# The NSW Environmental Services Scheme: Results for the biodiversity benefits index, lessons learned, and the way forward

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**Summary** In 2002 the Environmental Services Scheme (ESS) was launched in New South Wales, Australia. Its aim was to pilot a process to provide financial incentives to landholders to undertake changes in land use or land management that improved the status of environmental services (e.g. provision of clean water, healthy soils, biodiversity conservation). To guide the direction of incentive funds, metrics were developed for use by departmental staff to score the benefits of land use or land management changes to a range of environmental services. The purpose of this paper is to (i) report on the development of one of these metrics – the biodiversity benefits index; (ii) present the data generated by field application of the metric to 20 properties contracted to the ESS; and (iii) discuss the lessons learned and recent developments of the metric that aim to make it accessible to a wider range of end-users and applications.

**Key words:** *biodiversity benefits index, biodiversity conservation, environmental services, incentives, land use change.*

## Introduction

In June 2002, the then Minister for Land and Water Conservation in New South Wales launched Australia's first Environmental Services Scheme (ESS; NSW Government 2002). Its aim was to pilot a process to provide financial incentives to landholders to undertake changes in land use or land management that improved the status of environmental services (e.g. provision of clean water, healthy soils, biodiversity conservation; DIPNR 2002; DPI 2004). This scheme was a pioneering trial for Australia because: (i) it supported a wide range of restorative land use changes and management actions across a range of pilot properties throughout NSW (Box 1, Fig. 1) and (ii) potential environmental benefits were predicted for a wide range of environmental services (Box 2).

Implementation of the ESS required the development of approaches for (i) measuring the status of an environmental service under different land uses, (ii) predicting the potential change in status following land use or management change, and (iii) combining these assessments into a metric that reflected the benefit to an

**Box 1.** Land use and management changes supported by the New South Wales Environmental Services Scheme

- Establishing deep-rooted exotic or native perennial pastures on land previously used for cropping or annual pastures
- Improving the management of existing exotic or native perennial pastures (e.g. through strategic grazing management)
- Establishing commercial plantings (e.g. tree-lots, plantations) of exotic or native trees and/or shrubs (including saltbush)
- Establishing environmental plantings (e.g. rehabilitation, restoration) of native trees and/or shrubs
- Undertaking activities to aid the regeneration of existing native vegetation
- Engineering works (such as earthworks to control run-off or drainage)*
- Reintroduction of natural wetting or drying cycles in former wetlands or estuarine areas*

*These land use changes were largely restricted to the management of acid-sulphate soils in coastal environments (see Grieve & Uebel 2003).

**Figure 1.** Location of properties contracted to the NSW Environmental Services Scheme.

**Box 2.** Metrics were developed to score land use change or land management change-derived benefits to the following environmental services

- Reducing the mobilization of salt
- Reducing the export of products from acid sulphate soils
- Reducing soil loss
- Improving water quality
- Reducing greenhouse gasses
- Enhancing biodiversity

environmental service of the land use or management change. Metrics needed to provide a measure at a property level that could be related to the environmental service at a catchment or regional scale. They needed to be simple to understand, cheap to measure and reliable. They also needed to be capable of being combined into a single environmental benefits index that summarized the combined benefits to a range of environmental services from a range of land use or management changes on a property. With these criteria in mind six environmental services benefit metrics were developed (Box 2) and subsequently used to rank applications from landholders interested in becoming part of the NSW ESS (see Grieve & Uebel 2003).

The purpose of this paper is threefold: (i) to report on the development of one of these metrics – the biodiversity benefits index; (ii) to present the data generated by field application of the metric to 20 properties contracted to the NSW ESS; and (iii) to discuss the lessons learned and recent developments of the metric that aim to make it accessible to a wider range of end-users and applications.

## Methods

### Development of the biodiversity benefits index

A Technical Advisory Group (TAG) was established in early 2002 to guide the development of a metric for scoring the benefits to biodiversity of restorative land use or land management change. The TAG was comprised of individuals experienced in incentive schemes, biodiversity assessment and/or vegetation management. The purpose of the metric was to focus on terrestrial species-level biodiversity and be relevant to a broad range of terrestrial flora and fauna. That is, it did not focus on individual (rare or threatened) species or aquatic systems. The TAG resolved to adopt, as templates, the *Habitat Hectares* (Parkes *et al.* 2003) and *BushTender* approaches pioneered in Victoria for remnant vegetation (see DSE 2004), but also recognized the need for modifications because of the broader range of current and proposed land uses applicable to the NSW ESS.

The first requirement for the biodiversity benefits index was to develop a measure of a site's biodiversity value under current land use. Biodiversity value was defined as the degree to which the site was likely to contribute to the conservation of native plants and animals at the scale of bioregions. Because complete species inventories do not exist for any site on Earth let alone sites under application for incentive funding, the TAG resolved that biodiversity value should be based on three surrogate measures of species-level biodiversity: landscape context, conservation significance, and vegetation condition (see Oliver 2003 and Parkes *et al*. 2003 for further introductory discussion of these surrogates).

Landscape context assessment scores the biodiversity value of the site according to its size and location in the wider landscape. Small sites surrounded by intensive agriculture score poorly whereas large patches of native vegetation score highly because they satisfy the habitat requirements of more species and are less susceptible to negative impacts from the surrounding agricultural landscape (e.g. weed invasion, agricultural spray-drift and eutrofication). In addition, areas closer to large patches of native vegetation score highly because of the site's proximity to source populations and other critical resources. Landscape context assessment was based on Parkes *et al*. (2003) but added a 'site context' component designed to encourage landholders to undertake land use or management changes in areas that would provide maximum biodiversity benefit (Table 1). Because landscape context scores the biodiversity value of the location of an area given the surrounding landscape, non-native vegetation (see Native Vegetation Conservation Act 1997) still scored for landscape context.

**Table 1.** Landscape context assessment*

| | Maximum score |
|---|---|
| Regional context (biodiversity priority areas, regional corridors, etc.) | 10 |
| Local context: | |
| area of patch of native vegetation of which assessment area is part | 25 |
| native vegetation within the neighbourhoods 100, 1000, 10 000 ha | 25 |
| distance to core area of native vegetation patch greater than 50 ha | 10 |
| Site context: | |
| assessment area is adjacent to existing remnant | 6 |
| assessment area connects two or more remnants | 6 |
| assessment area incorporates a riparian zone | 6 |
| assessment area contains large trees | 6 |
| assessment area has a large area to perimeter ratio | 6 |

*Modified from Parkes *et al*. (2003), see Oliver and Parkes (2003) for full details.

**Table 2.** Conservation significance assessment*

| Decline in preclearing distribution | Category | Score |
|---|---|---|
| | Non-native vegetation | 0 |
| < 30% | Native – least concern | 20 |
| 30–50% | Native – near threatened | 40 |
| 50–70% | Native – vulnerable | 60 |
| 70–90% | Native – endangered | 80 |
| > 90% | Native – critically endangered/ presumed extinct | 100 |

*see Oliver and Parkes (2003) for full details.

Conservation significance assessment scores the biodiversity value of a site in a regional context. For example, some sites may contain species that are common within the landscape, whereas others may contain species that are now rare and/or vulnerable. Although far from perfect, vegetation types were selected as the operational surrogate for the spatial distribution of species throughout regions (Saunders *et al*. 1998). Assessment was based on the amount of each vegetation type in the landscape compared with a time prior to agricultural development, as well as the likelihood of the vegetation type persisting under current pressures. Vegetation types that have been heavily cleared, or for which extent or condition is declining, were scored higher for conservation significance. Conservation significance categories (Table 2) were based on those used within the NSW Vegetation Classification Database (John Benson, pers. comm., 2002). Non-native vegetation did not score for conservation significance.

Vegetation condition assessment aimed to score the degree to which critical habitat components and other resources needed by native plants and animals were present at the site. A vegetation condition score was derived by comparing the status of vegetation condition attributes (Table 3) against a vegetation condition benchmark representing the average characteristics of a mature and apparently long undisturbed stand of the same vegetation type (see Parkes *et al*. 2003). Vegetation condition assessment was based on Parkes *et al*. (2003) but required a number of modifications because of the broader range of current and proposed land uses applicable to the NSW ESS (see Oliver & Parkes 2003: 12).

The first component of the biodiversity benefits metric therefore aimed to score the current biodiversity value of the site by combining landscape context (LC), conservation significance (CS) and vegetation condition (VC) into the Biodiversity Significance Score (BSS), where $BSS = VC(LC + CS)/200$. Vegetation condition was included as a multiplier to reflect the opinion of the TAG that this component contributes most to the biodiversity value of a site. The authors acknowledge that although the components of the BSS were based on sound ecological principles the construction of the score was based on expert opinion. The aim was to generate scores (in the range 0–100) that would be considered by end-users to reasonably reflect the biodiversity value

**Table 3.** Vegetation condition assessment*

| | Maximum score |
|---|---|
| Richness of benchmarked plant groups (20 × 20 m plot for ground cover, 20 × 50 m plot for woody vegetation) | 25 |
| Cover of benchmarked plant groups (20 × 20 m plot for ground cover, 20 × 50 m plot for woody vegetation) | 20 |
| Evidence of woody species recruitment (per 20 × 50 m plot) | 10 |
| Percentage cover of exotic ground cover species (per 20 × 20 m plot) | 15 |
| Percentage cover of organic litter (per 20 × 20 m plot) | 5 |
| Density of large trees (per ha) | 15 |
| Density of hollow-bearing trees (per ha) | 5 |
| Wood load (lineal metres of logs per ha) | 5 |

*Modified from Parkes *et al*. (2003), see Oliver and Parkes (2003) for full details.

of sites ranging from, for example, fallow paddocks with large scattered trees to remnant vegetation of high conservation value. We present the data here for consideration by readers and welcome feedback on the degree to which we have achieved this aim.

The second requirement for the biodiversity benefits index was a measure of the magnitude and direction of change in biodiversity value likely to result from land use or management change after a specified number of years. The Land Use Change Impact Score (LUCIS) was constructed to achieve this aim and was based on the differences between current and potential future vegetation condition, and current and future conservation significance, where LUCIS = $(VC_{t1} - VC_{t0} + CS_{t1} - CS_{t0})/2$. Conservation significance only affected the LUCIS when non-native vegetation (CS = 0) was replaced by native vegetation (CS = 20–100, see Table 2). The Biodiversity Benefits Index (BBI) was calculated as the products of these two scores and the area of land use or management change. The TAG considered it important to construct the BBI from both the current biodiversity value (BSS) and the change in biodiversity value (LUCIS) to recognize the importance to biodiversity conservation outcomes of starting conditions. That is, given the same magnitude of change, the biodiversity outcome (benefit) is likely to be greater for an ecosystem that is less degraded (and therefore more resilient) compared with one that is more degraded.

## Field application of the biodiversity benefits index

Field application of the biodiversity benefits index was undertaken on 20 properties (Fig. 1) contracted to the NSW ESS with the assistance of local vegetation management personnel from the then NSW Department of Land and Water Conservation. Field application required the stratification of each property into management units, assessment units and then survey plots and transects. Landscape context, conservation significance and vegetation condition data were collected for the three strata, respectively. The stratification process is discussed below and presented as an information flow chart in Figure 2.

Landscape context assessment used aerial photograph interpretation and field data (Table 1) and was undertaken for 75 management units across the 20 properties. A management unit was an area within a property defined by a similar management history, under the same current land use and to which the same restorative land use or management change would be applied. Conservation significance assessment was based on local expertise regarding the extent of clearing of the vegetation types within the region (Table 2). It was undertaken for 83 assessment units across the 20 properties. An assessment unit was an area defined by the same vegetation type within a management unit, so where a management unit contained two vegetation types, two assessment units were required.

Vegetation condition assessment was based on field data (Table 3) related to vegetation condition benchmarks. Prior to field assessment, the authors (Ede, Hawes and Oliver) developed six vegetation condition benchmarks expected to cover the range of vegetation types likely to be encountered. These were based on field experience, expert opinion and field trials.

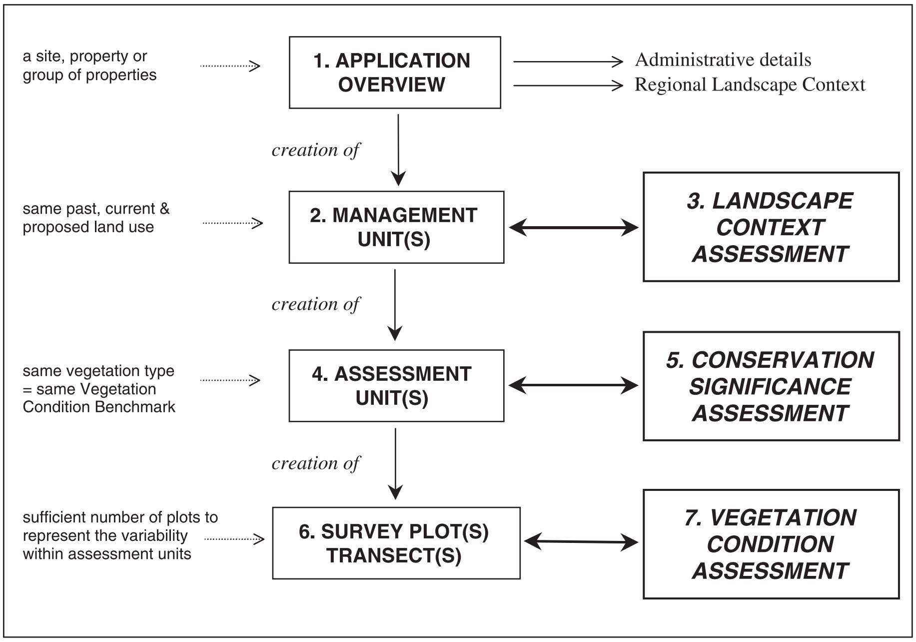

**Figure 2.** Overview of the steps involved in the stratification of each property and the data collected within each stratum.

They used broad vegetation type classifications, a data range rather than a single value for several condition categories, and provided for both a reduction in condition status for over-dense strata (e.g. for 'regrowth' or 'woody weeds'), and the existence of biological thresholds in condition status (see Appendix I). Particular benchmarks were applied on-site on the basis of the plant species and strata present in the assessment unit, the landscape position and the soil type. Vegetation condition benchmarks were applied at 114 survey plots/transects across the 20 properties. All assessment units contained at least one survey plot of dimension 20 × 20 m for herbaceous species and 20 × 50 m for woody species richness and cover, and one 1-ha transect for sparse condition attributes (see Table 3). Assessment units contained more than one survey plot when the assessment unit was large (> 100 ha) or contained obvious variation in vegetation condition status. For full details of vegetation condition and all other score calculations see Oliver and Parkes (2003).

Data generated by the above assessment steps were combined to generate the BSS. The local vegetation management personnel were also responsible for generating the LUCIS by predicting (on the basis of expert opinion) the potential future condition class of each vegetation condition attribute likely to result from a specified land use or management change over the 5-year contract period 2003–2008. Data for each survey plot/transect, assessment unit and management unit (and their size in hectares) for each property were entered into an Excel workbook (Oliver 2004; Oliver & Peterson 2004) to calculate the BBI for each management unit and the total BBI for the property.

### Data analysis

Data are presented as Tukey's box plots that show the median as a horizontal line within a box bounded by the upper and lower quartiles (interquartile range) and thus contain 50% of the data. The box appendages or whiskers encode the *adjacent values*. The upper *adjacent value* is the largest observation that is less than or equal to the upper quartile plus 1.5 times the interquartile range (similarly for the lower adjacent value). *Outside values* or outliers are values beyond the *adjacent values* and are plotted individually (Cleveland 1993). Data for the BSS and its component parts were grouped by land use/cover type as either; cropping or annual pasture (< 50% of the cover of groundcover vegetation comprised of native species), derived native grassland (< 10% tree canopy cover), or remnant woodland (> 10% tree canopy cover). Local vegetation management personnel considered all native grassland sites to be derived native grassland, that is, trees had been cleared in the past. Woodland benchmarks were therefore considered appropriate to all sites. Data for the LUCIS and the BBI were grouped by land use or land management change.

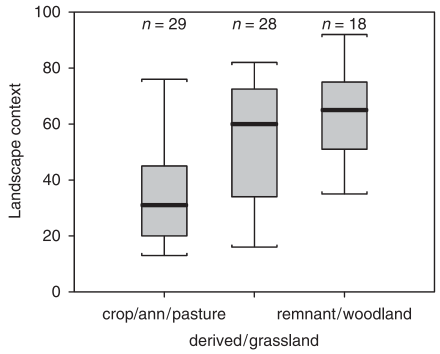

**Figure 3.** Landscape context (LC) assessment results grouped by current land use/cover (number of management units shown, values can take the range 0–100). Tukey's box plots show the median (horizontal bold line), interquartile range (box containing 50% of the data), adjacent values (whiskers), and outside values (open circles, see Methods).

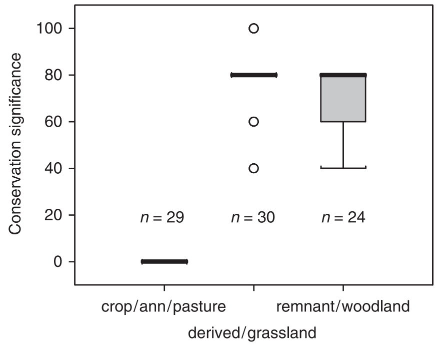

**Figure 4.** Conservation significance (CS) assessment results grouped by current land use/cover. Number of assessment units shown, values can take the range 0–100.

## Results

### Landscape context, conservation significance and vegetation condition scores

With prior compilation of aerial photographs by regional staff (either as hard copy or as ortho-rectified images in geographical information systems), regional and local landscape context assessment was office-based and took less than 5 min per management unit (see Table 1). Site-level landscape context assessment was undertaken for 75 management units (range 2–5 per property) and also took less than 5 min per management unit. Median landscape context values were similar for derived native grassland and remnant woodlands (~65/100) but the interquartile range (50% of values) was smaller and contained higher values for the remnant woodland sites (Fig. 3). Although the full distribution of values for cropping and annual exotic pasture showed a large overlap with the other two land uses, the interquartile range for this land use/cover contained much lower values with a median score around 30. Importantly, these results showed that regardless of current land use/cover, scores for LC varied widely.

Conservation significance assessment was undertaken for 83 assessment units (range 2–7 per property) and was based on the expert opinion of clearing status of the vegetation type within the assessment unit (Fig. 4). Twenty-nine assessment units were in areas under crop or sown to exotic annual pastures and received a score of zero because they were dominated by non-native vegetation. The median score for derived native grassland and remnant woodland was equal at 80/100. In fact, 18 of the 30 derived native grassland sites received a score of 80 so that the interquartile range and adjacent values were all represented by a score of 80. However with five scores of 100/100 and fewer low scores, the conservation significance was, on average, higher for the derived native grassland sites than the remnant woodland sites. This finding was largely due to the derived grassland sites occupying low-lying fertile soils where vegetation has generally been extensively cleared.

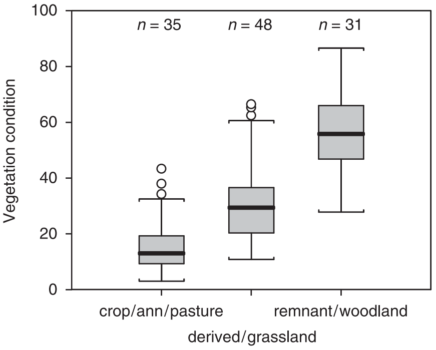

**Figure 5.** Vegetation condition (VC) assessment results grouped by current land use/cover. Number of survey plots shown, values can take the range 0–100.

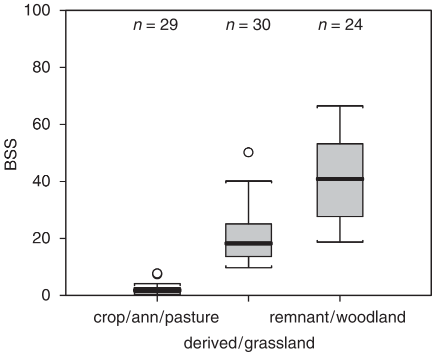

**Figure 6.** Biodiversity Significance Scores (BSS) grouped by current land use/cover. Number of assessment units shown, values can take the range 0–100 and = VC(LC + CS)/200).

Vegetation condition assessment was undertaken on-site for 114 survey plots/transects (range 2–11 per property) and was generally completed within 15–30 min per survey plot/transect. Current land use/cover clearly affected the score with the lowest values for cropping and exotic annual pasture, intermediate scores for derived native grassland, and the highest scores observed for remnant woodlands (Fig. 5). Positive scores for the cropping and exotic annual pastures were due to the presence of large, hollow-bearing trees in some of these systems; many exotic pastures still contained native ground-cover species in low cover/abundance; and some vegetation condition benchmarks were developed such that absence of a stratum (e.g. because of seasonal dynamics) did not necessarily result in a zero score for that stratum (see Appendix). The majority of the scores for derived grassland fell within the range 20–40 because of the low richness and cover of woody vegetation elements, and low density of tree hollows and logs. Scores for remnant woodlands revealed a very large range in condition status with several very high scores and several remnants receiving a lower condition score than derived native grassland and exotic pasture sites.

## Biodiversity significance scores, land use change impact scores, and the biodiversity benefits index

The BSS, which aimed to score the current biodiversity value of the areas to which land use or management changes would be applied, suggested that land under crop or sown to exotic annual pasture was likely to contribute little to biodiversity conservation (Fig. 6). However, these data did have a distribution of values showing that even for this land use, the BSS discriminated among assessment units. Similarly, a distribution of values was observed for derived native grassland and remnant woodland assessment units, but these data clearly showed that the majority of woodland patches were scored as contributing more to biodiversity conservation than derived native grassland.

Evidence of the magnitude and direction of change in biodiversity value due to land use or management change was revealed by the LUCIS (Fig. 7). The score was highest when restoring native vegetation to those areas classed as non-native vegetation (for example, a change from *crops or annual pastures* to *commercial plantations* (of native species); *environmental plantings*; or *native perennial pastures* (one site only, Fig. 7)). Scores were low for all other land use changes because of minimal predicted improvements in vegetation condition over the short contract period (5 years). Two small negative values for LUCIS (−1.5, −2.8) were reported for the land use change *improved management of existing perennial pastures* (Fig. 7, grass->imp). The first negative score was due to a predicted increase in weed cover and a reduction in native forb richness due to planned fertilizer application, the second resulted from the proposed planting of exotic pasture species within existing derived native grassland.

The effect of these two small negative scores for the LUCIS multiplied by moderate scores for BSS (34, 27) and large assessment unit areas (305, 67 ha, respectively) resulted in two large negative BBIs for the land management change *improved management of existing perennial pastures*

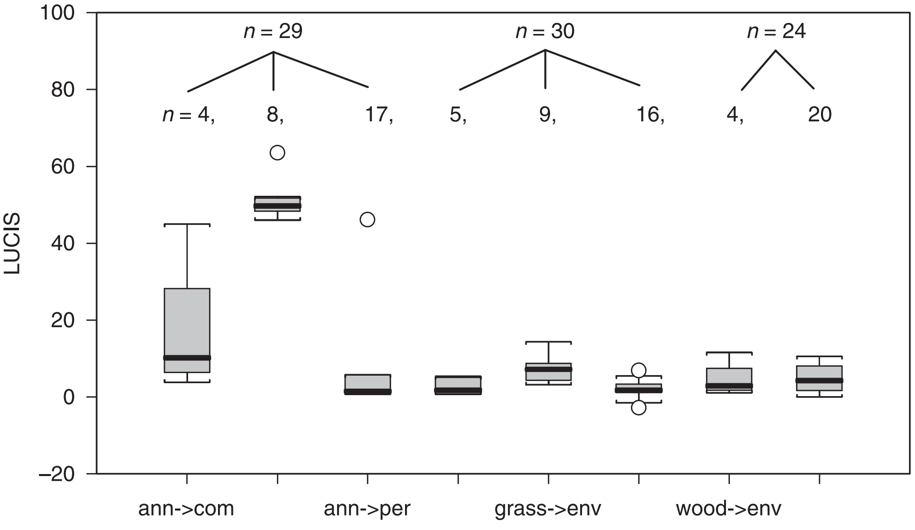

**Figure 7.** Land Use Change Impact Scores (LUCIS) grouped by land use/management change. Ann, crop/annual pasture; grass, derived native grassland; wood, remnant woodland; com, commercial plantation; env, environmental planting; per, perennial pasture/grassland; imp, improved management of existing derived native grassland; regen, regeneration of existing remnant woodland; number of assessment units shown; values can take the range 0–100 and = ($VC_{t1} - VC_{t0} + CS_{t1} - CS_{t0}$)/2.

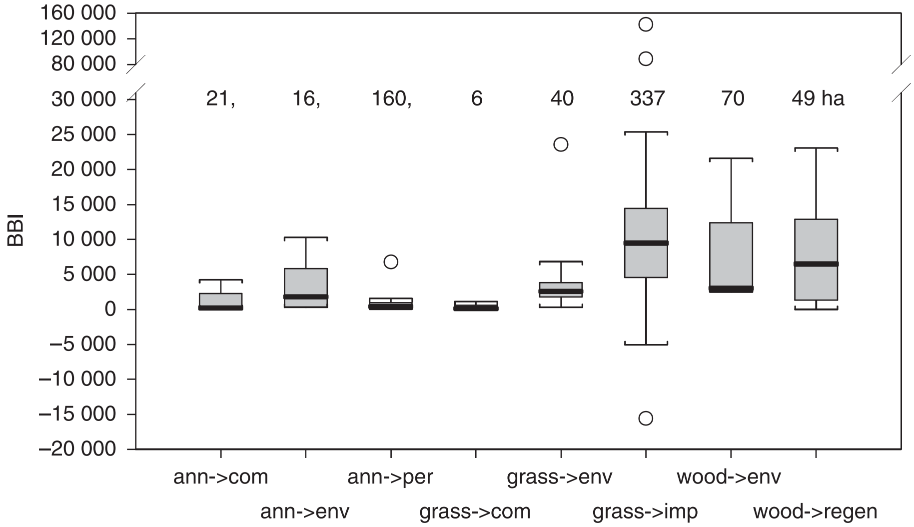

**Figure 8.** Biodiversity Benefits Index (BBI) grouped by land use/management change. Average area of assessment units are shown, values are unbounded and = BSS × LUCIS × Ha.

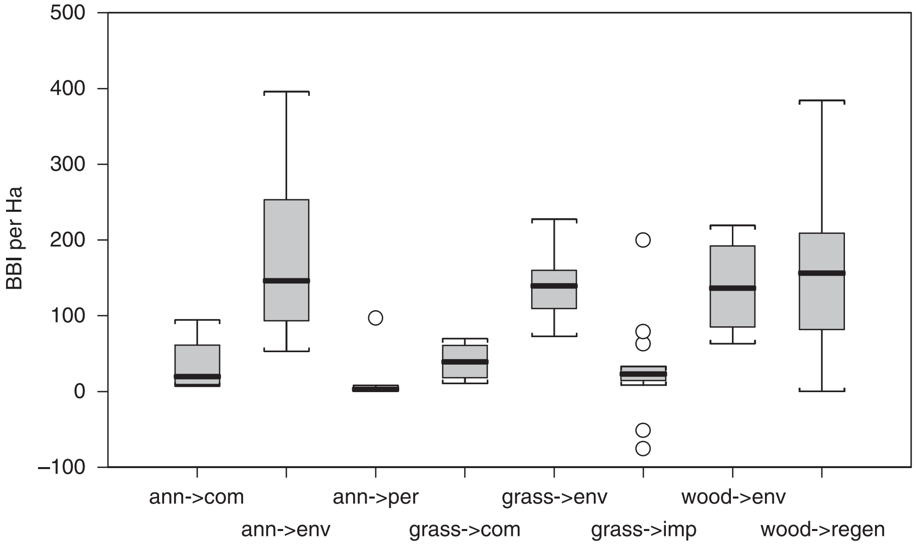

**Figure 9.** Biodiversity Benefits Index (BBI) per hectare grouped by land use/management change. Values are unbounded and = BSS × LUCIS.

(Fig. 8, grass->imp). In two separate proposals, very high BBIs resulted for this land management change when relatively large BSS (50, 40), LUCIS (7, 5), and large management unit areas (441, 445 ha, respectively) were multiplied together. Incorporating area as a multiplier within the BBI considerably increased the range of scores for this often extensive land management change (Fig. 8). Regeneration of woodland and environmental planting within woodland remnants also scored well, the highly skewed distribution for the latter land use change because of the skewed distribution of assessment unit areas (13, 15, 50, 200 ha).

Given the important influence of area as a multiplier in the BBI metric, we also analysed data for the BBI per hectare (Fig. 9). Comparison of these two figures revealed that the relative importance of the land use/management change, *improved management of existing perennial pastures* was much lower on a per-hectare basis; *establishing commercial plantations* (which included exotic trees, native trees and saltbush) scored favourably on a per-hectare basis compared with *conversion of annual to exotic perennial pastures* and *improved management of existing perennial pastures*; and land use change to *environmental planting* and *regeneration of woodland remnants* scored well with (Fig. 8) and without (Fig. 9) area as a multiplier.

## Discussion

The Wentworth Group of Concerned Scientists' Blueprint for a Living Continent set out five key challenges needed 'to deliver a sustainable future for our continent and its people' (Wentworth Group 2002: 4). One of these challenges was to pay farmers for the provision of environmental services. Biodiversity underpins all environmental services and is the keystone upon which a sustainable future for this continent is based (Morton *et al*. 2002; Wentworth Group 2002). Clearly, a need exists for transparent, practical and defensible approaches to assist administrators of incentive-based programs in their efforts to provide payments to landholders for the delivery of environmental services. This paper has documented the development and application of one such approach designed to: score the status of biodiversity value under different land uses; score the potential change in status following land use or management change; and combine these assessments into a metric that reflects the benefit to biodiversity conservation of land use or land management changes.

The terms of reference for the development of the biodiversity benefits index stated that it needed to be simple to understand, cheap to measure and reliable. We have previously published a user-friendly summary of the biodiversity benefits index for landholders (Oliver 2003) but welcome feedback from readers on the ecological surrogates, component scores and results presented here. The application of the BBI was relatively straightforward and affordable with all assessments (a maximum of 11 survey plots/transects per property) completed within 1 day by two personnel. Field-based application of the toolkit did, however, require experienced personnel with local vegetation management knowledge. This need may be problematical for other end-users with limited access to similarly experienced personnel. There is clearly a need to reduce the dependence on such highly skilled (and potentially expensive) field personnel, a point to which return below.

The need for reliability can also be considered as the need to minimize interoperator variability. McCarthy *et al*. (2004) and Williams (2004) raised the same concern with the *Habitat Hectares* method (Parkes *et al*. 2003) and suggested that operators may vary widely in their assessments. Interoperator variability was an inevitable consequence of the NSW ESS given the large geographic area involved and the need to employ the local skills and knowledge of experienced vegetation management personnel. Efforts to minimize interoperator variability included the use of a standard sampling protocol and the presence of one of use (Oliver) at all assessments to ensure adherence to the protocol. There are, however, three main areas where interoperator variability can affect the BBI: (i) field assessment of current vegetation condition, (ii) prediction of potential future vegetation condition, and (iii) assessment of conservation significance. Recent developments in the biodiversity benefits index methodology have sought to minimize the effects of interoperator variability and at the same time make the approach less dependant on expert field personnel and more accessible to a wider range of end-users and applications.

Our vegetation condition benchmarks aimed to minimize interoperator variability by using data ranges for the attributes, *richness* and *cover of benchmarked plant groups* (see Appendix). Earlier field trials did find that data ranges and their associated condition categories (very low to very high) provided for minimal interoperator variability (Ede & Hawes 2004 unpubl. data). However, to capitalize on the benefits provided by condition classes and data ranges we have revised our existing benchmarks so that all vegetation condition attributes are scored within the same five condition categories ranging from very low to very high. The use of data ranges for all attributes of vegetation condition will further reduce interoperator variability for this assessment component.

An additional benefit of using condition categories and the associated data ranges is that the process of vegetation condition assessment is simple to convey to landholders. For example, it is straightforward to communicate that condition scores increase from very low to very high and that, for example, perennial grass cover of 11–25% in a shrubby woodland is considered to be in moderate condition and needs to increase to greater than 40% to be considered in very high condition. Our revised benchmarks provide in one A4 page a standard set of five condition categories with their associated data ranges for each vegetation condition attribute along with a brief description of the vegetation types covered by the benchmark (available upon request from the authors for the Border Rivers/Gwydir and Namoi Catchment Management Authorities, NSW). We believe that with this simple vegetation condition benchmark approach a wide range of end-users can undertake their own condition assessments for a variety of purposes.

The second area in which interoperator variability may be a concern is the prediction of potential vegetation condition, which is required for the calculation of the LUCIS. For the NSW ESS the LUCIS was based on the knowledge and experience of the assessor. Although prediction was restricted to qualitative change in condition classes (e.g. from moderate to high condition), it remained a subjective decision. We have revised the approach so that the change in vegetation condition attributes is automated by the Excel workbook dependent on which land use change and management actions are selected by the user. Although these potential changes in condition attributes are still based on the expert opinions of the authors, they are available for scrutiny by others, they ensure repeatability of assessment, and they promise to make the tool accessible to a wide range of end-users.

The final area that required expert advice was assessment of the conservation significance of the vegetation type within the assessment unit. Recent work by the NSW Department of Environment and Conservation (DEC) to support the regulations under the NSW Native Vegetation Act 2003 may provide a solution for NSW. DEC has generated a list of approximately 1600 vegetation types for NSW and has estimated for each the percentage cleared within each Catchment Management Authority. Use of these or similar data would remove the need for expert opinion but do require the on-site identification of vegetation types, which may be problematical for less-experienced field personnel.

Based on our lessons learned through development and application of the biodiversity benefits index to the NSW ESS and the subsequent developments in the methodology we believe that the biodiversity benefits index provides a practical, transparent, repeatable and defensible tool appropriate for widespread application to biodiversity incentive schemes. Strict validation of the scores generated by the approach is currently not possible because complete biodiversity data are not available for any site on the planet. The measure of success of the biodiversity benefits index will therefore be the degree to which the approach and resultant scores are accepted as reasonable by both the scientific community, but more importantly by the administrators of incentive programs and the landholders on whose properties the approach is applied. This paper continues our efforts to make available to potential end-users sufficient information on which decisions concerning the adoption of market-based instruments for the delivery of incentive funds can be based.

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**Appendix I.** **The shrubby woodland vegetation condition benchmark used within the New South Wales Environmental Services Scheme**

| | | | | | | Over-dense | |
|---|---|---|---|---|---|---|---|
| **Cover:** | V. Low | Low | Moderate | High | V. High | High | Moderate |
| (score) | (4/20) | (8/20) | (12/20) | (16/20) | (20/20) | (16/20) | (12/20) |
| Trees | NA | 1–10 | 1–10 | 1–10 | 11–50 | 51–60 | > 60 |
| Shrubs | NA | 1–10 | 1–10 | 1–10 | 11–70 | 71–80 | > 80 |
| Forbs | 0 | 1–5 | 6–10 | 11–20 | > 20 | NA | NA |
| Perennial Grasses | 0 | 1–10 | 11–25 | 26–40 | > 40 | NA | NA |
| Others | 0 | 0 | 0 | 1–4 | > 4 | NA | NA |
| **Richness:** | V. Low | Low | Moderate | High | V. High | | |
| (score) | (5/25) | (10/25) | (15/25) | (20/25) | (25/25) | | |
| Trees | NA | NA | NA | 1 | > 1 | | |
| Shrubs | NA | NA | 1 | 2 | > 2 | | |
| Forbs | 0 | 1 | 2–4 | 5–7 | > 7 | | |
| Perennial Grasses | < 2 | 2–3 | 4–5 | 6–7 | > 7 | | |
| Others | NA | 0 | 1 | 2–3 | > 3 | | |
| **Other attributes:** | | | | | | | |
| Large tree size | 50 cm diameter at breast height | | | | | | |
| Large tree density | 10/ha | | | | | | |
| Hollow-bearing tree density | 5/ha | | | | | | |
| Coarse woody debris | 100 lineal m/ ha | | | | | | |
| Litter cover | 30% | | | | | | |

Benchmarks aim to represent the average characteristics of a mature and apparently long undisturbed stand of the same vegetation type (Parkes *et al*. 2003). Average characteristics are shown for other attributes, as single data values; and for cover and richness attributes as a data range within the very high condition category. Data ranges within condition classes were based on expert opinion and provide for flexibility in the relationship between condition category and attribute status. For example, a decline in condition category (and hence score) for over-dense tree and shrub cover is simply implemented (see over-dense columns). Condition classes also provide for known or perceived condition thresholds. For example, in this benchmark a lack of shrub cover scores zero, cover of 1–10% scores 12/20 (moderate condition) and cover of 11–70% scores 20/20 (very high condition). The authors acknowledge that the philosophy, development and application of vegetation condition benchmarks is a developing field and interested readers are directed to recent publications within *Ecological Management & Restoration* by Parkes *et al*. (2003), McCarthy *et al*. (2004) and Parkes *et al*. (2004).