Selecting and Costing a Representative Expansion of the NSW Protected Area Network

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Abstract

The conservation of biological diversity is seen as a national and an international issue of importance to Australians. This is indicated by Australia's decision to sign the Convention on Biological Diversity. However, without significant policy change to funding levels and the types of conservation mechanisms used, biological diversity values are likely to be conserved at a less than the socially optimal level implied by Australia's ratification of the convention.

Traditional approaches to meeting conservation targets have been via land acquisition and management by government, future approaches may need to include off-reserve conservation mechanisms that use a variety of economic instruments. This paper combines economic and geographical information system techniques to estimate the cost of expanding the NSW protected area network to a range of target levels with on and off-reserve mechanisms. An algorithm was developed to select areas to complement the existing conservation system and be representative of 124 environmental domain classifications. To ensure cost effectiveness, target representation levels were achieved by selection of areas in a priority order based on land use.

Results indicate that land acquisition costs of achieving a 10% level of environmental region representation in NSW are not prohibitive, in fact they may equate to something like the purchase cost of four or five F-18 fighter jets. Acquisition costs of raising the area representation of each of the defined environmental domains to 10% is estimated at $360 million. However, ongoing setup and management costs to control threats to loss of biodiversity values represent a much stronger pull on the government purse.

Acknowledgement

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Introduction

Biological Diversity and the Control of Threats

Australia is the only 'developed' nation of twelve that are classified as 'megadiverse'. They are said to be megadiverse because of the number and variety of species they contain. Australia has long been an isolated island continent, consequently it has 210 endemic mammals, 349 birds, 605 reptiles and 160 amphibians. This gives Australia top score for mammals and reptiles, the silver for birds and bronze for amphibians (Groombridge, 1992). As the only developed nation hosting such diversity we have both an obligation and a good opportunity to protect it.

As indicated in the Draft National Biodiversity Strategy (now signed by all states except WA), Australia accepted an international obligation to protect its biodiversity when it signed and ratified the Convention on Biological Diversity. The Convention came into force on 29th December 1993. Article Eight of that convention stresses the need for the protection, maintenance, rehabilitation and restoration of biodiversity. Article Eleven, as far as possible and as appropriate, urges signatories to adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity.

Biological diversity (biodiversity) describes the variability found in living organisms and natural systems. The term is often used to refer to three levels of biological organisation, either separately or in combination. Genetic diversity refers to the genetic variability within species. Species diversity describes the variety of plants, animals and micro-organisms, whilst ecosystem diversity refers to the variety of habitats, biotic communities and ecological processes. Maintaining biodiversity is seen as one of the necessary requirements to achieve ecological sustainability. It is a natural insurance policy for present and future generations.

> "Through the conservation of functional integrity, the cycle of the elements is sustained; climates remain within reasonable predictable limits; and the needs of all components of the living system are met. Disrupt ecosystems, erode their integrity, and the carrying capacity of a region is at risk" (Holgate and Giovannini, 1994, p3).

The 200 years since European settlement in Australia, has resulted in the worst record of of mammal species loss. Seventeen mammals and one reptile are recorded as known extinctions, and some 2024 plants, 38 mammals, 39 birds, nine reptiles, three amphibians and 16 fish are regarded as threatened (Groombridge, 1992). The reasons for this alarming rate of biodiversity loss and threat to further loss are several, but all relate to various aspects of human activity and land management. Processes that threaten biodiversity include habitat loss, habitat modification, loss of genetic variability within a species, and direct attacks that result in species extinction. Whilst each of these threatening processes can result in a direct loss of biodiversity they may also serve to activate one or more of the other processes.

Habitat loss caused by clearing of native vegetation for purposes of agriculture, forestry, and urban and coastal development is a major cause of biodiversity loss. A total area of about 93 million ha of Australia's forests and woodlands have been cleared, with over 5 million ha of native vegetation cleared between 1983-1993 (Glanznig, pers.com.). Habitat modification includes: the effects of overgrazing, introduced pasture and tree species, fertiliser, herbicide and pesticide application, and land and water degradation. Modification from a non-point source include: fire management, air and water pollution, fatal litter that poisons or drowns wildlife, saline and inadequate water flow into waterways, sedimentation, toxification and eutrification of waterways.

Introduced weeds and animals, as well as humans, can have a direct effect on native flora and fauna. Many native species lack adequate defence mechanisms or the competitive advantage to cope with introduced plants, mammals, birds, insects and diseases. Indeed feral foxes and cats are regarded as one of the prime causes of the extinction of small mammals. Loss of genetic variability within a species can arise as a result of selective harvesting or the escape of selectively bred native species back into the wild. It is the goal of conservation networks to guard against this range of threats. Mechanisms to do so include the dedication of conservation reserves that are managed by government, and off-reserve incentives to encourage protection and sustainable resource use on private land.

A Representative, Complementary and Adequate Network

The goal is to protect biological diversity and maintain ecological processes and systems (DEST, 1993). Traditional approaches to meeting conservation and heritage objectives have been via land acquisition and management by government. Recognition of limited government resources led planners to aim for an efficient set of conservation reserves which are expected to be representative, complementary and adequate. For a protected network to achieve its role in conserving biodiversity, the network needs to contain examples of as many species as possible (Pressey *et al.*, 1993).

When resources for acquiring and managing a network are limited, it makes sense to ensure that any new area added to the system complements rather than duplicates the biological diversity already represented. Complementarity of reserves refers to having a system of reserves which contain sub-sets of species or habitat types with minimal overlap between them. A pattern of reserve selection that exhibits complementarity will also be efficient in that a minimal number of reserves will be required to fully represent all biological elements (Pressey *et al.*, 1993). Gaps in the protected network, in terms of features protected, need to be identified and considered as priority areas for selection. Provided ranking criteria can be agreed upon, features that are not currently in protected reserve systems can be prioritised for selection.

Adequacy is a factor that remains dependant upon subjective assessment and political will or pressure. This is an unfortunate reality, scientific uncertainty still surrounds the requirements of ecological processes and the very existence of species. We still don't know for sure what is required to maintain populations and ecosystems over sufficient time to allow evolutionary processes to function. A nominal estimate of adequacy is provided by the International Union for Conservation of Nature and Natural Resources (IUCN) which indicates representation of 10% of each environmental region by area to be a minimal starting point. "Since the ecological functions of many species or populations are still only partly known, the wisest course is to apply the precautionary principle and avoid actions that needlessly reduce biodiversity" (McNeely, 1994, p10).

The traditional approach to rely on gazetted reserves to achieve this type of target is now recognised to be inadequate, it is now realised that integrated planning and land management are necessary at the bioregional level. Perspective has shifted to develop a mix of conservation mechansisms that control of threats to biodiversity loss on land off reserve as well as in traditional conservation reserves. A system of management that integrates national parks with off-reserve protection is advocated for arid Australian by Morton *et al.* (1994). Recognising the contribution that non-reserve lands can make .o the biodiversity objectives, Australian policies are being revised to e.icourage off-reserve habitat protection and change management so that resource use is sustainable.

This Paper

This paper uses NSW as a case study to evaluate the cost of expanding the terrestrial conservation network over a range of target levels of environmental region representation using a mix of conservation mechansisms. Representation levels from 2.5% to 20% of the state by area were studied, this in effect generates a cost curve for the supply of conservation. The first goal of the study was to select a representative sample of environmental regions to compleme^t those already existing within the existing reserve system. The next step was to estimate the cost of this conservation network, under conditions of acquisition and management by government, and with components he!d off-reserve and managed privately under negotiated agreements.

Easements and covenants are mechanisms for limiting the ability of landholders to exercise certain rights over their land. The details are registered on the land title and bind all succeeding owners. Management agreements are a legally binding contract, entered into for a set period of time. Under these agreements, the landholder agrees to refrain from particular activities or to undertake other activities, in return for financial rei .bursement (Colman, 1992). In most cases, management agreements only reimburse the incremental cost of protecting biodiversity that can not be recovered through the normal market process.

Off-reserve mechanisms provide an advantage in that the' may still permit other forms of land use to be undertaken in conjunction with conservation requirements. This may serve to reduce opportunity costs from enterprise foregone. Moreover, any required management activities may be undertaken at less expense by on-site landholders than by government employees. A variety of issues may however need to be considered with this regard.

A component of conservation benefits are tangible and relativley easy for economists to quantify in dollar terms, however many conservation benefits maybe classified, for instance as, option value, bequest bequest and existence value that are unpriced (Walsh, Loomis and Gillman, 1984). These unpriced benefits are not so easily quantified. This paper does not attempt to identify an optimal level of conservation, benefit from improved levels of conservation are made explicit and expressed in terms of the degree to which target levels of representation are achieved.

This paper focuses on the costs involved in providing biodiversity conservation. It does so, not with the purposes of indicating a potential burden to society but, with the assumption that society is already beginning to recognise perceived benefits and the political will to meet these obligations is in motion. We choose, instead, to reveal the nature of the costs to government of meeting its committments to construct a "complementary, representative and adequate" protected area network. Our focus is upon the improvement of information necessary for decision making.

Selecting Conservation Network Scenarios

A methodology was developed to use spatially referenced biological data, land-value data, and land-use data to select a representative conservation network that would complement existing conservation reserves. The selection criteria required discrimination of areas on the basis of threat to biodiversity loss, land tenure and land value. Threat to biodiversity loss was considered in terms of land use only. State-wide data of sufficient accuracy describing threats such as those from exotic plants and animals is unavailable.

The size and shape of any selected on or off-reserve conservation may also determine vulnerability to threats. There is a widespread belief that isolation or inadequate size of habitat may lead to loss of species (Shafer, 1990). The ongoing debate as to the advantages/disadvantages of selecting single large or several small conservation areas is recognised. The selection process aimed, where possible, to select the largest of any available area in preference. However, no strict rules are prescribed for minimum block size for particular ecosystem types. The philosophy of the approach to utilise off-reserve mechanisms is for an integrated approach to conservation rather than designating isolated islands to single use classification. It is stressed that the selection scenarios are based on state-wide data and hence, should only be regarded as indicative of the areas likely to be included in an efficiently designed conservation network.

Selection Elements

Each data set provided spatially referenced information that could be used in a Geographical Information System (GIS). Data sets were constrained by the need for a complete and unbiased coverage of all NSW. The environmental domain set (Belbin, 1993) provided a description of environmental regions, whilst the vulnerable and threatened species set (NSW NPWS, 1994) provided point data that described some sites of irreplaceable value. A description of each data set follows.

Environmental Domains

Environmental regions were defined by data describing "environmental domains" that were obtained from CSIRO Division of Wildlife and Ecology (Belbin, 1993), see Figure 1. Environmental domains are quantified by variables, such as temperature, precipitation, soil properties, slope and solar radiation. These variables are classified using ALOC (Belbin, 1987) into relatively homogenous areas which have similar bio-environmental characteristics. The number of clusters (domains) that the algorithm produces is defined by the user (Belbin, 1993). The NSW data was extracted from an Australia wide classification of 301 domains, of which 124 occurred in NSW. Conservation targets can be measured by the proportion of each domain, and the number of domain types protected within reserves or by off-reserve conservation mechanisms.

Environmental factors such as soil type, climate and topography are held to be good surrogate measures for the distribution and richness of biotic communities (Richards *et al.*, 1990). Given the limitations of species data, it may be preferable to depict a set of reserves for undisturbed examples of broad ecosystems rather than identify and protect unique habitats for specific species (Belbin, 1993). Environmental domains may be used when it is desirable to protect ecosystem function and ensure that habitats for less known taxa are protected adequately. Areas that have similar environmental characteristics are assumed to provide habitat for similar flora and fauna.

Species

The species data set (NSW NPWS, 1994) provided some 3050 points locating 145 species listed as vulnerable or threatened (VAT). Sites of recorded VAT species indicated areas that may be considered irreplaceable. Locations containing 'special' species, such as rare, endangered and threatened species, migratory species, remnant vegetation and wetlands may need to be explicitly assigned to the reserve system. Irreplaceability is defined by (Pressey *et al.*, 1993) as: the potential contribution of a site to a reservation goal, and the extent to which the options of reservation are lost if the site is lost. Irreplaceability may also be defined by degree, where the frequency of occurrence in representative combinations can be called, levels of irreplaceability (Pressey *et al.*, 1993).

Any irreplaceable location should be included in a protected network on the assumption that their exclusion from the network means that the option for protecting species present at these locations is lost. VAT species were used in this analysis to provide examples of irreplaceable sites, either absolute or by degree. Their inclusion also provide a means to check the efficiency of a system, representative for environmental domains, to include species directly.

Land Use and Land value

Two sets of digitised land-use maps provided data to describe disturbance (based on agricultural use) on private lands. One was supplied by NSW Atlas Land Use (Central Mapping Authority, 1987) and the other by the Statewide Resource Information and Accounting System (SRIAS), being developed by CSIRO Division of Wildlife and Ecology. Crown land boundaries were supplied by AUSLIG (1992) and NSW NPWS

(1994) provided an accurate description reserve boundaries managed by that authority, see Figure 2. Accurate description of flora reserve boundaries were unavailable, however the total area of flora reserves is small relative to other reserve classifications.

A land value map was developed for the project from a state-wide coverage provided by some 28,000 records describing geographically referenced unimproved land-value data (Valuer-General's Office, 1994), and limited point data describing market value (Valuer-General's Office, 1993). An R square value of 0.82 indicated a good correlation between the coverage of unimproved land-values and the market values and enabled a contour map of market values to be produced from this data.

Using the GIS Format

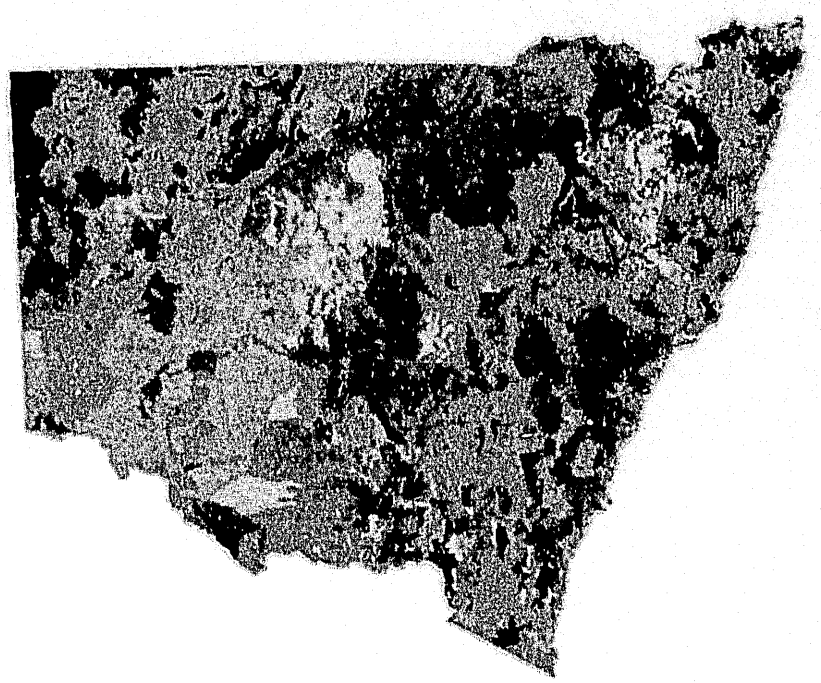
A Geographical Information System (GIS) was used to prepare the data for input into a selection algorithm. Individual data sets were formatted as maps or point data in the case of the species data, then an overlay or 'unique conditions' map was produced to show the combined set of information as one data set. The unique conditions map was produced by overlaying the landuse map, the domains map and a grid defining a block size of four minutes by four minutes and the existing reserve areas. Each grid cell would be subdivided into areas described by a combination of domain type or land-use classification. Each identifiable grid reference is linked to a description of domain type, domain area, land use, and any VAT species that maybe contained within that boundary. The species data set provided some 3050 points locating 145 species, after appending these points to the segmenting 'unique conditions' grid the sites were located within 1458 of the grid cells, of which 258 were existing reserves.

The Selection Algorithm

An algorithm was required to select representative areas to complement the existing conservation reserves with spatially referenced biological data, land-value data, and land-use data. The 'minimum set' selection algorithm developed by Margules, Nichols and Pressey (Margules et al, 1988) provided the mechanism to undertake these selections. Target representation levels were defined by the percentage of the area of each environmental domain included in the conservation network, and a number of replicate sites for each VAT species.

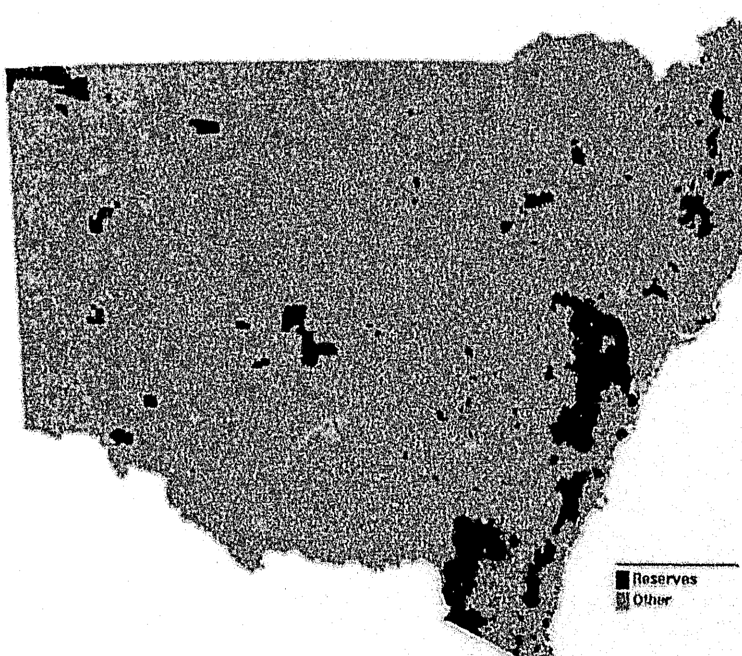
Although the algorithm succeeded in providing an approach that prioritised selections on the basis of block size and on the ability of that block to represent environmental regions and species with respect to land use/ownership, it was not however possible to select environmental domains as the basis of current land use/land ownership and cost simultaneously. Areas were selected on the ability to contribute to a representative network, the choice between allocation to on or off-reserve classification was made post the selection process. It is recognised that a variety of alternative targets may also have been applicable, for instance the inclusion of areas required to preserve viable populations or ecosystems, and irreplaceable areas required by migratory species.

Figure 1 Environmental Domains (124 Classes)



Source: CSIRO Division of Wildlife & Ecology

Figure 2 Conservation Reserves Managed by NSW NPWS (1994)



Source: NSW National Parks & Wildlife Service

Selection scenarios

Five sets of selections were undertaken to provide a comparison between the two available sets of land-use data, selection based on land-value (as opposed to land use) and to investigate the effect of including species point data. Areas were selected on the basis of either domain representation, domain and species representation, or species only representation. Environmental domains were selected, to complement those contained within existing reserves, at levels ranging from 2.5% by area to 20%, with 2.5% increments. Species representation was based on the number of replicate sites for each VAT species. Selection were based on;

1) environmental domains, five sites (if possible) for each vulnerable or threatened species, and the NSW Atlas land use classification. Where the NSW Atlas Land-use map was used, environmental domains were selected in order of decreasing priority from areas defined by this map as; existing reserves, forest reserves, other crown lands, limited grazing, grazing of native/improved pastures and intensive agriculture,

2) environmental domains and the NSW Atlas land use classification,

3) environmental domains and land market value classification,

4) environmental domains and the SRIAS land use classification. Where the SRIAS Land-use map was used, environmental domains were selected in order of decreasing priority from areas defined by this map as; existing reserves, forest reserves, other crown lands, residual, grazing, and intensive agriculture, and

5) sites recorded as locations of vulnerable or threatened species. Sites were selected in order of decreasing priority from areas defined as; existing reserves, forest reserves and other crown lands. Further selections from private land were made on the basis of land market value.

Costing Conservation Network Scenarios

The cost to government in setting up a conservation network goes beyond the initial step of targeting and acquiring the land. Ongoing commitment is required to setup any required infrastructure, the area also requires ongoing management to control threats to biodiversity loss, and to supply services to visitors. Society may also bear another cost in the form of economic opportunity foregone as a result of resources used for conservation instead of other enterprises.

Off-reserve conservation may involve the use of a variety of economic instruments and mechanisms, but this project assumed the use of easements in combination with management agreements. This approach maintains private ownership of the land and requires management and control of threats to biodiversity loss by the landholder, who would be compensated for their effort. Should off-reserve mechanisms be used then it is expected that landholders would also be compensated for any reduction in land value caused by the attachment of an easement to the land title. The selected scenarios were costed at four levels; 1) land acquisition cost, 2) setup and management cost, 3) compensation costs and 4) opportunity costs. Activities are only costed when they represent an addition to existing activities, they represent the cost of achieving target levels of representation above the existing status.

Acquisition Costs

The acquisition cost of each of the five selection scenarios was undertaken by intersecting maps describing the selected areas (for example see Figure 4) with a state-wide land value map. Acquisition costs only applied to any private land that was selected. Selected crown lands are costed by the opportunity costs of any foregone use, for example forest royalties. The acquisition costs reflect market value but exclude the value of buildings and any premium that may be extracted with landowner knowledge of conservation value.

Setup and Management Costs

Setup costs describe capital infrastructure such as roads, visitor facilities and ranger facilities, whilst management costs include items salary and equipment expenditure required to protect the resource. Setup and management costs will apply to both on and off-reserve conservation areas. A case study (Ulph and Reynolds, 1984) and NSW NPWS Annual Reports provided an indication of setup and management costs as they apply to government managed reserves. It is recognised that more detail is required and this is one of the ongoing components of the project. For instance reserve management costs may reflect: economies of scale, or visitor pressure, and the type of ecosystem and threats to biodiversity loss. It is also recognised that historical expenditure levels may not have enabled a level of management that is satisfactory to deal with threats to biodiversity loss. This is indeed a heard complaint.

It is expected that management requirements on off-reserve remnants may well be more intensive than for larger contiguous blocks held in existing reserves, but this trend could be off set by efficiencies in using local on-site labour. Unfortunately, no studies were found to substantiate these suggestions. This study assumes the same management cost applies to like environmental regions whether they be designated as on-reserve or off-reserve. Adjustment was made to differentiate between environmental regions located in forest and coastal areas, and those in, for example, pastoral zones. Off-reserve setup costs were assumed to be half those for government gazetted conservation reserves, since infrastructure for management is likely to be in place and this type of conservation is unlikely to attract the same visitor pressure as would a notional park for instance.

Compensation Costs

Compensation costs were assessed at two levels, full compensation for grazed land required to remove all stock, and half compensation for grazed land where stocking rates are reduced to half those currently indicated. Compensation rates are based on production gross margins calculated from value of agricultural production and farm cost data produced by (SRIAS). As yet we have not investigated the issue of preventing people from clearing land via the use of clearing easements.

Opportunity Costs

Opportunity costs from forgone production were calculated on the basis of gross agricultural production on private land, or forest royalties from selected areas designated as state forests. No account was made for likely substitution effects between primary industries and, recreation and tourism industries. It may also be expected that social costs arising from land degradation would also decline with increased emphasis on conservation and sustainable use. The value of these effects was not estimated either.

Gross agricultural production value was derived from data generated by SRIAS. Data describing the spatial distribution and value of timber production were not directly available. However, average production levels and royalty values (RAC, 1992) for each Australian Forestry Council (AFC) region were calculated and appended to a digitised map of the NSW AFC regions. This map was then intersected with selected areas of state forest to provide an approximate value of forest production. It is recognised that royalty values may have increased since the Resource Assessment Commission (RAC) study and that royalty values are only one component of the true opportunity cost of removing a forest from timber production. It is likely the calculated value is an underestimate of foregone opportunity costs.

How Much?

Conservation to control threats to loss of biodiversity is special when framed as an economic problem because of the importance of risk aversion and the length of 'project life'. One of the goals of biodiversity conservation is to maintain evolutionary processes, this usually requires consideration of a time a little greater than 25 years. Mechanisms that provide a short term holding capacity may enable time for knowledge to be gained but eventually the comparison between options should acknowledge the very long term nature of conservation requirements. This assumption is important if governments remain unwilling to delist a national park if it is shown to be surplus to conservation requirements. When information is lacking and consequences are possibly irreversible, precautionary action such as the aquisition of an easement can be justified (Young, 1993).

Is the Existing Network Representative and Adequate?

The representiveness of the existing NSW conservation reserve system was evaluated by two measures. Firstly, by calculating the proportion of the total area of each of the 124 domain classifications that are contained within that reserve system, and secondly by counting the number of domain classes that are represented. The second approach measures the representativeness of a reserve system by the number of the domain types contained in the reserve system, rather than the per cent area that those classes represent.

Representation by domain area is classified into six categories and displayed as Figure 3. The area coloured dark blue and described as >15% represents all the domain types of which more than 15% of the total area of each domain is held within conservation reserves. In general, domain types located in the south-eastern areas are better represented with large areas showing a level of representation greater than 10 per cent. The majority of domain types located west of the divide in the wheat-sheep and rangeland areas are represented at 2.5 per cent of their area and lower. Clearly adoption of the Draft National Biodiversity Strategy has significant implications for Australia's agricultural and pastoral areas.

Table 1 describes the area of domain types within each representation classification. Domain types not represented in the reserve network cover some 5.7 per cent of the area of NSW. Domain types represented at a level between zero and 2.5 per cent cover approximately 54 per cent of the state's area. Some 87 per cent of the area of NSW is categorised by environmental domains represented in the conservation reserve system at a level of less than 10 per cent. This provides strong indication of the representative bias of the existing reserve network.

Table 1 Portion of Environmental Domain Areas Represented in Reserves

Portion of Domain Areas in Reserves (%)	0	0-2.5	2.5-5	5-10	10-15	>15
Area in Classification (% of NSW)	5.7	54.0	10.1	16.9	4.0	9.3
Cumulative Area in Classification (% of NSW)	5.7	59.7	69.8	86.7	90.7	100

Table 2 indicates the portion of domain classes that exist within the reserve system. Approximately 27% of environmental domain classes are not represented in the reserve network at all and 82% of domain classes are represented at a level where less than 10% of their area of each is held within reserves.

Table 2 Portion of Environmental Domain Classes in Reserves

Surrogate Classes in Reserves (% of Total)	0	0-2.5	2.5-5	5-10	10-15	>15
% of Domain Classes	27.2	27.2	12.0	16.0	5.6	12.0
Cumulative % of Domain Classes	27.2	54.4	66.4	82.4	88.0	100

The level of representation needs to be considered within the context of the area of each domain type that may be present and conserved in other states, and the level of threat to undisturbed areas that exist outside the reserve system. However, these results indicate a bias in the representation level between environmental domains and the inadequacy of the reserve system alone to represent 27 % of domain types even at a level of only 2.5% of their area. Eight two per cent of domain types are represented at a level of less than 10% by area, and these domains cover some 87% of the states area. What is the cost to lift the level of representation of all domain classifications to the range of target levels? What is the additional cost if species are included in the analysis?

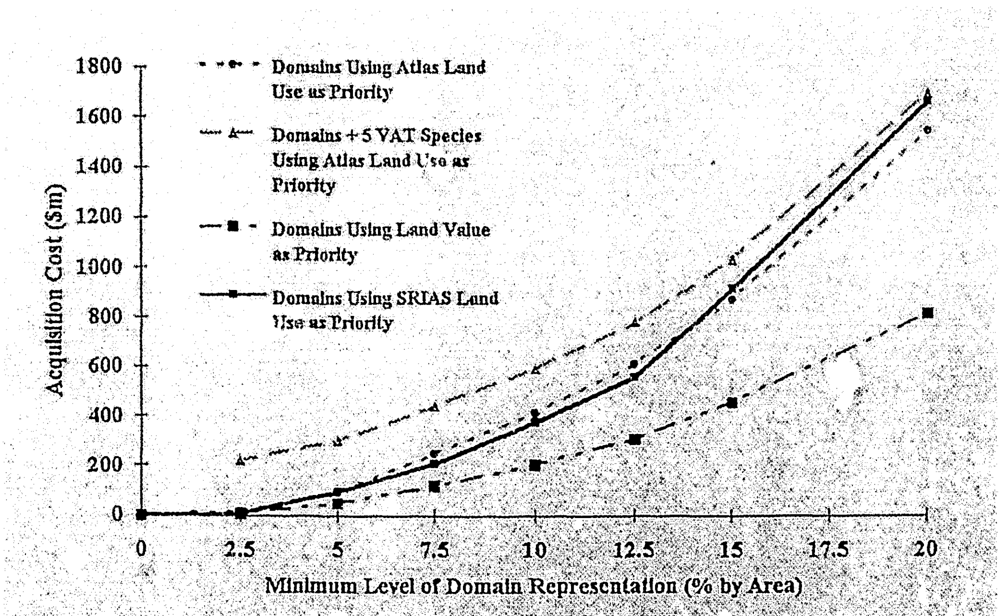
Key Observation 1 27% of environmental domain classes in NSW are not represented in a reserve.

Acquisition Only

The acquisition cost represents the cost of acquiring privately held land to complement existing reserves and areas selected from crown lands. The cost of land acquisition to achieve domain and VAT species representation is displayed as Figure 5. The selection scenario that used the land value as the selection priority and ignored land use indicates the minimum bound of acquisition cost. The selections made with the NSW Atlas, and the SRIAS land-use data provide a similar set of cost estimates. To fill the gaps and achieve 2.5% representation the cost is indicated at some $7 million, at 5% the cost is $90 million, and at 10% the cost is $360 million.

Key Observation 2 It would cost $7 million to aquire enough reserves to represent each domain at 2.5%, $90 million at 5%, and $360 million at 10%.

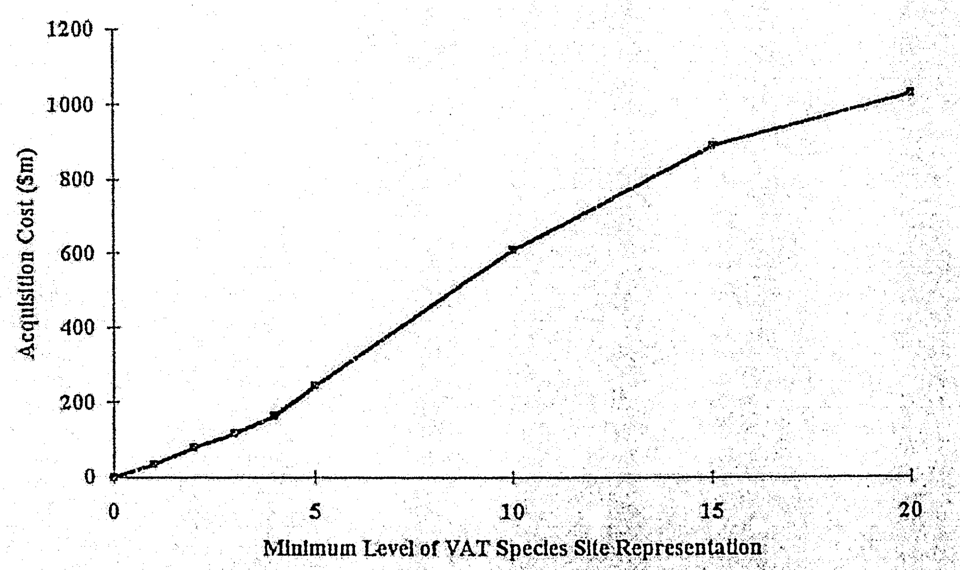
Figure 5 *Acquisition Cost to Achieve Domain & Species Representation Targets*



Inclusion of a minimum of five sites for each of the vulnerable and threatened species adds some $240 million to the cost where domains are selected at a 2.5% representation level. As the level domain of representation is increased more of the VAT sites are picked up and the cost difference between the domain only selection is reduced. At low levels of environmental region representation it is increasingly important to target special sites. The relatively high cost of achieving the VAT species representation is because the majority of sites are located in high-value agricultural areas. This is possibly the very reason the species are classified as vulnerable and threatened. Braithwaite *et al.* (1993) in their study in the Batemans Bay forests in NSW found that the tree association that characterise the most productive native forest were least represented in National Parks and most extensively disturbed by logging or clearing.

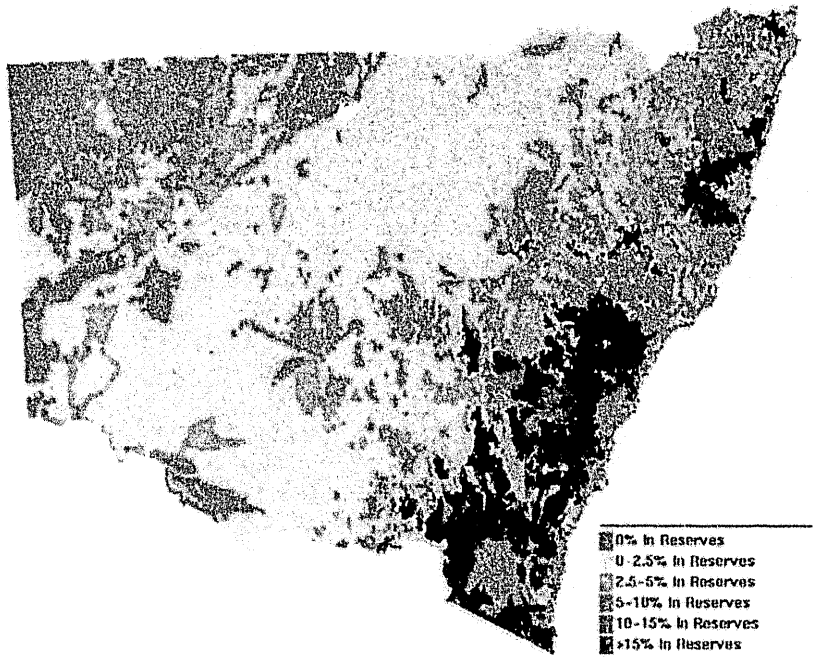
The cost of representing the VAT species without consideration of domain representation is presented as Figure 6. The achieve 10 sites, where possible, for each species the land acquisition cost is indicated at over $600 million.

Figure 6 Acquisition Cost to Achieve VAT Species Representation Targets



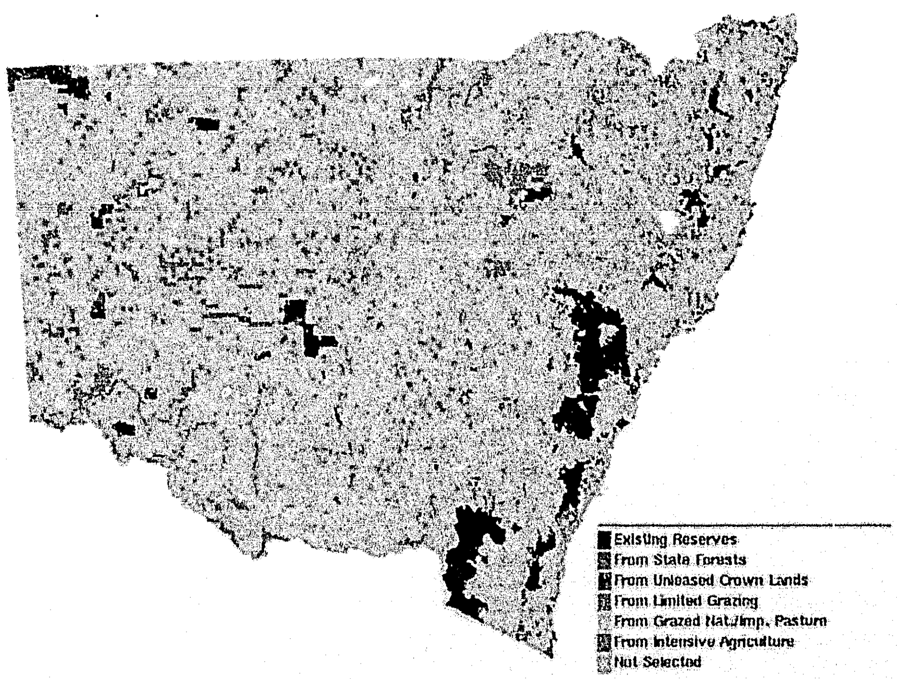
Key Observation 3 To represent all domains at 2.5% would cost $7 million, to acquire sites to represent each vulnerable and threatened at least five times would cost an additional $240 million. At 20% representation the marginal cost of VAT species representation is trivial.

Figure 3 ***Status of Existing Domain Representation***



Source: CSIRO Division of Wildlife & Ecology

Figure 4 ***Selection Scenario: Domains at 10% Plus 5 Sites per VAT Species***



Source: CSIRO Division of Wildlife & Ecology

Present Value of Budget Costs

Budget costs describe the expense to government, they include acquisition costs with on-reserve conservation and compensation costs with off-reserve conservation. Setup and management costs also apply, they relate to both on and off-reserve conservation alternatives. Note that off-reserve setup costs were assumed to be half those required with on-reserve areas. Compensation for lost production only applies to any selected private lands. These costs were calculated only for the areas selected using the domain/SRIAS land use selection scenario, a discount rate of 6% was used.

Remember the acquisition only cost at the 10% representation level was $360 million, the same scenario with setup and management added is near to $585 million, see Figure 7. At a 2.5% representation level, acquisition costs are $7 million, with setup and management added to cost to society is estimated at $42 million. At all levels of domain representation the acquisition option is cheapest and the compensation for complete removal of stock is the most expensive. Note that the level of threat abatement achieved under the two compensation scenarios is not equal for a given level of domain representation.

Key Observation 4 Reserve setup and management cost as much or more than land aquisition. If compensation costs are paid in perpetuity then an off reserve easement strategy is not cheaper

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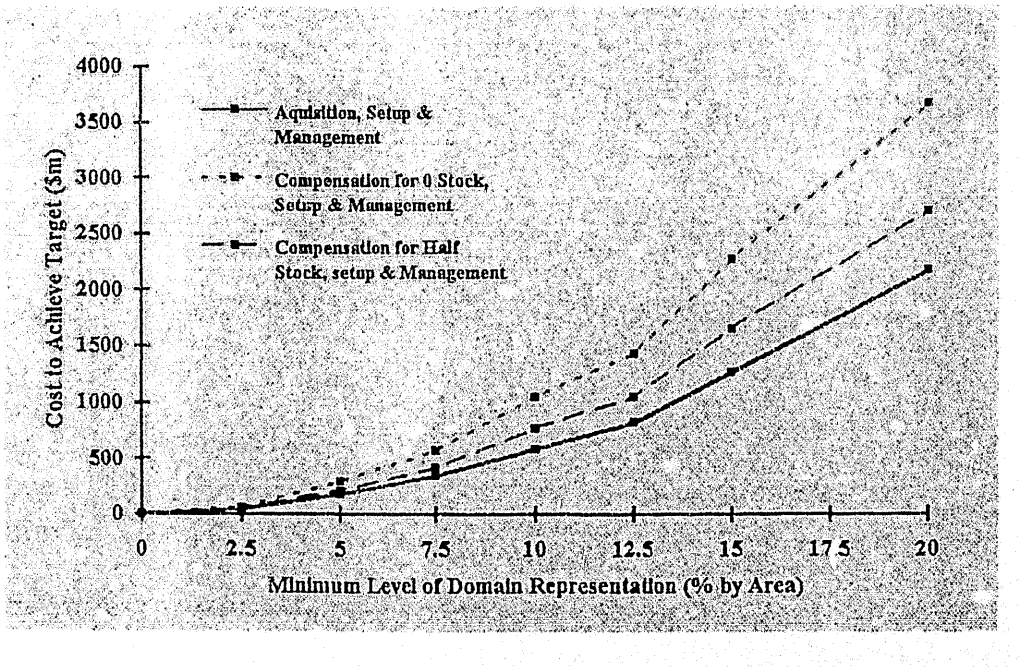
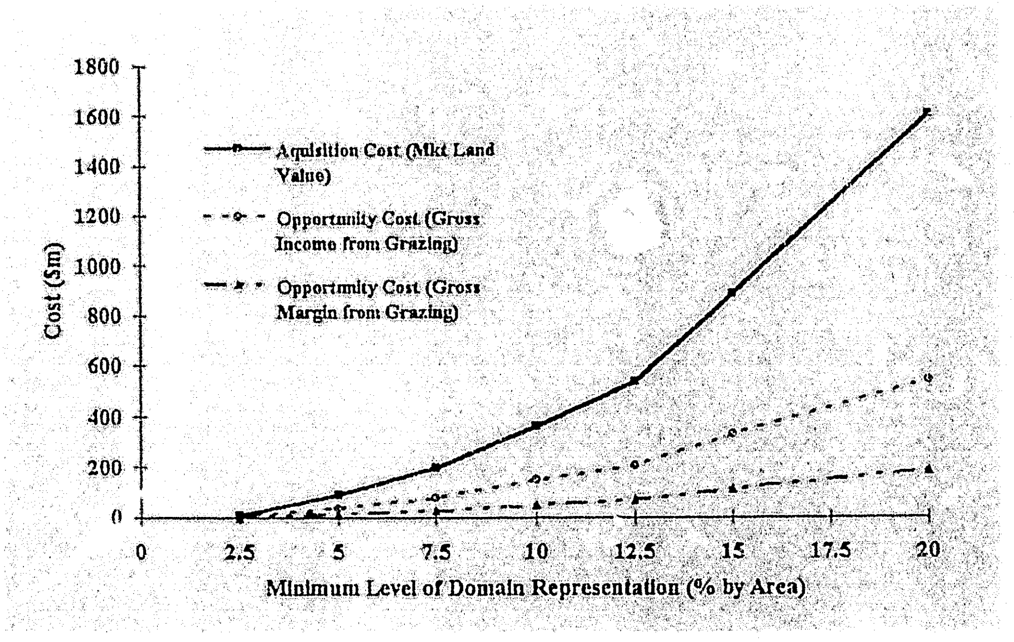
Figure 7 Present Value of Budget Costs to Achieve Representation Targets



The relative costs under each scenario is governed essentially by the relative values derived for land value and the net annual value of agricultural production, the management costs have been assumed to apply equally to each scenario. The land and net agricultural production values are presented as Figure 8. These values are considered sufficiently robust such that the ranking of the acquisition and compensation scenarios should not be altered. The absolute values depend on the estimates of setup and management costs. Improving this data is an ongoing component of the project, it should be recognised the absolute values may alter marginally as a result.

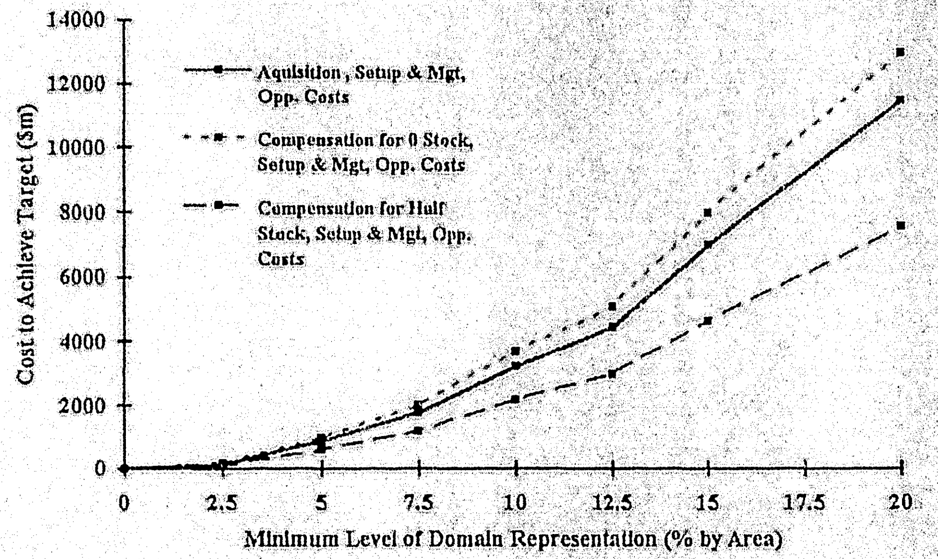
Figure 8 *Land and Agricultural Production Values from Areas Selected*



Present Value of Budget and Opportunity Costs

The inclusion of opportunity costs from lost agricultural production and forest royalties increases the absolute cost dramatically. Note again that these costs were calculated only for the areas selected using the domain/SRIAS land use selection scenario and a discount rate of 6% was used. The benchmark example for the 10% representation level showed the acquisition cost at $360 million, with setup and management added, the cost rose to $585 million. The inclusion of opportunity cost increased the cost of this scenario to $3.2 billion, see Figure 9. The relative cost of the three options changed with the half stocking rate scenario appearing as cheapest.

Figure 9 *P.V. of Budget & Opp. Costs to Achieve Domain Representation Targets*



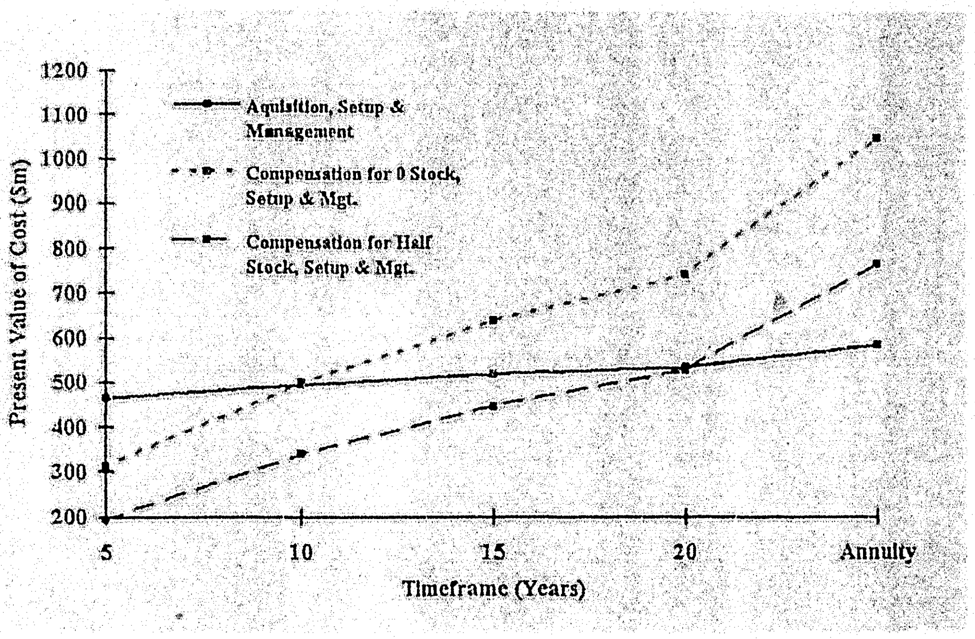
It needs to be stressed again that these values are not net of any benefits either priced or unpriced. Indeed if the activities presented eventuated it would be expected that enterprise substitution would occur and that other degradation costs would be abated. Put in perspective $3.2 billion equates to about $450 per person living in NSW.

Key Observation 5 When opportunity costs are considered, off-reserve conservation becomes more cost effective.

Effect of Project Life

The goal of conservation is long-term security from threat to biodiversity loss, but mechanisms that provide a means of securing cost effective short term protection may be important when the requirements of conservation are uncertain. Figure 10 shows the present value of budget costs (as with the above example) with the project life costed at five-year intervals. This indicates that even full compensation for complete destocking is cheaper than the acquisition for the first ten years. Compensation for halving the stocking rate is the cheaper option for a project life of up to 20 years.

Figure 10 *Effect of Project Life*



Key Observation 6 Easements provide a cost effective holding strategy whilst more information is collected. Acquisition will be a cheaper strategy if the collection of information takes more than twenty years, providing unrequired reserves can be sold.

Concluding Comments

Throughout this paper we have highlighted the key policy implications that arise, in conclusion we would like to make several further observations. Firstly, the focus of acquiring land for conservation purposes is often put on the cost of land acquisition. These results have indicated that setup and ongoing management costs are at minimum of equal proportion, or as shown at low levels of domain representation, much greater. Consideration of opportunity costs increase the overall cost to society and change the relative cost of conservation options. An understanding of management requirements and their costs, for example, under scenarios of fragmented and dispersed land parcels, and different ecosystem types, is topic of required study.

Key Observation 7 .More information is required about the costs of administering and managing a protected area network, both on-reserve and off-reserve. More information is required about the opportunity costs.

Figure 10 indicated that the value of paying compensation on an easement that requires control over stocking rate may only be advantageous in the short term. If such mechanisms are employed, policy needs to apply permanency to the easement without permanent compensation requirements. As yet, we have not noted the implications of using clearing easements to preclude a move from grazing natural vegetation to cropping. We suggest that these are likely to be a more cost effective strategy but in each case all actions need to be assessed against the degree to which threats to biodiversity loss are reduced.

Clever mixing of mechanisms should enable land use activities to provide adequate biodiversity conservation at a cost effective price to the community. The mixing of conservation and production at an appropriate level is necessary. Conservation has to be paid for, and land managers of some form will have to be present to deal with threats posed, for example, by feral animals (Bennett, 1994). Opportunity costs, risks and benefits have to be appreciated.

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