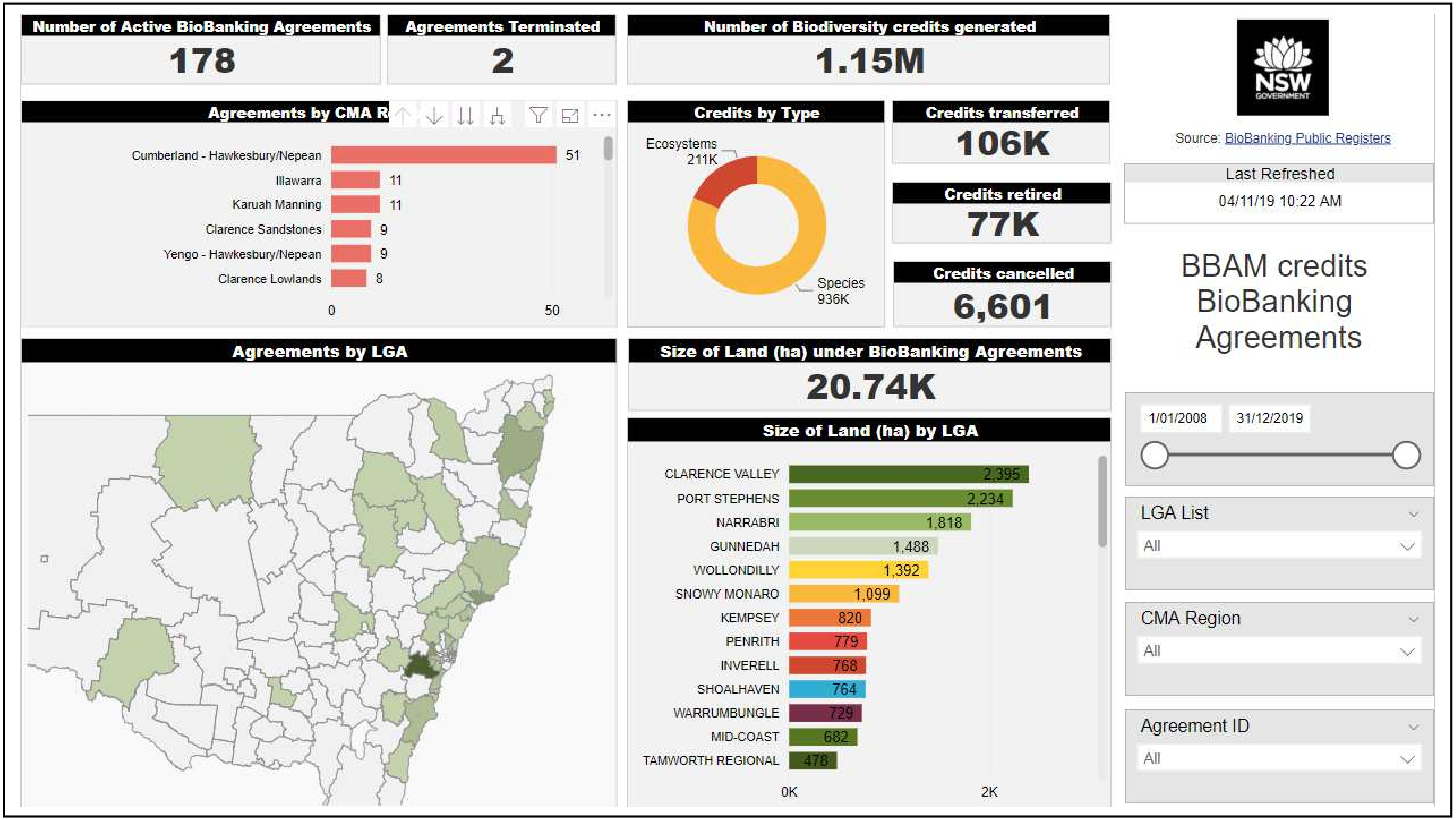
Department of Planning, Industry and Environment 6/11/2019



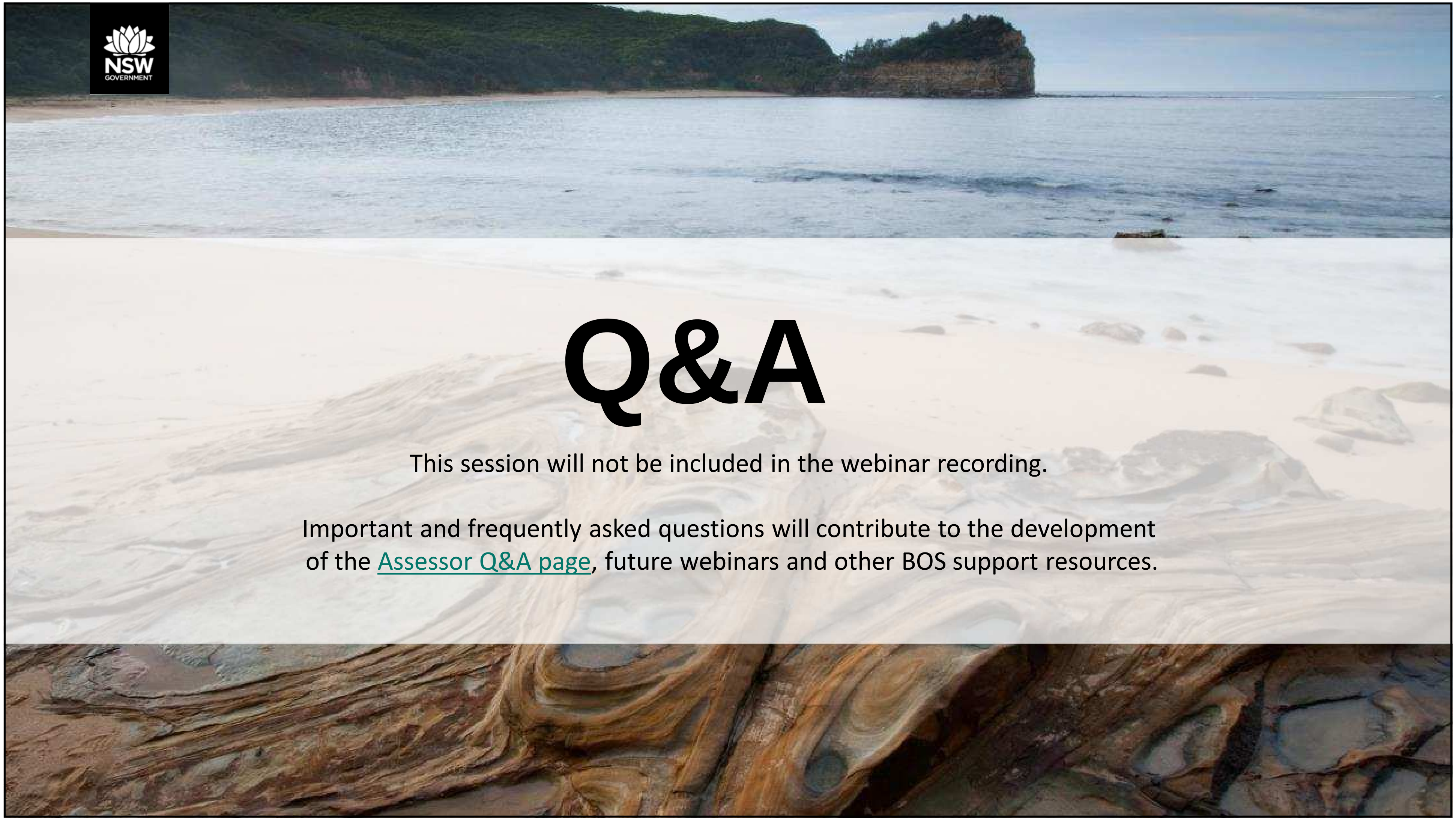
Stewardship Agreements

(a.k.a BioBanking Agreements)

NSW GOVERNMENT


Number of Active BioBanking Agreements
178
Agreements Terminated
2
Number of Biodiversity credits generated
1.15M
Source: BioBanking Public Registers
Last Refreshed
04/11/19 10:22 AM
Agreements by CMA R
Cumberland - Hawkesbury/Nepean 51
Illawarra 11
Karuah Manning 11
Clarence Sandstones 9
Yengo - Hawkesbury/Nepean 9
Clarence Lowlands 8
0
50
Credits by Type
Ecosystems 211K
Species 936K
Credits transferred
106K
Credits retired
77K
Credits cancelled
6,601
BBAM credits BioBanking Agreements
Agreements by LGA
Size of Land (ha) under BioBanking Agreements
20.74K
Size of Land (ha) by LGA
CLARENCE VALLEY 2,395
PORT STEPHENS 2,234
NARRABRI 1,818
GUNNEDAH 1,488
WOLLONDILLY 1,392
SNOWY MONARO 1,099
KEMPSEY 820
PENRITH 779
INVERELL 768
SHOALHAVEN 764
WARRUMBUNGLE 729
MID-COAST 682
TAMWORTH REGIONAL 478
0K
2K
1/01/2008
31/12/2019
LGA List
All
CMA Region
All
Agreement ID
All

End presentation


NSW GOVERNMENT
Q&A
This session will not be included in the webinar recording.
Important and frequently asked questions will contribute to the development of the Assessor Q&A page, future webinars and other BOS support resources.

Thank you for your participation

Webinar recordings will be available to view online on the BOS Vimeo Showcase at vimeo.com/showcase/6271450 and via the BAM Support Webinar webpage

Contact us at www.environment.nsw.gov.au/biodiversity/bos-help-advice

Simone Cottrell/DPIE

DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Biodiversity Offsets Payment Calculator – BTD

(Biodiversity Assessment Methodology credits, offset trading groups and discount rate)
Methodology note

Cover photo: Native vegetation, Wallumatta Nature Reserve. John Spencer/DPIE

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Overview

This technical note describes in detail the pricing model used by the Biodiversity Offsets Payment Calculator (BOPC), which incorporates the offset trading groups, and accounts for the changes in the discount rate (BOPC–BTD) (version 2.0.0.6). BTD refers to Biodiversity Assessment Methodology credits, offset trading groups and discount rate.

This technical note provides information on:

- the economic model that underpins the biodiversity market in New South Wales
- the financial model from the supply side
- the rationale which supports the extension of the economic model when a reduction in the quantity of credits is incorporated, derived from the change to the biodiversity assessment methodology (BioBanking Assessment Methodology (BBAM) → Biodiversity Assessment Method (BAM)) for both supply and demand
- the application of the like-for-like offsetting rules that govern the types of offsets that can be used to meet an offset obligation under the Biodiversity Offsets Scheme
- the risk premium for purposes of securing ecosystem credits
- the administration cost for purposes of securing ecosystem credits.

Scope of this technical report

This document describes the underlying economic and financial models for the BOPC–BTD and is a reference for developers who are required under the *Biodiversity Conservation Act 2016* (the BC Act) to retire biodiversity credits and who may satisfy that requirement by instead paying an amount into the Biodiversity Conservation Fund (BCF), determined in accordance with the offsets payment calculator established under Division 6 of the BC Act.

The total credit cost calculated with the BOPC–BTD is a best estimate of the market value, plus a risk premium, plus an administration cost of the biodiversity credits at the time of the calculation session and is valid only during the quarter of the current year. For the purposes of the BOPC–BTD, the four quarters that make up the year are January, February and March (Q1); April, May and June (Q2); July, August and September (Q3); and October, November and December (Q4). The underlying models of the BOPC–BTD are updated each quarter with the latest data available. The Department of Planning, Industry and Environment (DPIE), through the Energy, Environment and Science group (EES) will publish the schedule of such updates on the online tool webpage.

Disclaimer

The content of this technical report is provided for information purposes only. It does not constitute economic advice for current and future biodiversity credit transfers and should not be used as such.

It is the responsibility of the BOPC–BTD manager to update this technical note and make it available on the online tool webpage. It is the responsibility of the user of the tool to download the latest version of the technical note.

1. The biodiversity offsets market in NSW

1.1 Background

The Biodiversity Offsets Scheme (BOS) is a market-based scheme that provides a consistent biodiversity assessment process for development, a rigorous and credible offsetting scheme, as well as an opportunity for rural landowners to generate income by managing land for conservation. The BOS enables 'biodiversity credits' to be generated by landowners and developers who commit to enhance and protect biodiversity values on their land through a biodiversity stewardship agreement. These credits can then be sold, generating funds for the management of the site. Credits can be used to counterbalance (or offset) the impacts on biodiversity values that are likely to occur because of development. The credits can also be sold to those seeking to invest in conservation outcomes, including philanthropic organisations and government. The principle is that creating a market in biodiversity credits gives incentives to protect biodiversity values for future generations.

1.2 Transition to an improved biodiversity offsets scheme

The NSW BOS commenced on 25 August 2017 and is an extension of the previous NSW Biodiversity Banking and Offsets Scheme (the BioBanking program), which was implemented in 2008. The BOS is also a market-based scheme that operates in a similar way to BioBanking; however, there have been a number of changes including:

- replacement of the BioBanking Assessment Methodology (BBAM) with the Biodiversity Assessment Methodology (BAM)
- replacement of BioBanking agreements with biodiversity stewardship agreements (BSAs)
- establishment of the Biodiversity Conservation Trust (BCT)
- while BioBanking was a voluntary scheme, the BOS will apply to all local developments that are likely to significantly affect threatened ecological communities and/or species[1].

While the replacement of the BBAM with the BAM represents an improvement in terms of the scientific method that assesses biodiversity and calculates losses and gains at development and stewardship sites, from the supply side, it directly impacts the number of biodiversity credits created under the improved offsets scheme. Compared with the BBAM, the introduction of the BAM adjusts the number of biodiversity credits created, varying the relative cost of the management action per credit.

The replacement of BioBanking agreements with BSAs has a neutral effect in the market (since it represents only a change in the name of the 'contract'.)

Among others, the BCT acts as a market intermediary. Developers with an offset obligation can buy biodiversity credits in the market or they can make a payment into the BCF at a price set by the BOPC. If they do, the obligation to procure the biodiversity credits transfers to the BCT. This enables developers to proceed with the development while allowing the BCT to bundle credit obligations and secure strategic offset outcomes.

---

[1] The biodiversity impacts of developments will trigger the BOS if either:
- they impact on an Area of Outstanding Biodiversity Value
- they exceed the BOS threshold
- they are likely to significantly affect threatened species, ecological communities or their habitats according to the test of significance in section 7.3 of the BC Act.

1.3 Lowering of the discount rate

A central component of the BOS is the requirement to pay the total fund deposit (TFD) into the BCF to be invested for the management of each stewardship site. The TFD for each stewardship site provides the funds for annual management payments to be made to the owner of that site in perpetuity. The TFD needs to be sufficient to provide for the future costs of annual management payments to the stewardship site.

The value of the TFD for each stewardship site is determined based on calculations made by the landowner of the costs of the management actions required to manage the stewardship site into the future. This amount is adjusted to ensure calculations estimate the present value of the total of all the scheduled management payments for that particular site. The present value is the amount required to be set aside at the current time in order to meet the necessary future payment amounts (it has to account for investment returns and the inflation rate). The calculation of the present value of these payments relies on the application of a discount rate.

The discount rate for the calculation of the TFD under the BioBanking program was set at 3.5% in 2009 and adjusted to 2.6% on 20 November 2018. The current discount rate applies to new BSAs and reflects prevailing market conditions, and aims to ensure the long-term financial and environmental sustainability of stewardship sites.

Lowering the discount rate will result in a higher TFD for stewardship sites. The Department estimates that the resulting increase in the TFD could range between 13% and 30% (23% in average), depending on the management requirements for each site, with impacts on the profits made by stewardship site owners over and above the amount required for the TFD. However, lowering the discount rate reduces the long-term risk of insufficient management funding being available for stewardship sites.

2. The economic model that underpins the biodiversity market in NSW

In general, the supply and demand curves for biodiversity credits are not directly observable; however, prices and quantities traded are. Therefore regarding $S_{i,t}(.,.,.)$ and $D_{i,t}(.,.,.)$ as latent random processes, it is assumed that the economic agents only directly observe the equilibrium prices and quantities (i.e. the intersection of the two curves, for any point in time), denoted by $P_{i,t}$ and $Q_{i,t}$, respectively, where

$S_{i,t}(.,.,.)$ *is the supply curve, with unknown parameters*

$D_{i,t}(.,.,.)$ *is the demand curve, with unknown parameters*

$i = \{biodiversity\ assets, either\ species\ or\ ecosystem\}$

$t = time.$

At this point, the model does not make any assumption about the linearity of the supply and demand curves, except that both are monotonic[2].

When thinking about the biodiversity market, a dynamic design can represent the agents' best decision-making process. Since 'production' of biodiversity credits takes time, the adjustment on the supply side is not instantaneous, but may be perceived in the market only after n periods[3] $(t-n)$. When suppliers (i.e. landholders) have naive credit price expectations, they think current credit prices are the same as in the n previous periods. An alternative behaviour is when suppliers have adaptive expectations, and they think the new expected credit price is a weighted average of the old expected price and the old actual credit price. Formally:

$$\hat{P}_{i,t} = \hat{P}_{i,t-1} + w_i\left(P_{i,t-1} - \hat{P}_{i,t-1}\right), 0 \leq w_i \leq 1 \qquad (1)$$

$$\hat{P}_{i,t} = (1 - w_i)\hat{P}_{i,t-1} + w_i P_{i,t-1} \qquad (2)$$

where:

$\hat{P}_{i,t} = expected\ price\ in\ t, for\ biodiversity\ i$

$P_{i,t-1} = the\ price\ in\ t-1, for\ biodiversity\ i$

$w_i = expectations\ weight\ factor\ for\ biodiversity\ i$

If $w_i = 1$ then $\hat{P}_{i,t} = P_{i,t-1}$, and the suppliers follow a naive credit price expectation.

When $0 \leq w_i \leq 1$, suppliers follow an adaptive credit price expectation.

Since the demand side of the biodiversity market (developers) can adjust immediately to current prices, the market equilibrium might be subject to fluctuations given the lagged adjustment on the supply side.

---

[2] When supply and demand are both monotonic, the composite map $Q_d \circ Q_s$ is also monotonic, and it follows immediately that chaos cannot occur; however, in presence of non-linear supply and demand curves, chaotic dynamical behaviour can occur, even if both the supply and demand curves are monotonic (Hommes 1994).

[3] Agricultural commodities often provide good examples of lagged supply.

2.1 The cobweb models

2.1.1 Classic form – deterministic and linear supply and demand curves

The cobweb model describes the temporary equilibrium market prices in a single market with one lag in supply. The model has been a benchmark model in economic dynamics (Ezekiel 1938; Hommes 1994; Chiarella 1988).

In its classic form, the following assumptions are made (Doorn 1975; Dufresne & Vázquez-Abad 2013):

- A1 – supply depends only on the price forecast
- A2 – actual market price adjusts to demand and, therefore, eliminates excess demand instantaneously in the trading period
- A3 – price forecast equals the most recent observed price
- A4 – there are no inventories, and neither buyers nor sellers have an incentive to speculate.

The general and linear cobweb model assumes $n = 1$ and $w = 1$, and is given by the following equations (Dufresne & Vázquez-Abad 2013; Hommes 1994):

Demand curve

$$\mathrm{D_t(P_t) = Q_{d(t)} = a - \frac{b}{c} P_t} \tag{3}$$

Supply curve

$$\mathrm{S_t(\hat{P}_t) = Q_{s(t)} = d + \frac{e}{f} \hat{P}_t} \tag{4}$$

Where:

$Q_{s(t)} = quantity\ supplied$

$Q_{d(t)} = quantity\ demanded$

$a, b, c, d, e, f = parameters\ of\ the\ model\ supply\ curve\ (s)\ and\ demand\ curve\ (d)$

Since we assumed that $n = 1$ and $w = 1$, then from $\hat{P}_t = (1 - w)\hat{P}_{t-1} + wP_{t-1}$, $\hat{P}_t = P_{t-1}$.

From equations (3) and (4)

$$\mathrm{Q_{d(t)} = a - \frac{b}{c} P_t} \tag{5}$$

$$Q_{s(t)} = d + \frac{e}{f} P_{t-1} \tag{6}$$

The equilibrium price is at $Q_{s(t)} = Q_{d(t)}$, making the substitution

$$d + \mathrm{\frac{e}{f} P_{t-1} = a - \frac{b}{c} P_t} \tag{7}$$

It is seen that the price sequence follows

$$\mathrm{P_t = \left(-\frac{e/f}{b/c}\right) P_{t-1} + \frac{a-d}{b/c}} \tag{8}$$

Equation (8) is a first order difference equation and it gives P_t as a function of P_{t-1}. The solution for P_t is given by

$$P_t = (P_0 - P^*)\left(-\frac{e/f}{b/c}\right)^t + P^* \qquad (9)$$

where P^* is the equilibrium solution to equation (9), where $P_t = P_{t-1} = P^*$.

From equation (7)

$$d + \frac{e}{f}P^* = a - \frac{b}{c}P^* \qquad (10)$$

$$\left(\frac{e}{f} + \frac{b}{c}\right)P^* = a - d$$

$$P^* = \frac{a-d}{\left(\frac{e}{f}+\frac{b}{c}\right)}$$

Therefore, the sequence defined in equation (9) converges to P^* if and only if $e/f < b/c$. In words, the supply function is flatter than the demand function, i.e. the supply curve is steeper than the demand curve, $|e/f| < |b/c|$ or $\left|\frac{1}{e/f}\right| > \left|\frac{1}{b/c}\right| \rightarrow \left|\frac{e/f}{b/c}\right| < 1$. In this case, the absolute value of $\left(-\frac{e/f}{b/c}\right)^t$ diminishes as t increases. Although the system is stable in this case, there are fluctuations, 'but it is a property of markets in which price fluctuations tend to dampen over time' (Dufresne & Vázquez-Abad 2013, p. 2).

2.1.2 The cobweb model – random disturbances and non-linear supply and demand curves

Landholders might adjust the size of their land to be put into biodiversity stewardship based on their expected price (therefore changing the number of biodiversity credits), introducing randomness in the price process. Various authors have studied the case when random disturbances are included in the cobweb model (Pryor 1982; Turnovsky 1968; Dufresne & Vázquez-Abad 2013). This section is based on the rationale developed by those authors, and makes an extension of the cobweb model with random disturbances and non-linear supply and demand curves to the biodiversity market in New South Wales, introducing:

$i = \{Biodiversity\ assets, either\ species\ or\ ecosystem\}$.

The system in equations (3) and (4) has demand and supply curves that are fixed through time. Introducing an additive and multiplicative random disturbance in the *logprice* process and a time-varying supply curve, and letting the demand curve remain fixed, the system becomes:

from equations (3) and (4)

$$Q_{d(t)} = \kappa_d a P_t^{(-d)} \qquad (11)$$

$$Q_{s(t)} = \kappa_{s,t} b P_{t-1}^{(s_t)} \qquad (12)$$

where κ_d and $\kappa_{s,t}$ are the random disturbances.

From equations (11) and (12), the equilibrium condition is when $Q_{d(t)} = Q_{s(t)}$.

$$\kappa_d a P_t^{(-d)} = \kappa_{s,t} b P_{t-1}^{(s_t)} \qquad (13)$$

$$P_t = \left(\frac{\kappa_{s,t}}{\kappa_d}\right)^{-1/d}\left(\frac{b}{a}\right)P_{t-1}^{(s_t)} \qquad (14)$$

Taking logarithms in equation (14)

$$p_t = \left(-{}^{1}/_{d}\, log \frac{\kappa_{s,t}}{\kappa_d}\right) + g + \left(-{}^{s_t}/_{d}\right) p_{t-1} \quad (15)$$

$$p_t = g + \beta_t p_{t-1} + \varepsilon_t \quad (16)$$

where $p_t = \log(P_t)$; $p_{t-1} = \log(P_{t-1})$; $g = log\left(\frac{b}{a}\right)$; $\beta_t = \left(-{}^{s_t}/_{d}\right)$; and $\varepsilon_t = \left(-{}^{1}/_{d}\, log \frac{\kappa_{s,t}}{\kappa_d}\right)$.

Dufresne and Vázquez-Abad (2013) assume that $\{(\beta_t, \varepsilon_t), t \geq 1\}$ is a sequence of independent and identically distributed $(i.i.d)$ random vectors. When $\beta_t = \beta$ is deterministic (i.e. only $\{(\varepsilon_t), t \geq 1\}$ is a random vector), equation (16) is an autoregressive process of order 1, and there are well-known conditions for its stability (an autoregressive process is stable if the roots of the lag polynomial lie outside the unit circle; i.e. $|\beta_t| < 1$).

$$p_t = g + \beta p_{t-1} + \varepsilon_t \quad (17)$$

For the purposes of the biodiversity market in New South Wales, for the prediction of credit price when i are tradable, equation (17) can be expressed as:

$$p_{i,t} = g + \beta_i p_{i,t-1} + \alpha_i + \varepsilon_{i,t} \quad (18)$$

Where α_i captures the heterogeneity, or individual effect for biodiversity assets (i.e. fixed or random effects settings) (Greene 2003). Equation (18) can be empirically estimated through a dynamic panel data model.

2.2 Extension of the economic model with a shift in the supply and demand curves

From equations (11) and (12), we assume that the proportional change in both the supply and the demand curves is represented by $\theta\ and\ \varphi$, respectively. Then

$$Q_{d(t)} = \varphi \kappa_d a P_t^{(-d)} \quad (19)$$

$$Q_{s(t)} = \theta \kappa_{s,t} b P_{t-1}^{(s_t)} \quad (20)$$

where $\kappa_d\ and\ \kappa_{s,}$ are the random disturbances.

From equations (19) and (20), the equilibrium condition is when $Q_{d(t)} = Q_{s(t)}$.

$$\varphi \kappa_d a P_t^{(-d)} = \theta \kappa_{s,t} b P_{t-1}^{(s_t)} \quad (21)$$

$$\frac{\varphi}{\theta} P_t = \left(\frac{\kappa_d}{\kappa_{s,t}}\right)^{-1/d} \left(\frac{a}{b}\right) P_{t-1}^{(s_t)} \quad (22)$$

If $\theta = \varphi$, then

$$P_t = \left(\frac{\kappa_d}{\kappa_{s,t}}\right)^{-1/d} \left(\frac{a}{b}\right) P_{t-1}^{(s_t)} \quad (23)$$

and the solution is given by equations (15) to (18).

If $\theta \neq \varphi$ then from equation (22)

$$\frac{\varphi}{\theta} P_t = \left(\frac{\kappa_d}{\kappa_{s,t}}\right)^{-1/d} \left(\frac{a}{b}\right) P_{t-1}^{(s_t)} \quad (24)$$

$$\frac{\varphi}{\theta} \neq 0\ if\ \theta \neq 0\ and\ \varphi \in \mathcal{R}$$

Taking logarithms in equation (24)

$$(log\varphi - log\theta) + p_t = \left(-{}^{1}/_{d}\, log\frac{\kappa_{s,t}}{\kappa_d}\right) + g + \left(-{}^{s_t}/_{d}\right)p_{t-1} \quad (25)$$

$$\vartheta + p_t = g + \beta_t p_{t-1} + \varepsilon_t \quad (26)$$

$$p_t = -\vartheta + g + \beta_t p_{t-1} + \varepsilon_t \quad (27)$$

where $p_t = \log(P_t)$; $p_{t-1} = \log(P_{t-1})$; $g = log\left(\frac{a}{b}\right)$; $\beta_t = \left(-{}^{s_t}/_{d}\right)$; and $\varepsilon_t = \left(-{}^{1}/_{d}\, log\frac{\kappa_{s,t}}{\kappa_d}\right)$.

In equation (24), $\vartheta = (log\varphi - log\theta)$ states that an immediate change in the price level depends on the proportional change in the supply and demand curves.

3. The financial model from the supply side

Equations (28) to (31) below define the financial model that describes the impact of the change in the discount rate and in the number of credits created under the BAM, i.e. the supply side of the offset market.

$$TFD + \gamma\pi = n_{BBAM} * p_{tfd} + n_{BBAM} * p_{\pi^{obs}} \quad (28)$$

$$\pi \le n_{BBAM} * p_{\pi^{obs}} \text{ holds if } \gamma \ge 1$$

$$\pi \ge n_{BBAM} * p_{\pi^{obs}} \text{ holds if } 0 \le \gamma \le 1$$

and

$$\gamma \ge 0 \quad (29)$$

for any case

$$\gamma\pi = n_{BBAM} * p_{\pi^{obs}} \quad (30)$$

$$\gamma \sim N(\mu, \sigma) \quad (31)$$

where

$TFD = total\ fund\ deposit$

$\pi = declared\ expected\ profits$

$\pi^{obs} = observed\ profits$

$\gamma = profit\ adjustment\ parameter$

$n_{BBAM} = number\ of\ credits\ under\ the\ BBAM$

$p_{tfd} = portion\ of\ credit\ price\ to\ cover\ TFD\ under\ the\ BBAM$

$p_{\pi^{obs}} = portion\ of\ credit\ price\ to\ cover\ expected\ profits$

Please note that the TFD is the present value of the future payments in perpetuity and therefore that, if r is the discount rate, these payments will be set to $r * TFD$ indefinitely (Bradley 2013).

Although we have assumed $\gamma \ge 0$, it is more likely that $\gamma \ge 1$. In other words, observed profits, i.e. realised by market trade, are at least the same as the declared expected profits at the moment of biodiversity agreement creation.

From equation (28)

$$TFD + \gamma\pi = n_{BBAM} * (p_{tfd} + p_{\pi^{obs}}) \tag{32}$$

$$\frac{TFD}{n_{BBAM}} + \frac{\gamma\pi}{n_{BBAM}} = p_{tfd} + p_{\pi^{obs}} \tag{33}$$

where, $\frac{TFD}{n_{BBAM}}$ is a measure of the 'production' cost by credit under the BBAM and $\frac{\gamma\pi}{n_{BBAM}}$ is a measure of the profits by credit under the BBAM.

From equations (30) and (33), the following equations hold.

$$\frac{TFD}{n_{BBAM}} = p_{tfd} \tag{34}$$

$$\frac{\gamma\pi}{n_{BBAM}} = p_{\pi^{obs}} \tag{35}$$

Then, a change in the discount rate and in the number of credits is represented as

$$\frac{r*TFD}{\theta*n_{BBAM}} = \frac{r*p_{tfd}}{\theta} \tag{36}$$

$$\frac{\gamma\pi}{\theta*n_{BBAM}} = \frac{p_{\pi^{obs}}}{\theta} \tag{37}$$

where,

$r = impact\ derived\ from\ the\ (new)\ discount\ rat$

$\theta = \frac{n_{BAM}}{n_{BBAM}}$

From (36) and (37)

$$\frac{r*TFD}{\theta*n_{BBAM}} + \frac{\gamma\pi}{\theta*n_{BBAM}} = \frac{r*p_{tfd}}{\theta} + \frac{p_{\pi^{obs}}}{\theta} \tag{38}$$

$$\frac{r*TFD}{n_{BAM}} + \frac{\gamma\pi}{n_{BAM}} = \frac{r*p_{tfd}}{\theta} + \frac{p_{\pi^{obs}}}{\theta} \tag{39}$$

The new level of the discount rate affects the TFD amount in $r * TFD$. To cover the new amount of TFD, the price increases to $r * p_{tfd}$. Furthermore, a variation in the number of credits, which can be represented as a ratio, $\theta = \frac{n_{BAM}}{n_{BBAM}}$, derived from the improvement in the biodiversity assessment method, i.e. BBAM→BAM, impacts the production cost per credit in $\frac{r*TFD}{\theta*n_{BBAM}}$. To cover this new amount of production cost per credit, the price increases $\frac{r*p_{tfd}}{\theta}$.

We assume that the profit adjustment parameter, the declared expected profits and the observed expected profits (γ, π, π^{obs}) do not change for the landholder, but are affected by the variation in the number of credits in$\frac{\gamma\pi}{\theta*n_{BBAM}}$ and $\frac{p_{\pi^{obs}}}{\theta}$, respectively.

Finally, the right side of equation (39) states that if we know the market price of a credit, based on known parameters r and θ, we can estimate the credit price for BAM credits. The left side of equation (39) states that if market price is unknown because no trade has been recorded, but both TFD and the variation in the number of credits are known, i.e. credits have been created but not traded, then we can estimate the credit price for BAM credits, with a degree of uncertainty determined by γ.

Therefore, for credits with market trades under BBAM:

$$p_{BAM} = \frac{r*p_{tfd}}{\theta} + \frac{p_{\pi^{obs}}}{\theta} \tag{40}$$

And, for credits without market trades under BBAM, but that have been created by a biodiversity agreement:

$$p_{BAM} = \frac{r * TFD}{n_{BAM}} + \frac{\gamma\pi}{n_{BAM}} \quad (41)$$

For credits that have not been created yet, the agreed set of rules, based on offset trading groups and vegetation class need to be applied.

The above financial model and the economic model, which defines the dynamic process in the market equilibrium, have both strong economic and financial foundations and should be used in conjunction with the like-for-like offsets rules and variation rules to assure an efficient functioning of the offsets market, and consequently, an adequate financial position to the BCT, during the transitory period until the offset market records the first BAM market trades and BSAs.

4. The pricing model for ecosystem credits

The methodology developed combines the offsets price rules, the economic model to forecast market price (i.e. the dynamic panel data model), and the method to account for the change in the discount rate and the BBAM–BAM conversion ratios; plus, the inclusion of the administration fee and the risk premium to prevent any under-funding of the BCF.

4.1 Use of trading groups for establishing the BCT’s offset obligation charge

4.1.1 The offset trading groups

The offset trading groups are established in Section 11.3 of the BAM to identify a class of credits and then allow that class of credits to match to other ‘like’ classes or apply the ‘variation rules’. A credit class in the ecosystem credit category has seven attributes. Attribute (c) is the offset trading group for threatened ecological communities (TECs):

a. name of the plant community type (PCT) impacted by development or conferral of biodiversity certification
b. name of any critically endangered ecological community (CEEC) or endangered ecological community (EEC) or vulnerable ecological community (VEC) associated with the PCT identified in (a)
c. offset trading group for the PCT or ecological community, as identified in the ancillary rules in clause 6.5 (2)(d) of the Biodiversity Conservation Regulation 2017 (BC Regulation)
d. vegetation class of the PCT identified in (a)
e. vegetation formation of the PCT identified in (a)
f. presence or absence of hollow bearing trees
g. Interim Biogeographic Regionalisation of Australia (IBRA) subregion in which the development, clearing or biodiversity certification occurs.

4.1.2 The offset rules

The offset rules govern the types of offsets that can be used to meet an offset obligation under the BOS. The offset rules are established through the BC Regulation.

4.1.3 Offset rules for proponents

The offset rules permit proponents to meet their offset obligation by either:

1. Retiring credits based on the like-for-like rules.
2. Funding a biodiversity conservation action that benefits the threatened entity impacted by the development. The action must be listed in the Ancillary rules: Biodiversity conservation actions and meet the other requirements set out by these rules.
3. Committing to deliver mine site ecological rehabilitation that creates the same ecological community or threatened species habitat (available for major mining projects only). The ecological rehabilitation must meet the requirements set out in the 'ancillary rules for mine site ecological rehabilitation' which will be published by the Environment Agency Head.
4. Making a payment to the Biodiversity Conservation Fund calculated using the offset payments calculator.
5. If a proponent can demonstrate they were not able to find like-for-like credits and chooses not to use the other offset options, they can seek approval to offset with a broader suite of biodiversity using the variation rules.

4.1.4 Offset rules for the Biodiversity Conservation Trust

There is a hierarchy of offset options for the Biodiversity Conservation Trust (BCT).

If the BCT decides to move down through the hierarchy of options, the BC Regulation requires that this decision is justified in annual reporting.

The hierarchy of options is:

1. retire credits under the like-for-like rules or fund a biodiversity conservation action that benefits the entity impacted and is listed in the ancillary rules
2. retire credits under the variation rules (noting the variation rules can be applied to all threatened entities, unlike for proponents where impacts on entities identified in the ancillary rules are excluded from the variation rules)
3. fund a biodiversity action that benefits the entity impacted but this action does not need to be listed in the ancillary rules
4. retire credits under the variation rules but these credits can be generated from anywhere in the state, i.e. the location requirement in the variation rules does not apply
5. use any other conservation measure approved by the Minister for the Environment.

The BCT has some additional flexibility compared to proponents to ensure it can meet its offset obligations.

4.1.5 The like-for-like offsetting rules

The like-for-like rules seek to ensure biodiversity impacts are offset with biodiversity that is very similar to the biodiversity that is being impacted.

The like-for-like rules require that:

Impacts on native vegetation must be offset with vegetation that is in the same local area as the impact (based on near or adjacent IBRA subregions[4] and:

1. if a threatened ecological community was impacted, the offset must be for the same threatened ecological community
2. if native vegetation that is not a threatened ecological community was impacted, the offset must be vegetation that is the same vegetation class and in the same or higher offset trading group[5].

In addition, if the impacted vegetation contained hollow bearing trees then the offset site must also contain hollow bearing trees.

Impacts on threatened species (that are not associated with a particular type of vegetation) must be offset with the same threatened species. This offset can be located anywhere in New South Wales.

4.1.6 The variation rules

The BC Regulation contains variation rules that provide some flexibility by allowing offsetting with a broader suite of biodiversity that is the same or more threatened than the biodiversity impacted.

Use of the variation rules to allow offsetting using this broader suite of biodiversity must be approved by the consent authority through conditions of consent.

Before applying the variation rules, the proponent must demonstrate to the consent authority that they have been unable to find like-for-like credits after following the reasonable steps set out in the Ancillary rules: Reasonable steps to seek like-for-like biodiversity credits. In summary, these steps are:

- checking the 'credit register' for the required credits
- contacting landholders on the 'landholder expression of interest register'
- lodging an expression of interest on the 'credits wanted register'.

The variation rules cannot be applied by proponents for impacts on some threatened entities, listed in the Ancillary rules: impacts on threatened entities excluded from variation. All critically endangered entities are included on this list. This restriction does not apply to the Biodiversity Conservation Trust.

The variation rules require that:

- Impacts on native vegetation must be offset with vegetation that is in the same region as the impact (based on the IBRA region and nearby IBRA subregions) and:
  - is in the same vegetation formation and is in the same or higher offset trading group
  - in addition, if the impacted vegetation contained hollow bearing trees then the offset site must also contain hollow bearing trees or artificial hollows.
- Impacts on threatened species (that are not associated with a particular type of vegetation) must be offset with threatened species in the same local area as the impact (based on surrounding IBRA subregions) and:
  - impacts on threatened plants must be offset with a threatened plant that is the same or more threatened under the BC Act

[4] IBRA subregions are identified under the Interim Biogeographic Regionalisation for Australia (IBRA) system, which divides Australia into bioregions and subregions on the basis of their dominant landscape-scale attributes.

[5] Offset trading groups are based on how extensively a vegetation type has been cleared and on associations with a threatened ecological community in the NSW BioNet Vegetation Information System.

  - impacts on threatened animals must be offset with a threatened animal that is the same or more threatened under the BC Act.

4.1.7 The offset price rules

The offset price rules are based on the like-for-like rule and the variation rules, which provide some flexibility by allowing offsetting with a broader suite of biodiversity that is the same or more threatened than the biodiversity impacted.

The below principles are applied in order to have a consistent use of the offset price rules:

1. Every plant community type (PCT) is part of a non-threatened ecological community (non-TEC) trading group

Every PCT, irrespective of whether it is a TEC or not, is part of a non-TEC trading group. A non-TEC trading group is defined by the PCT's vegetation class and percentage cleared status.

Note that PCTs associated with a TEC can still be classified as a non-TEC. The reason for this is that a vegetation area may be a PCT associated with a TEC, however, may not meet the floristic composition or geographic location requirements in the listing. The PCT is therefore classified as a non-TEC.

2. PCTs associated with a TEC have at least two trading groups

In addition to a non-TEC trading group, a PCT that is associated with a TEC also has a TEC trading group. A PCT may be associated with more than one TEC trading group. In other words, every non-TEC PCT has a single trading group. Every PCT associated with a TEC has at least two trading groups.

3. PCTs must be assigned to a trading group before a price can be determined

If a PCT is a TEC and has more than one trading group, then the predicted credit price for the PCT can only be determined if the PCT is assigned to a trading group.

For example, PCT 1281 has four trading groups:

- TEC – Blue Mountains Shale Cap Forest
- TEC – Shale Sandstone Transition Forest
- TEC – Sydney Turpentine-Ironbark Forest
- Non-TEC – Vegetation class; ≥90% cleared.

PCT 1281 will have a different predicted credit price depending on the trading group that it's assigned to.

A PCT cannot be assigned to more than one trading group at a time. In other words, a vegetated area is a PCT that can be assigned to a specific TEC or a non-TEC, not both[6].

4. Determining the price for non-TEC trading groups

The predicted credit price for a non-TEC trading group is determined from:

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[6] Note that an assessor assigns a PCT to a specific TEC or a non-TEC as part of the BAM assessment for a development. The decision is made based on the floristic composition and location of the vegetation.

1. the previous trade data for BBAM credits[7] for all PCTs within the trading group (i.e. vegetation class and percentage cleared status), irrespective of whether the PCT is associated with a TEC or not
2. from trades of BAM credits for the PCTs within the trading group, excluding trades of TECs.

As an example, PCT 792 is associated with an EEC, Blue Mountains Shale Cap Forest. The assessor has not identified the vegetation as being a TEC. The predicted credit price for PCT 792 is determined from the BBAM trade data for all PCTs in the trading group and BAM trade data for non-TEC PCTs in the trading group.

Note that BBAM credits are identified only by the PCT without information on whether the vegetation is a TEC or not.

5. Determining the price for TEC trading groups

The predicted credit price for a TEC trading group is determined from:

1. the previous trade data for BBAM credits for all PCTs associated with the TEC
2. the trades of BAM credits for the specific TEC.

As an example, Blue Mountains Shale Cap Forest is an EEC associated with three PCTs – 1281, 1284 and 792. The predicted credit price for the EEC is determined from the BBAM trade data for these PCTs and as well, trade data for BAM credits for the EEC.

6. Using vegetation formations to determine the predicted price

TEC price rule 2 in Table 1

TEC price rule 2 states that if there are no trades for a TEC then the predicted credit price is determined by all trades for all TECs in the same formation and same threat status as the PCT being impacted.

It is possible that the TEC is associated with more than one PCT and that each PCT is associated with a different vegetation class and formation. If this is the case then under TEC price rule 2, the predicted credit price is determined for all PCTs that occur in the same formation as the PCT being impacted and that also have the same threat status as the TEC (refer to clause 6.4 (1)(b) of the BC Regulation).

For example, if there are no trades for Blue Mountains Shale Cap Forest (EEC) and PCT 1281 is being impacted, then under TEC price rule 2 the predicted credit price for the offset charge is determined from the trade data for the PCTs in the same formation as PCT 1281 that are also EECs.

Note that a PCT can only be assigned to a single vegetation class and a single formation.

TEC price rule 4

Similarly, for TEC price rule 4, the predicted credit price is determined for all PCTs that occur in the same formation and in the same percentage cleared status as the PCT being impacted (refer to Clause 6.4 (1)(b) of the BC Regulation).

For example, if there are no trades for Blue Mountains Shale Cap Forest (EEC) and PCT 1281 is being impacted, then under TEC price rule 4 the predicted credit price for the offset

[7] Trade data of BBAM credits require a credit equivalence conversion in order to be used to determine the predicted price for BAM credits.

charge is determined from the trade data for the PCTs in the same formation and the same percentage cleared class as PCT 1281.

The base credit price, dynamic and market coefficients and risk premium are based on all trades, regardless of IBRA subregion.

Table 1 TEC offset price rules

TEC offset price rules	Support
1 The TEC being impacted	Like-for-like rule BC Regulation cl. 6.3(2)
If there are no trades for the TEC being impacted, then: 2 All TECs that are: i) in the same vegetation formation ii) same threat status as the TEC being impacted	Variation rule BC Regulation cl. 6.4(1)(b)
If there are no trades within this group, then: 3 All TECs that are: i) in the same vegetation formation ii) same or higher threat status as the TEC being impacted	Variation rule BC Regulation cl. 6.4(1)(b)
If there are no trades within this group, then: 4 All trading groups that are: i) in the same vegetation formation ii) same or higher percentage cleared class as the TEC being impacted	Variation rule BC Regulation cl. 6.4(1)(b)
If there are no trades within this group, then: 5 All TECs with the same threat status	Interim response until trades occur for the vegetation formation

Note: The above rules for determining the BOPC price also apply to any threatened species or TECs which have been excluded from use of the variation rules as a result of clause 6.4(2) of the BC Regulation.

Table 2 Non-TEC offset price rules

Non-TEC offset price rules	Rationale
1 The trading group of the PCT being impacted (i.e. same vegetation class as the PCT and same percentage cleared class)	Like-for-like rule BC Regulation cl. 6.3(3)
If there are no trades within this group, then: 2 The trading group and all higher trading groups of the PCT being impacted (i.e. same vegetation class as the PCT and same or higher percentage cleared class)	Like-for-like rule BC Regulation cl. 6.3(3)
If there are no trades within this group, then: 3 All trading groups that are: i) in the same vegetation formation ii) same percentage cleared class as the PCT being impacted	Variation rule BC Regulation cl. 6.4(1)(b)
If there are no trades within this group, then:	Variation rule

Non-TEC offset price rules	Rationale
4 All trading groups that are: i) in the same vegetation formation ii) same or higher percentage cleared class as the PCT being impacted	BC Regulation cl. 6.4(1)(b)
If there are no trades within this group, then: 5 All non-TEC trading groups in the same or higher percentage cleared class	Interim response until trades occur for the vegetation formation

4.2 Dynamic panel data model

4.2.1 Advantages of the dynamic panel data model to predict ecosystem credit prices in New South Wales

Information about ecosystem credits trading is generated and available in terms of longitudinal data, i.e. information for multiple cases (offset trading groups) is observed in different time periods. Despite this potential for generating additional information there are limited trades for a number of offset trading groups. Furthermore, contemporaneous levels of credits transferred do not statistically determine contemporaneous levels of biodiversity credit prices. Hence, we face statistical issues to predict credit prices based on the trade history for the ecosystem credit alone.

A dynamic panel data model overcomes the above challenges by blending the inter-individual differences and intra-individual dynamics, in a manner that allows the analyst to:

1. more accurately infer model parameters because they contain more degrees of freedom and more sample variability than cross-sectional data, which may be viewed as a panel with $t = 1$, or time series data which is a panel with $i = 1$, hence improving the efficiency of econometric estimates (e.g. Hsiao, Mountain & Illman 1995)
2. control for the impact of omitted variables (Hsiao 2007)
3. uncover dynamic relationships (Hsiao 2007)
4. generate more accurate predictions for individual outcomes by pooling the data rather than generating predictions of individual outcomes using the data on the individual in question.

If individual behaviours are similar, conditional on certain variables, panel data provide the possibility of learning an individual’s behaviour by observing the behaviour of others. Thus, it is possible to obtain a more accurate description of an individual’s behaviour by supplementing observations of the individual in question with data on other individuals (e.g. (Hsiao et al. 1989; Hsiao, Appelbe & Dineen 1993; Greene 2003; Hsiao 2007).

4.2.2 Formal representation of the dynamic panel data model to predict ecosystems credit prices based on offset trading groups in New South Wales

In terms of a dynamic panel data model, equation (18) can be expressed as in Greene (2003):

$$\begin{aligned} p_{i,t} &= x_{it}'\gamma + \beta p_{i,t-1} + \alpha_i + \varepsilon_{i,t} \\ &= w_{it}' * \delta + \alpha_i + \varepsilon_{i,t} \\ \varepsilon_{i,t} &= \mu_i + v_{it} \\ E(\alpha_i) &= E(\varepsilon_{it}) = E(\alpha_i \varepsilon_{it}) = 0 \\ i &= 1, \dots, N \\ t &= 1, \dots, T \end{aligned} \tag{42}$$

$$\begin{aligned} \boldsymbol{w}_{it}' &= \left(\boldsymbol{x}_{it}' \cup p_{i,t-1}\right) \\ \boldsymbol{\delta} &= (\boldsymbol{\gamma} \cup \beta) \\ |\beta| &< 1 \end{aligned} \tag{43}$$

where $\boldsymbol{w}_{it}'$ now includes the lagged dependent variable $p_{i,t-1}$. From equation (42), the term $\boldsymbol{w}_{it}' * \boldsymbol{\delta}$ captures the influence of the independent variables $(\boldsymbol{x}_{it}'\boldsymbol{\gamma})$ conditioned to the impact of the lagged dependent variable $(\beta p_{i,t-1})$; in this case, any impact of $\boldsymbol{x}_{it}'$ represents the effect of new information. Substantial complications arise in estimating such a model. In both the fixed and random effects settings[8] (α_i), the difficulty is that the lagged dependent variable is correlated with the disturbance $\varepsilon_{i,t}$, even if it is assumed that $\varepsilon_{i,t}$ is not itself autocorrelated.

We aim to get a matrix of consistent and efficient estimators $\boldsymbol{\delta}$ based on observed data. Hence, a good approach is the Arellano–Bover/Blundell–Bond method (Arellano & Bover 1995; Blundell & Bond 1998) to obtain the dynamic panel estimators of interest $\hat{\boldsymbol{\delta}}$.

The Arellano–Bover/Blundell–Bond method transforms all regressors by differencing, and using the generalised method of moments (GMM) (Hansen 1982). Further, it makes an additional assumption that first differences of instrument variables are uncorrelated with the fixed effects. This allows for the introduction of more instruments and can improve efficiency. It builds a system of two equations – the original equation and the transformed one – and is known as system GMM (Roodman 2009).

The Arellano–Bover/Blundell–Bond method is designed for situations with: 1) few time periods and many individuals; 2) a linear functional relationship; 3) one left-hand-side variable that is dynamic, depending on its own past realisations; 4) independent variables that are not strictly exogenous, meaning they are correlated with past and possibly current realisations of the error; 5) fixed individual effects; and 6) heteroskedasticity and autocorrelation within individuals but not across them.

Roodman (2009) noted that the first difference transform has a weakness. It magnifies gaps in unbalanced panels. If some $y_{i,t}$ is missing, for example, then both $\Delta y_{i,t}$ and $\Delta y_{i,t+1}$ are missing in the transformed data. One can construct datasets that completely disappear in first differences. This motivates the second common transformation, called 'forward orthogonal deviations' or 'orthogonal deviations' (Arellano & Bover 1995). Instead of subtracting the previous observation from the contemporaneous one, it subtracts the

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[8] For a complete discussion regarding heterogeneity, or individual effects (i.e. fixed or random effects), see Green 2003, Hsiao 2007.

average of all future available observations of a variable. No matter how many gaps, it is computable for all observations except the last for each individual, so it minimises data loss. And because lagged observations do not enter the formula, they are valid as instruments[9].

Following Roodman (2009), we want to fit the model:

$$p = x'\beta + \varepsilon \qquad (44)$$
$$E[\varepsilon|z'] = 0$$

where $\boldsymbol{\beta}$ is a column vector of coefficients, p and ε are random variables, $\boldsymbol{x} = (x1, \ldots, xk)'$ is a column vector of k regressors, $\boldsymbol{z} = (z1, \ldots, zj)'$ is a column vector of j instruments, $\boldsymbol{x}$ and $\boldsymbol{z}$ can share elements, and $j \geq k$. We use $\boldsymbol{X}, \boldsymbol{P}$, and $\boldsymbol{Z}$ to represent matrices of N observations for $\boldsymbol{x}$, p, and $\boldsymbol{z}$, and we define $\boldsymbol{E} = \boldsymbol{P} - \boldsymbol{X\beta}$. Given an estimate, $\hat{\beta}$, the empirical residuals are $\widehat{\boldsymbol{E}} = (\widehat{e1}, \ldots, \widehat{eN})' = \boldsymbol{P} - \boldsymbol{X}\widehat{\boldsymbol{\beta}}$. We make no assumption at this point about $E\,(\boldsymbol{EE}'\,|\boldsymbol{Z}) = \boldsymbol{\Omega}$ except that it exists.

One issue in estimating this model is that while all the instruments are theoretically orthogonal to the error term, $E(\boldsymbol{z}\varepsilon) = \boldsymbol{0}$, trying to force the corresponding vector of empirical moments, $E_N(\boldsymbol{z}\varepsilon) \equiv (1/N)\boldsymbol{Z}'\widehat{\boldsymbol{E}}$, to zero creates a system with more equations than variables if $j > k$. The specification is then *overidentified*. Because we cannot expect to satisfy all the moment conditions at once, the problem is to satisfy them all as well as possible in some sense; that is, to minimise the magnitude of the vector $E_N(\boldsymbol{z}\varepsilon)$.

The GMM estimator for $\boldsymbol{\beta}$ in equation (44) can be derived as follows:

Let $\boldsymbol{A}$ be the matrix for such a quadratic form

$$\|E_N(z\varepsilon)\|_A = \left\|\frac{1}{N}Z'\hat{E}\right\|_A \equiv N\left(\frac{1}{N}Z'\hat{E}\right)' A\left(\frac{1}{N}Z'\hat{E}\right) = \frac{1}{N}\hat{E}'ZAZ'\hat{E} \qquad (45)$$

To derive the implied GMM estimate, call it $\widehat{\boldsymbol{\beta}_{\boldsymbol{A}}}$, we solve the minimisation problem $\widehat{\boldsymbol{\beta}_{\boldsymbol{A}}} = argmin_{\hat{\beta}}\left\|\boldsymbol{Z}'\widehat{\boldsymbol{E}}\right\|_A$, whose solution is determined by $0 = \frac{d}{d\widehat{\boldsymbol{\beta}}}\left\|\boldsymbol{Z}'\widehat{\boldsymbol{E}}\right\|_{\boldsymbol{A}}$. Expanding this derivative with the chain rule gives

$$0 = \frac{d}{d\hat{\beta}}\left\|Z'\hat{E}\right\|_A = \frac{d}{d\hat{E}}\left\|Z'\hat{E}\right\|_A \frac{d\hat{E}}{d\hat{\beta}} = \frac{d}{d\hat{E}}\left\{\frac{1}{N}\hat{E}'(ZAZ')\hat{E}\right\}\frac{d(P - X\hat{\beta})}{d\hat{\beta}} \qquad (46)$$
$$0 = \left\{\frac{2}{N}\hat{E}'ZAZ'(-X)\right\}$$

The last step uses the matrix identities $d\boldsymbol{Ab}/d\boldsymbol{b} = \boldsymbol{A}$ and $d\,(\boldsymbol{b}'\boldsymbol{Ab})\,/d\boldsymbol{b} = 2\boldsymbol{b}'\boldsymbol{A}$, where $\boldsymbol{b}$ is a column vector and $\boldsymbol{A}$ is a symmetric matrix. Dropping the factor of $-2/N$ and transposing

$$0 = \hat{E}'ZAZ'X = \left(P - X\hat{\beta}\right)'ZAZ'X = P'ZAZ'X - \widehat{\beta_A}'X'ZAZ'X \qquad (47)$$
$$X'ZAZ'X\hat{\beta}_A{}' = X'ZAZ'P$$

$$\widehat{\boldsymbol{\beta}}_{\boldsymbol{A}} = (\boldsymbol{X}'\boldsymbol{ZAZ}'\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{ZAZ}'\boldsymbol{P} \qquad (48)$$

Equation (48) is the GMM estimator defined by $\boldsymbol{A}$, and it is linear in $\boldsymbol{P}$. Note that $\boldsymbol{\delta}$ in equation (42) is equal to $\widehat{\boldsymbol{\beta}}_{\boldsymbol{A}}$ in equation (48), hence, our interest is to estimate $\boldsymbol{\delta}$ through a system GMM.

[9] See Section 2 in Roodman (2009) for pedagogical purposes. It refers to an introduction to GMM in the cross-section case (N observations). Its generalisation to panel data is non-trivial as exemplified in Roodman's Section 3.

4.3 Outlier detection and treatment

One of the most important steps in the BOPC data pre-processing is outlier detection and treatment. Outliers are generally observations with large deviations, i.e. cases whose values differ substantially from the other observations. Data outliers can deceive the robustness of the econometric model resulting in less accurate credit price forecasting.

Outliers are defined as samples that are significantly different from the remaining data. Those are points that lie outside the overall pattern of the distribution. Statistical measures such as mean, variance and correlation are very susceptible to outliers.

These points require a special treatment because (a) extreme values of observed variables can distort estimates of regression coefficients, (b) they may reflect registered errors in the data, e.g. the decimal point is misplaced, or it has failed to declare some values as missing, (c) they may be a result of model misspecification – variables have been omitted that would account for the outlier, or the outlier belongs to a different population than the one we want to study. Rousseeuw (1987) provides a comprehensive approach to dealing with outliers in regression analysis through an outlier diagnostic with the purpose of 'pinpointing influential observations, which can then be studied and corrected or deleted …'.

4.3.1 Outlier detection in the BOPC

There are multiple methods to identify outliers in the dataset (Gupta et al. 2014). For the purposes of the BOPC, extreme value analysis is used to explore the data and identify the outliers (Selvanathan 2013). This technique determines the statistical tails of the underlying distribution of the variable and finds the values at the extreme ends of the tails. The general approach is to calculate the quantiles and then the interquartile range and set up the upper and lower boundaries. If the data point is above the upper boundary or below the lower boundary, it can be considered as an outlier. The extreme value analysis is based in the identification of both the percentile and quartile from the sample.

The pth percentile of a set of observations is the value for which at most $p\%$ of the observations are less than that value and at most $(100 - p)\%$ of the observations are greater than that value. The formula for the location of a percentile is given by $L_p = \frac{(n+1)p}{100}$, where n is the sample size and p is the percentile of interest.

Quartiles are values that divide the entire range of observations into four equal quarters. As noted by Selvanathan (2013), the word *quartile* is sometimes used to refer to one of these quarters. An observation in *the first quartile* is in the bottom 25% of the observations, whereas an observation *in the upper quartile* is among the top 25%.

Table 3 identifies some of the most commonly used percentiles, together with notation for the quartile.

Table 3 Commonly used percentiles, together with notation for the quartile

	First (lower) decile	= 10th percentile
$Q1 =$	First (lower) quartile	= 25th percentile
$Q2 =$	Second (middle) quartile	=median (50th percentile)
$Q3 =$	Third (upper) quartile	=75th percentile
	Ninth (upper) decile	=90th percentile

Source: Selvanathan (2013, p.159)

The quartiles are used to create the interquartile range (IQR), which is another measure of variability and is defined as $IQR = Q3 - Q1$. The IQR measures the spread of the middle

50% of the observations. Large values of this statistic mean that the first and third quartiles are far apart, indicating a high level of variability.

Fifty per cent of the observations are between Q1 and Q3. The ‘fences’ are $1\frac{1}{2}IQR$ far apart from the quartiles Q1 (lower fence $LF = Q1 - 1\frac{1}{2}IQR$) and Q3 (upper fence U$F = Q3 + 1\frac{1}{2}IQR$). The end of the ‘whiskers’ stretch to the furthest data values that occur at, or inside, the fences. Outliers are identified outside the ends of the whiskers.

4.3.2 Outlier treatment in the BOPC

The following steps are used to identify and deal with outliers:

1. Set the frequency of the time series component in the panel as quarterly.
2. Calculate the quarterly weighted average of credit price per offset trading group i.
3. All variables are in logs[10] and real levels. They have been deflated by the NSW Consumer Price Index[11] (December quarter 2018=100).
4. Apply the extreme value analysis; outliers are identified outside the ends of the whiskers by offset trading groups.
5. Include dummy variables to model the outliers by offset trading groups, as per equation 49.

$$dO_{t,i} = \begin{cases} 1 & if \text{ Observations are outside the 'fences'} \\ 0 & otherwise \end{cases} \qquad (49)$$

4.4 Model specifications and selection of instruments

4.4.1 Model specifications

In equation (42), we:

1. set the frequency of the time series component in the panel as quarterly, from June quarter 2010 to June quarter 2019
2. calculate the quarterly weighted average of credit price per offset trading group i
3. all variables are in logs[12] and real terms. They have been deflated by the NSW Consumer Price Index[13] (December quarter 2018=100)
4. include the first difference of the log of real NSW State Final Demand[14] seasonally adjusted as an instrument

[10] Taking the logarithm of the price means that the coefficients in equation (23) can be interpreted as elasticities.

[11] ABS 2017, *Consumer Price Index, Australia, Dec 2017*, Catalogue 6401.0, Australian Bureau of Statistics, Tables 1 and 2, www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6401.0Main+Features1Dec%202017

[12] Taking the logarithm of the price means that the coefficients in equation (23) can be interpreted as elasticities.

[13] ABS 2017, *Consumer Price Index, Australia, Dec 2017*, Catalogue 6401.0, Australian Bureau of Statistics, Tables 1 and 2, abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6401.0Main+Features1Dec%202017

[14] ABS 2017, *Australian National Accounts: National Income, Expenditure and Product*, Catalogue 5206.0, Australian Bureau of Statistics, Table 26, abs.gov.au/AUSSTATS/abs@.nsf/Lookup/5206.0Main+Features1Sep%202017

5. include dummy variables to model the outliers by offset trading groups, identified based on Section 4.3.

Since the Biodiversity Offsets Payment Calculator (BOPC) is used by the BCT to set the price developers must pay if they wish to offset their biodiversity loss by paying directly into the BCF, the model needs to provide a single price for each ecosystem that exists – regardless of whether it has been traded or not. Therefore, for those offset trading groups with sufficient data to estimate individual $\hat{\beta}_i$ from equation (42), the model captures the dynamic process between the current and past credit price. On the other hand, for those offset trading groups with insufficient data to estimate individual $\hat{\beta}_i$ from equation (42), the model allows the coefficients of lagged prices to vary for each cross-section unit in terms of offset trading group, and capture a 'pooled-average' market price[15].

4.4.2 Treatment for ecosystems with sufficient data to estimate individual coefficients by plant community type ID

In equation (42), we used the *xtabond2* command developed by Roodman (2009) for ®STATA/MP 14.2 to estimate $\hat{\beta}_i,\ i = \{Biodiversity\ assets, either\ species\ or\ ecosystem\}$.

The model allows the coefficients of lagged prices to vary for each cross-section unit, and captures the dynamic process between the current and past credit price (i.e. the 'dynamic coefficient'[16]).

Since the system GMM method does not assume that good instruments are available outside the immediate dataset, the only available instruments are 'internal', i.e. based on lags of the instrumented variables; however, the estimators do allow inclusion of external instruments (Roodman 2009). In this sense, for equation (25) we included the NSW state final demand seasonally adjusted (NSW SFD) as one instrument to capture the influence of NSW economic growth in ecosystem credit price processes.

4.5 The risk premium for purposes of securing biodiversity credits

4.5.1 Sources of market risk and the general risk model

For the BOS in New South Wales, when a developer pays into the Biodiversity Conservation Fund (BCF), and the Biodiversity Conservation Trust (BCT) takes on the developer's offset obligation, the BCF becomes responsible for securing the required offsets. Therefore, the BCF faces the risk that the actual credit price of acquiring ecosystem credits will exceed the amount paid by the developer in a previous period. Persistent net losses could exceed the capital of the BCF, resulting in insolvency in the long term.

The general risk model

A general concept of economic risk is the possibility of losing economic security, where most economic risk derives from variation from the expected outcome (Anderson & Brown 2005).

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[15] We assume that the latent individual behaviours of an offset trading group that has not been traded yet are similar according to the hierarchy established in the offset price rules, conditional on certain variables; therefore, panel data will provide the possibility of learning from observable data and use such learning for the case of offset trading groups that are 'newly' in the market.

[16] The 'dynamic coefficient' for the purposes of the payment calculator does not refer to the so-called dynamic factor models.

Applications in finance include risk measures such as the expected shortfall or conditional value-at-risk (VaR), where the expected return of some portfolio or trading position is computed conditional on the fact that the return has already fallen below some threshold (Rachev & Ebooks 2010). Since the return, either economic profit or loss, is a random variable, its probabilistic distribution plays an important role in risk measurement.

Hardy (2006) defines a risk measure as functional mapping of a loss (or profit) distribution to the real numbers.

$$\mathcal{H}: W \rightarrow \mathbb{R} \tag{49}$$

Where in $\mathcal{H}$ is the risk measure functional, and W is the appropriate random variable. Therefore, the risk measure is assumed in some way to encapsulate the risk associated with a loss distribution.

The first use of risk measures in actuarial science was the development of premium principles (Hardy 2006)[17]: 1) the expected value premium principle; 2) the variance premium principle; and, 3) the standard deviation premium principle. These three are widely applied to a loss distribution to determine an appropriate premium to charge the risk.

The risk measure for the expected value premium principle is:

$$\mathcal{H}(W) = (1 + \phi)E(W) \; for \; some \; \phi \geq 0 \tag{50}$$

The risk measure for the variance premium principle is:

$$\mathcal{H}(W) = E(W) + \phi V(W) \; for \; some \; \phi \geq 0 \tag{51}$$

where $E(W)$ is the expected value of random variable W, and $V(W)$ is its variance; ϕ is a measure of the attitude towards risk.

The difference between the premium and the mean loss is the premium (risk) loading. In the standard deviation and variance principles, the loading is related to the variability of the loss, which seems reasonable (Hardy 2006; Bühlmann 2007).

For purposes of the BOS, proponents still have the option to source biodiversity offsets themselves or pay into the BCF. Once a payment is made into the fund, the BCT becomes responsible for finding the offsets needed. The BCT must satisfy these offset obligations consistent with the rules of the BOS, where the like-for-like rule is preferable. In this sense, the BCT needs to manage the risk associated with acquiring biodiversity credits at different prices from those paid to the fund by the proponents. For simplicity, we adopt the conceptual framework of the insurance market to manage risk, pointing out the unique characteristics of the BCT when appropriate.

4.5.2 The risk loading for the general risk model

As noted by Zhang (2006), risk load calculation is important for insurance pricing, as it compensates insurers for taking the insurance risk. An insured pays a certain amount of premium to eliminate the uncertainty in future loss costs, and an insurer collects the premium and assumes the responsibility for paying any claims. Since both the insured and the insurer are risk averse, the insured is willing to pay a premium greater than the expected loss, and the insurer needs that additional premium to justify taking the risk. The size of the risk load depends on the riskiness of the insured loss and the competition in the insurance

[17] More premium principles are described in Gerber (1979), Bühlmann (2007) and Zhang (2007). For further information about the properties of premium principles see Kaas et al. (2008).

market. In the classic premium principles described above, a risk load is determined by the volatility of the insured loss itself, and the volatility is measured by the variance or the standard deviation (Miccolis 1977; Hardy 2006)[18].

Calculating risk loads is a complex task. Firstly, insurers often incorporate 'contingency' provisions in premium rates for unanticipated liabilities. Secondly, there is no established and simple procedure for determining the size of the risk load (Feldblum 1990).

There are four categories that can be used to group the numerous methods used to estimate the risk load (Feldblum 1990):

1. The risk load may vary with the random loss fluctuation of the individual's risk, e.g. the 'standard deviation' and 'variance' methods.
2. The risk load may vary with the characteristics of the overall portfolio of risk, e.g. the 'utility function' and 'probability of ruin' methods.
3. The risk load may vary with the empirical costs of reducing risk, e.g. the 'reinsurance' method.
4. The risk load may vary with fluctuations in profitability, e.g. the 'modern portfolio theory' method.

4.5.3 What are the differences between the Biodiversity Conservation Fund and an insurance company?

Modern financial theory[19], especially the Capital Asset Pricing Model (CAPM), is based on the assumptions that the insurance market is competitive, and the market players are 'rational' decision-makers; therefore, the supply and demand determine an equilibrium risk load. In a competitive market, the insured pay the lowest possible risk load, while the insurers collect the highest possible risk load from each policyholder and select the policies to minimise the total insurance risk. It may be further assumed that the market is efficient, so that the insureds and the insurers have perfect information regarding the expected loss and the risk of any policy, and they can easily access the entire market. Under these conditions there exists an equilibrium risk load for each policy; this is the market risk load (Zhang 2006).

'The real insurance market has inadequate competition and efficiency' (Zhang 2006, p. 506). The insureds do not have sufficient information about price, so they may not find the lowest one (Strauss & Hollis 2007). Insurers are limited by underwriting expertise and regulation, so they only write a few business lines and charge non-competitive rates. Besides, without a frictionless trading mechanism, it is not possible to reach equilibrium prices. Nevertheless, the market risk load is still a useful concept.

When comparing the Biodiversity Conservation Fund with an insurance company, a naive expectation is that the BCF will operate fully as an insurance company or an investment fund, under the same conditions and assumptions. While the general service is similar, the institutional framework under which the service is provided is different.

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[18] Although these methods are still used, they have been considered inadequate (Feldblum 1990) given the complexity of the insurance market, and some market failures that can arise due to this complexity (Strauss & Hollis 2007; Zhang 2006).

[19] In 1990 Harry M Markowitz, one of the founders of modern portfolio theory, received the Nobel Prize for Economics for his work. This author introduced the concept of risk into portfolio theory. Not only the expected return but also the risk of an investment becomes a decision criterion. In modern portfolio theory, the standard deviation of the annual return has established itself as a measure of risk. This statistical term expresses the average deviation of an expected value (Ufer 1996).

For instance, in the case of a large risk, an insurer has three options: 1) decline the application, 2) seek reinsurance, or 3) charge a 'risk load'; while the BCT has only two options: 1) seek reinsurance, or 2) charge a 'risk load'. Under the current legislation[20], the BCT should accept all types of offset obligation payments, since it aims to provide a more certain way for many proponents to meet their obligations.

The number of participants is another important difference between these markets, whether insurance or the BOS. While in the first market there are several insurers and insureds, the BOS has a relatively large number of 'insureds', but only one 'insurer' (the BCF)[21].

Furthermore, the insurance market manages the risk in a more flexible way since the premium and risk loading are paid on a regular basis (e.g. monthly) and can vary according to the annual risk assessment (each time the insured renews a contract). On the other hand, the management of risk by the BCT is more restrictive since the developer deposits into the BCF a single payment.

4.5.4 The Biodiversity Offsets Payment Calculator risk premium model

The Biodiversity Offsets Payment Calculator (BOPC) will determine how much a proponent must pay into the BCF to meet an offset obligation, thereby transferring the responsibility for finding offsets to the BCT.

The BOPC aims to predict the cost of securing credits for offsets but it does not do this with 100% accuracy because it uses a 'line-of-best-fit' based on historical credit trading, and is based on incomplete, sparse market information. Based on equation (25), it is expected that the BOPC may sometimes under or overestimate the credit price, creating the risk that the BCT will make a loss/profit.

Given the premium principles described in previous sections, a response to this sort of market risk is to apply a risk loading premium to estimated prices to avoid persistent losses and insolvency. For the BCT, the acceptable level of risk loading in the BOPC will determine how much risk it bears compared with the proponent paying into the fund.

We aim to estimate and manage such a market risk, setting up a risk premium to ensure the BCF remains solvent. To prevent insolvency, the available capital of the fund must cover unexpected losses to a high degree of confidence.

4.5.5 The risk premium for ecosystem credits

The individual risk (Feldblum 1990) premium for ecosystem credits is estimated based on the risk measure for the standard deviation premium principle (Hardy 2006). Therefore, we are interested in a statistical measure of possible losses, given that the model in equation (44) underestimated the credit price for the offset trading group.

In equation (44), let $w = p - \boldsymbol{x}'\boldsymbol{\beta} - \varepsilon > \mathbf{0}$ (the model underestimates the credit price); therefore, from equation (51), the total risk premium that any proponent should have to pay to the BCF equals the expected loss plus an additional risk loading to cover any unanticipated credit price movements, which is proportional to the standard deviation of the random variable w, where

[20] *Biodiversity Conservation Act 2016*, Division 6 Payment into Biodiversity Conservation Fund as alternative to retirement of biodiversity credits.

[21] A further paper from Department of Planning, Industry and Environment Economic and Strategic Analysis will address the monopolistic influence of the BCT on the BOS.

$$\mathcal{H}(W) = E(W) + \phi\sqrt{V(W)}\,for\ some\ \phi \geq 0 \tag{52}$$

In equation (52), the aversion parameter $\phi > 0$ should hold, to avoid getting ruined with probability 1 (Kaas et al. 2008). The parameter of risk aversion contains all relevant information about the BCF attitudes towards risk.

In economics and finance, utility functions are ideal tools for calculating risk aversion parameters, since they are the mathematical equivalent of the 'attitude towards risk' (Feldblum 1990). In this sense, the fund's utility function depends upon its degree of risk aversion, the composition of its biodiversity credits securing portfolio, and its corporate wealth. Based on the above, during the first financial year we set $\phi = 1.96$, which corresponds to the 95% confidence interval of the random variable X. As the BCF prepares its annual plan before the end of the first financial year, it will be in a position to assess whether its 'attitude towards risk' needs to be updated at the commencement of the second financial year, based on its financial outcomes related to biodiversity credit securing activity.

The risk premium per credit for ecosystem *i* expressed as a proportion of the weighted average predicted credit price is as in equation (55):

$$Risk\ premium_i = \frac{\mathcal{H}(X_i)}{E(\widehat{p_i})} \tag{53}$$

where $\widehat{p_i} = weighted\ average\ predicted\ credit\ price\ for\ ecosystem\ i.$

4.5.6 The standard method

This standard method identifies a baseline credit price using the weighted average price of trades for PCTs identified for the offset trading group using the trading group pricing rules. The market and dynamic coefficients are then applied to determine the predicted BBAM credit price.

The standard method incorporates four factors within the BOPC:

1. Trading groups – to acknowledge that credits within the same trading groups should be priced consistently to reflect the operation of the BAM. Based on results from the econometric model, we use new market and dynamic coefficients estimated based on offset trading groups.
2. Change in discount rate – to account for the change in discount rate in November 2018 from 3.5% to 2.6%, which results in a total fund deposit increase of ~30%.
3. Credit equivalence – to account for fewer credits being generated under the BAM compared to the BBAM.
4. Change in market demand/supply – a shift of both supply/demand curves that is derived from the proportional change in the ratio of BAM/BBAM equivalence for credit demand and credit supply.
5. The predicted credit price is based on actual trade data for the trading group. The following steps were applied:
    a. Identify the PCT ID by trading group.
    b. If the market price of a credit is available (actual trade data), we use it as a baseline price and estimate the credit price for BAM credits based on the credit equivalence and the change in market demand/supply.
    c. **(Not implemented in this version)** If the market price is unknown because no trade has been recorded, but both TFD and the variation in the number of BAM credits are

known, i.e. credits have been created but not traded, then we can estimate the credit price for BAM credits[22].

d. Estimate the weighted average trade data of all trades for the PCT's trading group.
e. If no trades for the trading group, then all trades form broader groupings in accordance with the BAM 'like-for-like' and variation rules (i.e. offset price rules).

6. The credit equivalence for the supply of credits is explicitly incorporated into the methodology in addition to the expected change in the market demand/supply curve.

Table 4 outlines the steps in calculating the developer charge based on the standard method.

Table 4 Steps in calculating the developer charge based on the standard method

Steps		Calculation
Predicted BBAM credit price		
A	Weighted average trade data of all trades for the PCT's trading group If no trades for the trading group, then all trades form broader groupings in accordance with the BAM 'like-for-like' and variation rules	Based on Section 4.4 of this technical report
B	Derive new market and dynamic coefficients for all BBAM trade data for the trading group	Based on Section 4.4 of this technical report
C	Apply the coefficients to determine the predicted BBAM credit price	Based on Section 4.4 of this technical report
Discount rate adjustment		
D	Identify the average Part A cost per credit for the trading group (i.e. the total TFD and total number of BBAM credits created for all biobank sites that contain PCTs in the trading group)	= TFD/# BBAM credits
E	Determine the Part A portion of the predicted credit price	= D/C
F	Identify the discount rate adjustment	
G	Calculate the 'predicted BBAM credit price with discount rate adjustment' (i.e. the Part A portion of the predicted credit price is multiplied by the DR adjustment. The Part A portion is added to this amount)	= (Part A with DR adjustment) + (Part B) = (C x E x F) + (C x (1 – E))
H	**Predicted BBAM credit price with discount rate adjustment**	= G
Inclusion of credit equivalence		
I	Identify the credit equivalence for credit supply using data for the trading group (i.e. the weighted average of the equivalence ratios issued by the Department for all vegetation zones at biobank sites that contain PCTs within the trading group)	= BAM/BBAM at biobank sites
J	Calculate the 'predicted BAM credit price'	= H/I
K	**Predicted BAM credit price with discount rate adjustment**	= J
Inclusion of market demand/supply adjustment		

[22] This step is based on the financial model described in Section 3.

L	Identify the credit equivalence for credit demand using data for the trading group (i.e. the weighted average of the equivalence ratios issued by the Department for all vegetation zones at development sites that contain PCTs within the trading group)	= BAM/BBAM at development sites
M	Identify the equivalence ratio for credit supply using data for the trading group (i.e. the weighted average of the equivalence ratios issued by the Department for all vegetation zones at biobank sites that contain PCTs within the trading group)	= BAM/BBAM at biobank sites = I
N	Calculate the market demand/supply adjustment factor	= L/M
O	**Predicted BAM credit price with discount rate adjustment AND market demand/supply adjustment**	= K x N
Risk premium		
P	Identify the risk premium	Based on equation (53)
Administration fee		
Q	Identify the administration fee	4% (determined by the BCT)
BOPC developer charge		
R	Calculate the developer charge	= O x (1 + P + Q)

5. The pricing model for species credits

This section will be included in a future version of the methodology report.

6. Assumptions

1. There is no change in the market dynamic, therefore, new parameters can be estimated by offset trading group using the dynamic panel data model.
2. As more trades under BAM happen, the model will be updated.
3. There is no change in the market risk, and the probabilistic model for the risk premium charge will respond to the new parameters based on the offset trading groups.
4. The adjustment methodology factor is applied based on the proportional change in the ratio of the elasticities of supply and demand, derived by the BBAM→BAM equivalence method.
5. There is no change in the ‘revealed’ preference for profits by landholders (or credit holders).
6. The cost per credit (unit cost) is equal for all types of ecosystems created by offset site.
7. In this version of the methodology, the total cost depends exclusively on the number of ecosystem credits created.
8. The number of species credits will be included in an upgraded version.

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NSW GOVERNMENT

Biodiversity Offset Payment Calculator

Version: 1.3.4.0
Last updated: 31/10/2018 15:34

Credit Offset Payment Calculator | Payments

Message!

If you would like to meet your offset obligation by making a payment to the Biodiversity Conservation Fund, please contact the BCT team at **bct@environment.nsw.gov.au**

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

IBRA sub region	PCT common name	Baseline price per credit	Dynamic coefficient	Market coefficient	Risk premium	Administrative cost	Methodology adjustment factor	Price per credit	No. of ecosystem credits	Final credits price
Cumberland	849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion *Note: This PCT has trades recorded*	$25,000.00	0.10629	8.783987	33.10%	$49.80	1.0000	$25,545.81	1	$25,545.81
Cumberland	835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion *Note: This PCT has trades recorded*	$17,500.00	0.5745632	4.072131	25.40%	$41.82	1.0000	$20,211.32	1	$20,211.32
Cumberland	725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion *Warning: This PCT has NO trades recorded*	$18,923.39	0.8611916	1.298759	33.10%	$45.96	1.0000	$23,571.38	1	$23,571.38
									Subtotal (excl. GST)	**$69,328.51**
									GST	**$6,932.85**
									Total ecosystem credits (incl. GST)	**$76,261.36**

Calculated as on: **06-11-2018 18:39:16**

Grand total **$76,261.36**