SCOPING STUDY

Mapping of Vegetation Communities

across the

Hawkesbury - Nepean and Shoalhaven Catchments

Prepared for

National Parks and Wildlife Service

and

Sydney Catchments Authority

Eco Logical Australia Pty Ltd

Ecological Assessment, GIS, Environmental Planning and Management

Ph (02) 9665 6353. **Fax** (02) 9665 2939

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Table of Contents

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1. INTRODUCTION

Background: The Sydney Catchment Authority (SCA) proposes mapping vegetation across the Hawkesbury - Nepean and Shoalhaven catchments (the catchments). A large number of potential users of this information have been recognised, including land managers, planners and agencies with a variety of statutory responsibilities. Eventhough the development of the vegetation map will satisfy many requirements of the multitude of users across the catchment, it is unlikely to meet all vegetation information needs.

By identifying the variety of user requirements and combining this information with appropriate mapping methodologies, it should assist in developing a mapping project that addresses as many of these land management and statutory needs as possible, thus maximising the effectiveness of the final product.

The Aim of this study is to develop a comprehensive proposal for mapping vegetation across the Hawkesbury - Nepean and Shoalhaven catchments. This will be achieved through assessing the variety of potential requirements for the users of the information and will demonstrate how these influence the approach to the production of a vegetation map.

The Approach: The study achieves this aim by undertaking a number of key tasks. These include:

- assessing potential user requirements,
- identifying how agencies use vegetation mapping information,
- compiling and describing the existing data available for the area,
- identifying links between different mapping projects that are currently in progress,
- developing an environmental attribute database,
- deriving mapping criteria,
- recommending approaches and possible options, and
- developing a project plan and costings.

This document was prepared by Andrew Morison of Eco Logical Australia Pty Ltd (formerly A.J. Morison & Associates Pty Ltd) with technical GIS information supplied and

maps prepared by Jeff Pickthall of the NSW NPWS. A wide range of individuals from various government agencies (Commonwealth, State and local councils) provided specialist comment.

The Catchment: The catchments cover a combined area of approximately 2.9 million hectares (**Figure 1**) encompassing all or part of 31 Local Government Areas.

Mudgee
Singleton
Cessnock
Newcastle
Gosford
Bathurst
Sydney
Wollongong
Bowral
Goulburn
Canberra
Ulladulla
Batemans Bay
Moruya

Colo River
Grose River
Coxs River
Nepean River
Kowmung River
Nepean River
Wollondilly River
Shoalhaven River
Clyde River

0 20 40 60 Kilometres

Legend

- Towns
- Coastline
- Major Rivers
- Hawkesbury/Nepean & Shoalhaven Catchments
- National Parks & Wildlife Estate

Hawkesbury/Nepean &
Shoalhaven Catchments Scoping Study

Figure 1 - Study Area

N
W E
S

Scale 1 : 1, 250, 000

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2. USER REQUIREMENTS

User requirements were assessed by:

- identifying the various statutory rolls and responsibilities with respect to land use planning and management
- assessing and summarising the biodiversity data requirements of these roles/responsibilities
- discussing the needs of various governments agencies with key staff likely to use mapping products

The statutory framework as it relates to biodiversity planning and management is briefly outlined below with a discussion on the consequential biodiversity information requirements.

2.1 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal planning legislation in NSW and is administered by the Department of Urban Affairs and Planning (DUAP). It provides a framework for overall environmental planning (Part 3 of the Act) as well as assessment of the environmental impact of development proposals (Part 4) or activities (Part 5).

The decision making process for the assessment of a development/activity occurs on a case by case basis and is usually guided by the relevant planning instrument/s. The EP&A Act places a duty on the consent/determining authority to adequately address a range of environmental matters including maintenance of biodiversity and the likely impact to threatened species, populations or ecological communities (under the TSC Act – refer to discussion in section 2.2 below).

Part 4 of the EP&A Act addresses environmental impact with a supporting Statement of Environmental Effects (SEE) or Environmental Impact Statement (EIS). Part 5 of the EP&A Act applies where development consent is not required and may include activities on NPWS land, SCA land and Council owned land. A Review of Environmental Factors (REF) is the established methodology for undertaking an assessment under Part 5. These documents are prepared by the applicant/proponent.

The aim is to identify and evaluate the impacts of a development/activity to ascertain whether there is likely to be a 'significant' impact to the environment and assist the approval/determination of whether an activity should be approved. The question of significance of impact is assisted by the 'Eight Part Test' under the TSC Act (refer to section 2.2) and integrated into the EP&A Act.

Part 3 of the EP&A Act has provisions for the preparation of environmental planning instruments such as local environment plans (LEPs), regional environmental plans (REPs) and state environmental planning policies (SEPPs). The Act provides for the protection or conservation of native flora and fauna within these environmental planning instruments.

Under the EP&A Act DUAP have a number of proposed reforms in place to review plan making in the state. The proposed reforms, 'Plan First', seek to reduce the need for ad hoc planning and replace this with a strategic approach that considers all relevant issues from the outset of a plan being made. Natural resource management will be better integrated with the plan making system at the regional level through Regional Strategies. DUAP proposes that Regional Strategies will be prepared across the State within 5 years of the amended legislation coming into effect. It is further proposed that Councils will prepare new Local Plans within 3 years of the Regional Strategy for their region coming into effect.

Biodiversity Data Requirements

The biodiversity data requirements to carry out responsibilities under the EP&A Act can be broadly classified under two headings: the case by case assessments for proposed developments and activities; and the wider area land use planning.

The approach to the case by case assessments under Part 4 and Part 5 of the EP&A Act differs widely but usually provides site specific data on presence of species, vegetation community descriptions, habitat availability and condition.

The data requirements to 'adequately' assess impacts on biodiversity for the consent/determining authorities to make case based decisions include:

- Species recorded on and adjacent to the site of the proposed development/activity.
- Vegetation communities and populations recorded on and adjacent to the site of the proposed development/activity.
- Species, populations or communities of significance that have been recorded, or have a probability of occurrence on, or adjacent to the subject site. It is important to note that to identify significance there is a need for broader contextual information. Significance should not be limited to those matters listed under the EPBC and TSC Acts.
- For species of significance the distribution information should address local connectivity, occurrence in the wider region and the known full extent of the distribution.
- The distribution of the significant species, population and communities being assessed in conservation reserves or protected areas within the region.
- Identification of habitat and ecological requirements for the species, populations and communities of significance.
- Condition, threats and viability of populations, communities and habitat on or adjacent to the subject site.

Rather than deferring to a process of case based assessments, the opportunity for specific land allocation outcomes to meet biodiversity objectives on a regional scale is available, which can then be supported and validated by targeted case based biodiversity questions. The preparation of planning instruments under the EP&A Act should consider and provide for the protection or conservation of native flora and fauna. The key questions that arise are what biodiversity values of significance occur in the study area and how can they be protected/enhanced.

Wider area planning requires contextual information to identify relative conservation value/s (or significance) of species, populations and communities. Biodiversity objectives and targets can then be developed and assessed (e.g. JANIS, Commonwealth of Australia, 1997).

The general biodiversity data requirements to facilitate wider area strategic land use planning include:

- Current distribution of species, populations or communities across their range.
- An assessment of relative viability of remnant vegetation communities across their range based on ecological requirements, condition and threats.
- Modelled pre1750 distribution of each vegetation community.
- Predicted distribution of species/populations/communities of concern (edge of known range/limit of known distribution).
- The viability of the species/populations/communities based on ecological characteristics (habitat requirements, population dynamics), habitat availability, connectivity, condition and threats.
- A transparent and consistent approach to classifying vegetation communities and any known variations in key floristics.

2.2 Threatened Species Conservation Act, 1995

The NSW *Threatened Species Conservation Act, 1995* (TSC Act) is administered by the National Parks and Wildlife Service (NPWS) and aims to protect and encourage the recovery of threatened species, populations and endangered ecological communities listed under the Act. The integration of the TSC Act with the EP&A Act requires consideration of whether a development (Part 4 of the EP&A Act) or an activity (Part 5 of the EP&A Act) is likely to significantly affect threatened species, populations and endangered ecological communities or their habitat. This is done through the preparation of a test of significance, referred to as an '8-part test' (Section 5A). Where there is a significant impact, the TSC Act requires a Species Impact Statement (SIS).

Criteria addressed in the '8-part test' include:

- whether the lifecycle of a species will be disrupted such that a viable local population is likely to be placed at risk of extinction;
- whether the viability of an endangered population is likely to be significantly compromised;
- in relation to the regional distribution, whether a significant area of known habitat is to be modified;
- whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat;
- whether critical habitat will be affected;
- whether they are adequately represented in conservation reserves (or other similar protected areas);
- whether the action proposed is recognised as a 'threatening process'; and
- whether it is at the limit of its known distribution.

Note: They have not been transcribed in full to allow a simple demonstration of the focus of questions on regional contextual information.

As discussed above the focus of the test is on threatened species, populations or ecological communities and other matters listed in the schedules of the Act.

The Act also outlines procedures for issuing a licence to 'harm or pick' a threatened species, population or endangered ecological community, and for the damage of their habitat or damage of identified critical habitat.

There are provisions within the TSC Act for the preparation of recovery plans for all scheduled threatened species, populations and endangered ecological communities. In addition, it is a requirement that a threat abatement plan is prepared for key threatening processes listed under the Act.

The consent or determining authority must seek the concurrence of the Director-General of National Parks and Wildlife where there is likely to be a significant effect on threatened species, populations or endangered ecological communities, or their habitats or where the proposal impacts on identified critical habitat.

Biodiversity Data Requirements

As with the EP&A Act the TSC Act involves both case based assessments (Eight-Part Tests, SISs, concurrence and licensing) and wider area planning (Recovery Plans). The approach to the case based assessments however attempts to incorporate regional and relevant contextual information to aid decision-making. Questions in the Eight-Part Test for example, raise the issues of viability, connectivity, regional distribution, limit of distribution and 'adequate' representation in conservation reserves or protected areas. Rarely is their sufficient information to answer many of these contextual questions.

The biodiversity data requirements to enable adequate assessment under the TSC Act include:

- What threatened species, populations or communities are present on or adjacent to the site?
- What threatened species, populations or communities have a probability of occurring on or adjacent to the site?
- What is the distribution of the threatened species, populations or communities (known or predicted to occur on the site) across its range?
- What are the ecological characteristics and habitat requirements for the threatened species, populations or communities? Information on threats and viability - population size and dynamics, habitat availability, connectivity and condition?
- Do any of the threatened species, populations or communities occur in reserves or protected areas? Is this representation adequate?

Information and data requirements specifically for recovery plans include:

- Current distribution of species/population or communities being addressed. Limits of known distribution. Predicted distribution.
- Size of population. Degree of isolation/fragmentation.

- General ecology and habitat.
- Response to disturbance – grazing, logging, fire, predators, weeds etc.
- Condition of habitat – need for management.
- Genetic variation.
- Threats and vulnerability to those threats.
- Level of protection and potential for conservation.
- In-situ and ex-situ conservation options.
- Other information required may be specific monitoring programs, research on ecology, etc and education.

2.3 Native Vegetation Conservation Act, 1997

The NSW *Native vegetation Conservation Act, 1997* (NVC Act) is administered by the Department of Land and Water Conservation (DLWC) and provides a comprehensive system for the conservation and management of native vegetation in NSW. One of the main features of the Act is provision for the development of Regional Vegetation Management Plans (RVMPs) that aim to provide a comprehensive plan for appropriate vegetation management in a region. Developed by committees and in consultation with key stakeholders an RVMP is to identify areas where native vegetation can be cleared without application, where an application is required and recommend areas that should be revegetated or improved.

The NVC Act promotes property planning and provides for property agreements and incentives to landholders.

Biodiversity Data Requirements

Roles and responsibilities under the NVC Act include:

- RVMPs.
- Assessing applications for vegetation clearing.
- Property Plans and agreements.
- Prioritisation, advice and managing incentive schemes.

The NVC Act incorporates site specific case based processes such as clearing applications, property planning and incentive schemes with a regional management framework developed under the RVMPs.

The biodiversity data requirements to assist the roles and responsibilities under the NVC Act include:

- Records of species/populations and communities across the study area/property.
- Presence or habitat of threatened species, endangered populations or endangered ecological communities.
- The known or predicted distribution of these species, populations or communities across their range.
- A transparent and consistent approach to classifying vegetation communities and any known variations in key floristics.

- An approach to identifying environmental significance and the data to assist in classification. Development of objectives and targets. For example, EPBC and TSC Act listings, regional significance or edge of range.
- Where JANIS (Commonwealth of Australia, 1997) criteria are used as targets will need to model pre1750 distribution of each vegetation community. Therefore need the range of environmental variables (terrain, climate, substrate etc).
- The RVMP may identify regionally protected land on the basis of attributes other than biodiversity, such as slopes steeper that 18 degrees. Therefore need detail on environmental attributes.
- May also identify conditions such as 'no primary koala browse tree species shall be cleared'. Would therefore need to identify where those trees are known to exist and the environmental attributes for those trees.
- Predicted distribution of species of concern. The viability of species based on ecological characteristics (habitat requirements, population dynamics), habitat availability, condition and threats.
- An assessment of relative viability of remnant vegetation communities across their range based on ecological requirements, condition and threats.
- Exemptions on clearing controls may be stipulated in the RVMP and could be up to 2ha per annum of clearing permissible per land holding. Where this is the case it would be advantageous for mapping to identify remnants of at least a minimum patch size of 2ha.
- Prioritising areas for incentive schemes and works are based on conservation objectives and values, condition, threat and other matters including potential for connectivity.

2.4 Local Government Act, 1993

The NSW *Local Government Act, 1993* (LG Act) defines the powers, duties and functions of local councils. The LG Act enables Councils to provide services ranging from roads and drainage to recreational facilities and education.

Under the LG Act, plans of management must be prepared for 'community land'. The plans should address a variety of factors including biodiversity conservation and management. Council must adopt a specific plan of management for community land affected by a recovery plan, threat abatement plan or containing critical habitat under the TSC Act.

The appropriate management of 'operational land' or 'community land' may involve weed control, rehabilitation or bush regeneration to protect and enhance natural habitat.

Biodiversity Data Requirements

Relevant roles and responsibilities include:

- Community land plans of management.
- Operations – such as maintenance and management of utilities and infrastructure, landscaping, rehabilitation etc.
- Information management and education.

The roles for local government under the LG Act are very site specific and case by case based. Rarely do they draw on regional or LGA-wide information. Where generic plans of management are developed for community lands of a similar type across a shire there are difficulties in identifying relative value and appropriate conservation management actions.

The biodiversity data requirements to assist Councils in fulfilling their responsibilities under the LG Act include:

- Species recorded on and adjacent to the community land.
- Vegetation communities and populations recorded on and adjacent to the community land.
- Species, populations or communities of significance that have a probability of occurrence on or adjacent to the community land. Therefore need a process to identify significance (EPBC Act, TSC Act, regional and local significance). May need contextual information on distribution, threats etc.
- Identification of habitat and ecological requirements for the species, populations and communities of significance.
- Condition, threats and viability of populations, communities and habitat on or adjacent to the community land.
- Species, populations or communities of significance that are known, or have a probability of occurrence, in the LGA. Therefore need a process to identify significance.
- The habitat requirements for significant biodiversity values and threats to those values.
- Which vegetation communities used to occur where? Modelling based on environmental variables. This enables the selection of landscaping species and assists in developing works programs for rehabilitation/regeneration and maintenance.

2.5 Sydney Water Catchment Management Act, 1998

The Sydney Water Catchment Management Act, 1998 (SWCM Act) is the Sydney Catchment Authority's (SCA) enabling legislation setting out its role and function. The Act requires regular audits of the catchment at intervals of no longer than 2 years. The regulations provide for the maintenance of the ecological integrity and other values of the areas of land declared as Special Areas.

The environment plan developed under the Act states as one of its objectives that environmental performance will be monitored. A set of environmental indicators have recently been adopted by SCA to address ecological health of the catchment areas, including vegetation cover, riparian zones and water quality.

Biodiversity Data Requirements

Relevant roles and responsibilities include:

- Area planning - a joint strategic plan of management between SCA and NPWS for the Special Areas.

- Land management - fire management, pest and weed management, maintaining and managing catchment/water supply infrastructure, landscaping and bush regeneration. Funding of certain complimentary management activities on private land.
- Plans of management.
- Ecological audit, monitoring and review.
- Information management and education.

The biodiversity data requirements to assist the SCA in fulfilling their responsibilities under the SWCM Act include:

- Vegetation communities mapped across the catchments. Including non-forest communities and riparian zones.
- A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Condition - including cover, weeds, pest species, disturbance, regrowth, erosion and fires.
- Changes to the extent of clearing and condition in the catchment areas.
- Species and populations recorded in the catchment areas.
- A context to identify relative conservation value/s (or significance) of species, populations or communities. May be EPBC, TSC, regional significance, edge of range, ecological function, etc.
- Development of objectives and targets (e.g. JANIS criteria. Commonwealth of Australia, 1997) and how they meet them.
- Modelled pre1750 distribution of each vegetation community.
- Current and predicted distribution of species, populations or communities of significance within the catchment areas.
- Identification of habitat and ecological requirements for the species, populations and communities of significance.
- The viability of the species based on ecological characteristics (habitat requirements, population dynamics), habitat availability, condition and threats.
- Long term monitoring sites – environmental indicators.
- Which vegetation communities used to occur where? Modelling based on environmental variables. This enables the selection of landscaping species and assists in developing works programs for rehabilitation/regeneration and maintenance.

2.6 National Parks and Wildlife Act, 1974

The NSW *National Parks and Wildlife Act, 1974* (NP&W Act) makes the Director-General of the NPWS responsible for the establishment, care, control and management of all conservation reserves in NSW, including national parks, nature reserves, state recreation areas, historic sites and regional parks. The Act also makes the Director-General of the NPWS responsible for the protection and care of native flora and fauna, as well as Aboriginal places and relics throughout NSW.

The Act requires that Plans of Management be developed for each area under NPWS control.

Biodiversity Data Requirements

Roles and responsibilities include:

- Reserve planning, including Voluntary Conservation Agreements.
- Plans of management.
- Fire management – biodiversity requirements dealt with under the Rural Fires Act (below).
- Pest species and weed management.
- Education and information services.
- Off-park and community conservation programs
- Aboriginal and European Cultural Heritage Management
- Scientific research

The biodiversity data requirements to assist the NPWS in fulfilling their responsibilities under the NP&W Act include:

- Vegetation communities mapped across reserves. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- The distribution and extent of species and populations recorded, or predicted to occur, in the reserves.
- Broader distribution of species, populations or communities of significance.
- A context to identify relative conservation value/s (or significance) of species, populations or communities. Conservation targets and objectives (and how they meet identified objectives or targets – e.g. CAR reserve system, JANIS criteria Commonwealth of Australia, 1997). Modelled pre1750 distribution of each vegetation community.
- Areas of conservation significance that address targets/objectives. Representation in reserves or protected areas.
- Identification of habitat and ecological requirements for the species, populations and communities of significance.
- Condition - including cover, disturbance, weeds, pest species and fires.
- Threats and viability of populations, communities and habitat both within and outside the reserves.
- Response of species to disturbance

2.7 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a national scheme for protecting the environment and conserving biodiversity values. Approval from the Commonwealth Environment Minister is required under the EPBC Act if the action (which can include a project, development, undertaking or activity) will, or is likely to, have a significant impact on matters considered to be of national environmental significance (NES matters). NES matters include threatened

species, ecological communities, migratory species, Ramsar wetlands and world heritage properties such as the Greater Blue Mountains World Heritage Area. The EPBC Act does not define significant impact but identifies matters that are necessary to take into consideration.

Schedule 5 of the EPBC Regulations states that the primary purpose of management of natural and cultural heritage of a declared World Heritage property must be to identify, protect, conserve, present, transmit to future generations and, if appropriate, rehabilitate the World Heritage values of the property (Environment Australia, 2001). Therefore in relation to the Greater Blue Mountains World Heritage Area (GBMWHA), which covers a large proportion of the Burragorang special area, it is important that an appropriate regime of monitoring is in place to assess the state of World Heritage values. Appropriate presentation and interpretation of those values is also a priority for managers

The EPBC Act has provisions for monitoring biodiversity and preparing bioregional plans, national recovery plans and threat abatement plans.

Biodiversity Data Requirements

Roles and responsibilities include:

- NES Matters – EPBC Act (referral, assessment and approval).
- Monitoring of world heritage values – Greater Blue Mountains World Heritage Area.
- Information and Education.
- Plans of management, bioregional and recovery plans.

The biodiversity data requirements to assist in meeting the roles and responsibilities of the EPBC Act include:

- Known and predicted distribution of threatened species, ecological communities, migratory species, etc listed under the EPBC Act.
- Threats and viability of populations, communities and habitat for threatened species, ecological communities, migratory species, etc listed under the EPBC Act.
- Adequate representation in reserves or protected areas.
- Vegetation communities mapped across the GBMWHA. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Condition - including cover, disturbance, pest species, weeds and fires.
- Species and populations recorded in the GBMWHA.
- A context to identify relative conservation value/s (or significance) of species, populations or communities (and how they meet identified objectives or targets – e.g. JANIS criteria. CoA, 1997).
- Modelled pre1750 distribution of each vegetation community.
- Distribution of species, populations or communities of significance known or predicted to occur within the GBMWHA.
- Identification of habitat and ecological requirements for species, populations and communities of significance.

- Viability of species, populations, communities of significance and their habitat on or adjacent to the GBMWHA (based on ecological characteristics, habitat requirements, availability, population dynamics, condition, threats).
- Long term monitoring of ecological characteristics.

2.8 Rural Fires Act

The NSW *Rural Fires Act 1997* (RF Act) deals with bush fire hazard management and imposes obligations on Council and other land management agencies. The RF Act has statutory obligations to protect life and property and prevent fire from leaving land vested in or under its control. It also provides for the agency to undertake appropriate fire management measures. 'Prescribed organisations', such as the NPWS, are required to implement the provisions of Bush Fire Management Plans.

It is acknowledged that there is a lack of information relating to the response of individual threatened species to fire. Maintaining fire regimes within the thresholds indicated for vegetation communities is believed to be the most appropriate way to manage many individual species. Species specific research is strongly recommended.

Some of the biodiversity management principles for fire management include:

- Maintenance of a diversity of fire regimes through a pattern of 'mosaic burning' where only a small proportion of any vegetation community is subject to the same fire regime. This ensures a variety of ages and lifecycles is present at any one time.
- Varying the inter-fire period within minimum and maximum thresholds at any given point to ensure individual species are neither advantaged nor disadvantaged by a homogenous fire regime.
- Maintaining refuges, to aid in protecting fauna during and after fire.
- Application of the precautionary principle to prescribed burning and undertaking studies into the effects of fire on species and communities.

Biodiversity Data Requirements

Biodiversity data requirements to assist in meeting the roles and responsibilities of the Rural Fires Act include:

- Mapping of vegetation communities in reserves. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Condition, in relation to fire history, cover, disturbance, understorey.
- The distribution and extent of species and populations of significance recorded, or predicted to occur, in the reserves.
- A context to identify relative conservation value/s (or significance) of species, populations or communities.
- Identification of habitat and ecological requirements for the species, populations and communities of significance.
- Identification of habitat and communities requiring exclusion of fire.
- Minimum and maximum inter-fire periods to ensure that species and communities are provided with an adequate inter-fire period to regenerate and to ensure

biodiversity is not compromised through removing the regenerative stimulus provided by fire.

- Fire history including location, frequency, intensity and season.

2.9 Rivers and Foreshore Improvement Act

The NSW *Rivers and Foreshore Improvement Act 1948* (RFI Act) requires individuals carrying out works that involve excavation or removal of material either in or within 40 metres of a river, to obtain a Part 3A permit. This does not apply to public or local authorities. The Act allows for the consideration of any environmental matter in the issuing of a permit.

Biodiversity Data Requirements

The assessments carried out are very site specific and rarely draw on any regional context as information is often not available. Biodiversity data requirements to assist in meeting the roles and responsibilities of the RFI Act include:

- Vegetation communities mapped, including seagrasses, saltmarsh, mangroves, wetlands and riparian zones. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Species and populations recorded both instream and in the riparian zones.
- A context to identify relative conservation value/s (or significance) of species, populations or communities.
- Distribution of species, populations or communities of significance known or predicted to occur instream, within or adjacent to the riparian zone.
- Identification of habitat and ecological requirements for species, populations and communities of significance.
- Condition of riparian zone and stream habitat – extent of clearing, weed growth, disturbance, erosion etc.
- Threats and viability of populations, communities and habitat instream, within or adjacent to the riparian zone.
- Connectivity and refuge areas

2.10 Noxious Weeds Act

The NSW Noxious Weeds Act 1993 provides for the identification, classification and control of noxious weeds.

Biodiversity Data Requirements

The biodiversity data requirements to assist in meeting the roles and responsibilities of the Noxious Weeds Act include:

- Weed mapping – species recorded and extent.
- Prioritisation of areas based on site significance, threats posed by noxious weeds and opportunity for success from treatment.

2.11 Catchment Management Act, 1989

Total Catchment Management is defined by the NSW *Catchment Management Act, 1989*, as 'the co-ordinated and sustainable use and management of land, water, vegetation and other natural resources on a catchment basis so as to balance resource utilisation and conservation'. The central co-ordinating mechanism for TCM is the State Catchment Management Co-ordinating Committee (DLWC, 1996). The objectives include 'to identify and rectify natural resource degradation' and 'to promote sustainable use of natural resources'.

The emphasis is on co-ordinating the policies, programs and activities of public authorities, groups and individuals. Plans and strategies are developed for the catchment to address specific resource needs and guide management activities.

Biodiversity Data Requirements

The Catchment Management Act attempts to provide a co-ordinated regional framework for prioritising case based work however there is rarely sufficient contextual information. Biodiversity data requirements to assist in meeting the roles and responsibilities under this Act the include:

- Vegetation communities mapped across the catchment. Include non-forest communities. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Condition - including cover, weeds, pest species, erosion, etc.
- Changes to the extent of clearing in the catchment area.
- Species and populations recorded in the catchment area.
- A context to identify relative conservation value/s (or significance) of species, populations or communities.
- Develop objectives and targets and asses if/how they are met (e.g. JANIS criteria. CoA, 1997). Modelled pre1750 distribution of each vegetation community.
- Distribution of species, populations or communities of significance, recorded or predicted to occur within the catchment area.
- Identification of habitat and ecological requirements for the species, populations and communities of significance.
- Threats and viability of populations, communities and habitat on or adjacent to the catchment area.

2.12 Crown Lands Act, 1989

The *Crown Lands Act, 1989* outlines the approach to management of lands owned by the State. It identifies a process of land assessment prior to Crown Land being sold, leased, licensed, dedicated or reserved to recommend appropriate use/s of that land. It is a case by case based assessment that in practice has focused on the physical attributes of the land. The legislation outlines principles of Crown Land management that incorporates the protection of natural resources, including flora and fauna. The Act provides for preparation of management plans.

Biodiversity Data Requirements

The biodiversity data requirements to assist in meeting the roles and responsibilities under the Crown Lands Act include:

- Species recorded on or adjacent to Crown Land (CL).
- Vegetation communities and populations recorded on or adjacent to CL.
- Species, populations or communities of significance that are known to occur, or have a probability of occurrence, on or adjacent to community land. Therefore require a process to identify significance (EPBC Act, TSC Act, regional and local significance).
- Identification of habitat and ecological requirements for species, populations and communities of significance.
- Condition, threats and viability of species, populations, communities of significance or their habitat on or adjacent to CL.
- Species, populations or communities of significance that are known, or have a probability of occurrence, on CL. The habitat requirements and threats to those biodiversity values.

2.13 Sydney Regional Environmental Plan No 20 Hawkesbury-Nepean River (SREP20)

This SREP aims to protect the environment of the Hawkesbury - Nepean River system by ensuring that the impacts of future land uses are considered in a regional context. It controls development that has potential to impact on the river environment. The plan applies to all parts of the catchment in the Sydney Region (15 local government areas), except for land covered by Sydney REP No. 11 — Penrith Lakes Scheme.

The objectives and strategies listed under Section 6 of the SREP cover a range of ecological issues. Of particular note are:

- The environmental quality of environmentally sensitive areas (such as riparian land, wetlands, significant flora and fauna habitats and corridors) must be protected and enhanced.
- Manage flora and fauna communities so that the diversity of flora and fauna communities, species and genetic variation is conserved.
- Minimise adverse impacts on water quality, aquatic habitats, riverine vegetation and bank stability.

The REP is supported by an Action Plan that includes actions necessary to improve existing conditions.

Biodiversity Data Requirements

The biodiversity data requirements to assist in meeting the roles and responsibilities of SREP 20 include:

- Vegetation communities mapped across the catchment. Include non-forest communities such as riparian land and wetlands. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Species and populations recorded in the area.
- Identification of significant flora and fauna habitats - a context to identify relative conservation value/s (or significance) of species, populations or communities.

- Distribution of species, populations or communities of significance, recorded or predicted to occur, within the area.
- Identification of habitat and ecological requirements for species, populations and communities of significance.
- Threats and viability of populations, communities and habitat on or adjacent to the catchment areas.

2.14 SEPP 58 – Protecting Sydney's Water Supply

State Environmental Planning Policy No. 58 – Protecting Sydney's Water Supply (SEPP 58) provides for the notification and concurrence for certain high risk developments within identified local government areas. It states that these developments need to be assessed to ensure they will have a beneficial or neutral effect on water quality. Also contains provisions for comment on LEPs etc. The SEPP is to be replaced with the REP (refer below). It is suggested that there is a connection between the protection of biodiversity ('ecological integrity') and the delivery of improved water quality.

Biodiversity Data Requirements

The biodiversity data requirements to assist in meeting the roles and responsibilities of SEPP 58 include:

- Vegetation communities mapped across the area. Include non-forest communities such as wetlands, instream and riparian habitats. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Condition - including cover and disturbance.
- Changes to the extent of clearing and condition in the area.
- Threats and viability of populations, communities and habitat on or adjacent to the catchment area.
- A number of biological indicators have been developed that are to be assessed and monitored.

2.15 Draft REP - Drinking Water Catchments

The draft Regional Environmental Plan (REP) for the drinking water catchments of Sydney and adjoining regional centres upgrades and replaces SEPP 58. It proposes a number of additional roles, including: undertaking Strategic Land and Water Capability Assessments (SLWCA), rectification action plans (RAPs) and catchment rectification action masterplans (CRAMs), catchment best management practices and developing small area management plans. SCA also have responsibility to ensure the 'ecological integrity' of the Special Areas is safeguarded. The relationship between ecological integrity (and how it is measured) and water quality has not been defined. There is a notification (advisory) and concurrence role for SCA based on impacts to water quality in the draft plan.

Biodiversity Data Requirements

The biodiversity data requirements to assist in meeting the roles and responsibilities of the drinking water catchments REP include:

- Vegetation communities mapped across the area. Include non-forest communities such as wetlands, instream and riparian habitats. A transparent and consistent approach to classifying vegetation communities and any known variations in floristics.
- Species and populations recorded in the area, including instream, riparian zones and wetlands.
- A context to identify relative conservation value/s (or significance) of species, populations or communities.
- Distribution of species, populations or communities of significance known or predicted to occur in the catchments.
- Identification of habitat and ecological requirements for species, populations and communities of significance.
- Condition - including cover, weeds, pest species, disturbance, erosion etc.
- Changes to the extent of clearing and condition in the area.
- Threats and viability of populations, communities and habitat on or adjacent to the catchment areas.
- Connectivity, refuge areas.

2.16 Other Strategies and Policies

NSW Biodiversity Strategy. The NSW Biodiversity Strategy recognises the collaborative responsibility of the community, local and state government and the importance of local planning in biodiversity conservation. It provides guidance for Councils to prepare and implement biodiversity plans (states that Councils need to implement biodiversity action plans by 2001).

Other relevant Policies and Programs include *inter alia* - the State Rivers and Estuaries Policy, State Wetlands Policy, Coastal Policy, Estuary Management Policy, Natural Resources Policy Directions Statement (currently in prep), Water Reform Package, Aquatic Habitat Policy and Guidelines.

2.17 Consultation with Users of the Data

A list of the individuals consulted is provided in **Appendix A**. The comments covered a range of topics, each of which have been grouped and listed below. They are discussed more fully in the following section (Section 3).

What we need to know - data

- What communities and where they still exist.
- Accurate locations of extent etc.
- Distribution of good condition vegetation.
- Regional context.
- Repeatable process.
- Full floristics, cover abundance.
- Condition - weeds, understorey, degree of intactness, fire, regeneration present, dieback. Focus is on presence of weeds and understorey.
- Use the latest aerial photos.
- Where the threatened species, EECs occur – known localities.
- Model the areas that have not been sampled.
- Where are threatened species modelled to occur?
- How much is reserved?
- Riparian vegetation – more detail in community descriptions. Not just 'riparian forest'. There are different types. Condition of riparian vegetation.
- Include areas that have no understorey and canopy of native spp.
- Include grasslands.
- Comprehensive coverage of World Heritage Area.
- Mark out plots so can revisit for modelling affects of fire.
- Indicators of post fire regeneration – resprouting, seedlings, observation on flowers.
- Fuel loads to link to structural data to assist with modelling fire risk.
- Possibility of permanent plots – urban or rural/natural interface, regeneration of previously disturbed sites and post fire floristic dynamics in different communities.

What the data means and how to apply it.

- Relative conservation values. Which are the priority remnants and priority communities? Communicate significance to land managers.
- Do we need to protect X% in a certain area?
- Need to be able to incorporate outcomes into planning instruments and other documents. Which areas to highlight.
- Prioritising areas for weeding, regeneration, grant funding, etc.
- Need lots more interpretation information, as we don't know how to use the data.
- What areas are suitable habitat for threatened fauna.
- Transparency of outcome or decision making process.
- How do we link patches together, where to provide corridors?
- Model what species/communities occurred where pre-1750 to provide spp lists to people for planting.
- How do the community descriptions relate to other mapping community descriptions carried out elsewhere, in our LGA? Lots of different approaches to community/association classification.
- Areas that have the same dominant canopy tree to an identified EECs but different associations – how do we treat?

- What monitoring questions are we to ask – the first round of surveys to use as an evaluation?
- Monitor the establishment/spread of weeds.

Limitations of the data
- Clearly spell them out.
- The data is out of date very quickly, usually by the time it comes to the users (dependent on date of aerial photography). Things change very quickly.
- Some areas modelled are incorrect.
- Would not use the map for identifying what vegetation community it is for an individual DA but API or site visit.

Information Updates
- Provision for Council to update data. To change and improve the accuracy of the mapping etc at a local scale.
- How to manage and update data?

Education and Training
- What are the outcomes of the mapping?
- How to interpret the data. What does it mean?
- Limitations.
- Survey methodology.
- Councils have limited resources and skills to understand and use the information.
- The consultation carried out in the development of strategic planning documents should educate people.

Other
- Pick up weeds in API.
- Spend more $$ on survey than on API.

3. DISCUSSION

3.1 Case Based Assessment Vs Regional Assessment

Individual case by case decision making is carried out on site specific proposals for changes to landuse or management of a particular site. They include decisions such as:

- Approvals for developments or activities under Part 4 and Part 5 of the EP&A Act.
- Concurrence and licensing under the TSC Act.
- Vegetation clearing applications, property planning and managing incentive schemes under the NVC Act.
- Approvals under EPBC Act.
- Part 3A Permit under the RFI Act.

Many of the case based assessments are impact assessments. It is essential that to assess impacts of a proposal on species, populations or communities of significance that wider contextual information be considered. The respective legislation for case based assessments does not always stipulate the need for incorporating a broader context in the discussions on impacts. The Eight-Part Test under the TSC Act clearly asks questions directed at the wider context – the viability and adequate representation in conservation reserves or protected areas, etc. These questions are impossible to answer without comprehensive regional information on the species, population or community being assessed, its distribution and ecology.

Activities such operational works for landscaping, bush regeneration, property planning, and community land plans of management may also focus on site specifics and not incorporate a broader contextual basis. Unless they have a broader plan of management driving the activities they can be driven by adhoc pressures including neighbour complaints, ease of access, location of resources, traditionally understood practices (such as providing landscaped gardens – underscrubbing, mulching, fertiliser), etc. Objectives and priorities should be developed incorporating a regional framework.

Problems for case based decision-making include:

- The integration of the TSC Act (refer below) in development assessment under the EP&A Act has meant a focus on matters listed in the Schedules of the TSC Act when other biodiversity values may be neglected, such as biodiversity values of regional or local significance and protection of important ecological processes.
- Site specific assessment may not incorporate the wider local and regional context, such as relative value of the site, connectivity, refugia or other ecological processes relevant to possible impacts on the site or adjoining lands.
- How to assess the conservation value and adequacy of representation in protected areas for the identified biodiversity values.
- Decisions out of context for the smaller sites can usually justify a 'no significant impact' result. There is limited knowledge on threats to biodiversity values. Predicting impact and identifying the most appropriate management approach is difficult.

- The decision-makers lack of resources and knowledge on what the biodiversity values are, their habitat requirements, ecological processes and potential threats in the area being assessed.
- Different methodologies and levels of survey effort results in difficulty comparing case based surveys and restricts data gathering opportunities for decision-makers. Different approaches to classifying vegetation community's makes the results difficult to compare with other assessments, including regionally based conservation assessments.

Regional assessments are carried out at a range of scales and could include activities such as:

- Plan making under the EP&A Act (Part 3).
- Recovery Plans, Threat Abatement Plans under the TSC Act and EPBC Act.
- Plans of management – SCA, NPWS, Council and Environment Australia.
- Specific plans of management for fire, weeds, pests etc.
- RVMPs under the NVC Act.
- Ecological audit – SCA.
- Catchment Management Plans.
- Reserve planning – NPWS.
- Bioregional plans.

As stated above not all these activities will use regional biodiversity information in their preparation, often because the information is not available. Where the information is available, it may involve vegetation mapping and historical records of threatened species. It rarely incorporates a comprehensive database that has been assessed, interpreted and presented for implementation.

In its simplest form the questions to be asked when preparing regional planning documents and ensuring adequate contextual information for case based decisions are what percentage of a population/community requires protection and which areas are to be protected/managed.

Regional biodiversity data required for case based and regional assessments includes:

- Mapping the vegetation communities across their range. Provides valuable information identifying potential biodiversity values and issues for consideration for decision-makers. Provides the basis for management of many threatened species (e.g. fire management plans). Modelling and assessment enables calculations of compliance with identified conservation targets (JANIS).
- What species recorded where? Identifies range extent and habitat requirements/potential.
- The condition of the vegetation community – understorey, weeds, fire, regeneration, evidence of logging. Provides guidance on prioritising management activities and the protection on areas of better condition. Assists in habitat assessment and could be useful for long term audit/monitoring – dependent on management performance criteria.

- Species, populations or communities of significance. To identify significance there is a need for broader contextual information. Significance should not be limited to those matters listed under the EPBC and TSC Acts and could include regional and local significance, limit of distribution, centres of endemism etc.
- For species of significance distribution information should address local connectivity, occurrence in the wider region and full extent of the distribution.
- The distribution of significant species, population and communities being assessed in conservation reserves or protected areas within the region.

Ecological questions including habitat requirements, life cycle and population viability arise with this information when considering planning and land management questions.

3.2 Landuse Planning Vs Land Management Planning

Documents such as SREP 20 and the Draft REP provide a landuse planning framework. Ideally these documents should assess regional biodiversity values and provide transparent directions on the most appropriate use of the land, including biodiversity conservation. To provide this they need to know what are the values and what areas need what level of protection.

A clear understanding of threats may assist in identifying the most appropriate land use to be applied at a location. Processes for site-specific assessment for particular areas and key performance criteria may be identified. For example, do certain areas provide habitat for a particular species or do they provide corridor/connectivity values? If so what is the performance objectives/criteria – e.g. minimise fragmentation, maintain canopy cover?

More specific information is required for management planning including weed or pest species management plans, reserve plans and community land plans of management. Management plans often require a regional context to enable prioritisation of activities and to highlight potential issues. Weed management and bush regeneration are clear examples where the efficient use of resources is facilitated by regional prioritisation based on conservation values, threats and potential effectiveness. Planning hazard reduction burns also benefits from an understanding of communities and species of significance occurring in certain areas and their fire management requirements (e.g. inter fire periods).

There is insufficient information available to answer these land use planning and management questions. Regional biodiversity data is required (as described above) to give clear guidance on significance, extent of distribution, current level of reservation and condition.

3.3 Role of a Vegetation Map

Vegetation mapping provides the basis for many regional biodiversity planning and management decisions. Vegetation maps indicate the spatial variability and extent of communities and habitat. With sufficient knowledge of habitat requirements and environmental variables covering the landscape a range of modelling exercises can be undertaken to add value to the mapping. The distribution of threatened species can be

modelled and assessments carried out on key conservation performance targets (such as NFPS/JANIS. CoA, 1997).

Vegetation mapping provides assistance to the case based decision makers to identify vegetation communities having a high probability of a species of interest occurring or providing habitat for threatened species. They can check that case based studies have targeted the necessary species in their assessments.

Regional vegetation mapping projects have usually focused on forest types. Results of the consultation indicated the need for inclusion of grasslands and other non-forest communities to the vegetation map, as they often exhibit considerable ecological value and are an issue in parts of the study area (e.g. around Goulburn). It was also suggested that the management of riparian areas would be supported by a more comprehensive classification of these communities.

3.4 Data Limitations

There are many limitations in the collection of data, mapping and interpretation of information that need to be clearly understood by land managers and decision-makers. When making case based decisions it must be recognised that information provided by regional assessments requires validation.

Limitations include *inter alia*:

- The mapping of remnants from aerial photos involves some subjectivity.
- There is distortion at the edges of aerial photos.
- They identify boundaries when in practice there is likely to be a transition in vegetation communities.
- The age of the photos by the time the final map has been produced means that significant clearing or regrowth may have occurred.
- Currently only remnants over a certain size are mapped.
- Technical limitations in transferring the API mapped remnants to a digital layer.
- The quality and accuracy of the baseline physical environmental data is variable. Vegetation community modelling uses this data.
- There are problems of accuracy in modelling areas that have a lack of native vegetation remaining.
- The sites selected for survey are based on a stratification of physical environmental variables – may not include some rare communities in the map.
- Accuracy of site data affected by different observer artefacts.
- Matching modelled vegetation to remnant vegetation identified in the API in areas that do not provide one clear community outcome.
- Comparing results with different vegetation maps is problematic due to possible differences in survey and analysis techniques.

Comments relating to the limitations of the data include the need to describe the limitations so that the users know how they can use the map and what assumptions have been made. It is suggested that mapping provides an indication of likely vegetation communities for case based assessment and that field validation is undertaken on a site

specific basis. A number of respondents have examples of where information is out of date and recognised the difficulty of a static product in a very dynamic landscape.

The limitations of data mean vegetation maps provides a comprehensive approach to regional assessment to identify conservation values, issues and areas that need to be validated for case based assessments. It is important to ensure that regional plans recognise and allow for these limitations in the development of plans and planning instruments.

As a consequence of changes to the landscape between the time when aerial photos are flown and maps produced there are likely to be considerable changes to the location and extent of remnants as land clearing or regeneration may have taken place. It is suggested that the API component requires the latest aerial photos to ensure mapping is of the highest currency.

3.5 Data Management

The most common use of the data was where environmental staff use the hard copy map for case based decisions where they were not familiar with the site and the digital information is rarely called upon. Other end users of the final mapped product may store digital information within their GIS team (where they had one) and then ask for maps to be extracted as required. State agencies usually had sufficient GIS capability to analyse the data for their specific needs and many staff could extract basic mapped products where required.

A number of people consulted, in expressing their concern over how quickly the information goes out of date, suggested that they need to know how to update the information for their own purposes. Data updates on the vegetation mapping could be carried out on the extent of a particular community and the classification (community type and condition - based on identified criteria and method). This information could be fed back to the central agency that is to analyse the information.

Another question arises over access to the information contained within the mapped product. Some data is under licence agreement and would be available through the appropriate channels however data such as survey plots locations, floristics, weed presence etc is not generally made available. If the capability to use the data was available then land managers could obtain addition information on the areas being assessed.

The question of data management and empowering the end user to get more out of the information and play a role in updating data is one that needs further consideration.

Data produced by vegetation mapping projects is typically of 3 types:

- Full floristic site data
- Environmental GIS database
- Map of vegetation communities

Generally the first two data sources are rarely made available to users outside of the custodian organisation. The site data is difficult to utilise by the general users, being a raw research-based product. Whilst the environmental GIS database is likely to be

valuable to a host of end users typically this data is under licence from other organisations and as such can not be passed on to third parties.

The vegetation map is the key product and contains information most likely to be useful in the planning decision making process. A number of issues have been identified relating to the final mapped product:

- Updating the information
- Interpreting the information
- Formats of the information

Concern has been expressed that a vegetation map can rapidly become out of date through either changes in extant vegetation or site specific vegetation community information. Two options exist for updating this information. Firstly end users can be trained as to how to update this information directly within a GIS system. The major problem here being that this information may only be recorded at the local level and is difficult to compare to the regional product. The preferred option would be to instigate a process whereby the data custodian is officially informed of any required modifications (using the specified format), make these modifications and provides the end user with the updated information. The key benefit here is that an up to date master layer is then available from a single organisation rather than there being pockets of updates scattered throughout the variety of end users. Regular audits would need to be carried out where the mapping revisions are checked for accuracy and consistency.

The data needs to be stored, managed and updated at the one location to enable the product to remain viable across a dynamic landscape.

Inappropriate interpretation of information is of concern particularly where it is used in the planning decision making process. Importantly end users must be educated that in many cases the map maybe indicative only and that site-specific field validation may be required.

Traditionally vegetation maps have been made available to end users in hardcopy format. With the improvements in GIS systems it is now possible to provide this information digitally. This can greatly assist land managers and is likely to be a valuable resource despite being fraught with the dangers of misinterpretation and inconsistent updates.

3.6 Policy Framework

A number of statutory and policy instruments address biodiversity management. They range from the broad principle statements to describing statutory assessment processes to plans and planning instruments.

The international and national context for biodiversity management includes:

- Japan–Australia Migratory Bird Agreement (JAMBA) and China–Australia Migratory Bird Agreement (CAMBA).
- International Convention on Biological Diversity.
- International Declaration on Environment and Development and Agenda 21.
- Ramsar Convention – Wetlands of International Importance as waterfowl Habitat.

- Intergovernmental Agreement on the Environment (IGAE).
- Commonwealth Environment Protection and Biodiversity Conservation Act, 1999 (EPBC Act).
- National Strategy for the Conservation of Australia's Biological Diversity.
- National Local Government Biodiversity Strategy.
- National Forest Policy Statement (NFPS).

A number of other national strategies and policies are relevant to the management and conservation of biodiversity including the Commonwealth *Wetlands Policy*, *National Water Quality Management Strategy*, and the *National Weeds Strategy*.

Most of these identify broad policy statements that outline principles for the management of biodiversity. Of more interest is the NFPS that identifies more specific criteria.

The Commonwealth Government, in their National Forest Policy Statement (NFPS), provide an undertaking to manage Australia's forests to conserve biological diversity. In order to achieve this it was agreed that a comprehensive, adequate and representative (CAR) reserve system be created. To achieve a CAR reserve system a number of criteria were developed that included, such as:

- Target the protection of 15% of the area of each forest type ecosystem? as existed before European arrival (referred to as pre-1750).
- Maintain ecological processes and the dynamics of forest ecosystems across their landscape context.
- Maintain viable examples of forest ecosystems throughout their natural ranges.
- The reserve system should seek to maximise the area of high quality habitat for all known elements of biodiversity.
- Reserves should be large enough to sustain the viability, quality and integrity of populations. It is recognised however that it is immensely difficult to collect sufficient data to confidently describe the conservation requirements of all species.

The NFPS recognises the need to promote the management of forests on private land to meet the conservation goals. It is important to note that its focus is on forests and not other communities such as heath, grassland, wetlands etc.

The conservation target of 15% of pre-1750 vegetation for forest communities provides clear direction for identifying the area that needs to be protected. In order to answer this question the pre1750 distribution of vegetation communities needs to be modelled based on a comprehensive set of environmental variables. The percent extant that is reserved or protected is useful in determining targets for regional conservation planning.

The State policy context is discussed earlier in this document but of particular note is the TSC Act that triggers an assessment process for listed species, populations and communities. The TSC Act also provides statutory direction in the preparation of recovery plans. By their very nature recovery plans provide a type of target for the subject species or their habitat.

It is worth mentioning that the NVC Act provides for the development of Regional Vegetation Management Plans, development of biodiversity objectives and management strategies.

As previously discussed the identification of biodiversity values of significance should not be limited to those values listed under the legislation but should include those of regional and local significance. Consideration should also be given to the protection and enhancement of ecological processes related to these values. In developing regional plans there should be clearly identified targets and objectives based on sound biodiversity planning principles and established policy.

3.7 Monitoring

The Sydney Water Catchment Management Act requires regular audits of the catchments at intervals of no longer than 2 years. The Regulations provide for the maintenance of the ecological integrity and other values of the areas of land declared as Special Areas. One of the objectives of the environmental plan developed under the Act states that environmental performance will be monitored. A set of environmental indicators have recently been adopted by SCA to address ecological health of the catchment areas, including vegetation cover, riparian zones and water quality.

A comprehensive monitoring program is required to adequately address the questions of environmental performance over time and to be able to state if the ecological integrity and values of the catchments have been maintained. Long term monitoring could include changes in vegetation cover, floristics, presence and distribution of threatened species, endangered populations and endangered ecological communities, spread of weeds and pest species and the status of ecological processes (e.g. fire regimes).

The approach to monitoring the values and condition of the Greater Blue Mountains World Heritage Area (GBMWHA) has not yet been developed. Permanent plots could be located in strategic locations that are likely to be subject to ongoing pressures/threats or management improvements to provide some baseline information on what, where and how to undertake monitoring in the GBMWHA. To ensure a scientifically robust analysis control sites should be established in areas that are not likely to be greatly impacted. Likely changes to the values and condition could result from edge effects from development intensification around the boundaries, spread of weeds and fire.

Fire managers suggested that the most important information they can be provided with is for the sites to be accurately marked so they can be used for longer term assessments on the impacts of fire (different intervals and intensities of fire). It was also suggested that information on post fire responses were useful if observations on what was resprouting (seedlings for a year or two after fire) or flowering (5-10 years after fire).

Operational staff dealing with fire planning and hazard management identified the need for good data that links fuel load and community type/structure and suggested this could be facilitated by collecting additional basic information on fuel loads at each site (0-12 tonnes, 12-25 tonnes or 25+ tonnes).

DLWC requires monitoring of vegetation clearance with the implementation of the NVC Act and preparation of RVMPs. The question of monitoring is difficult and usually either

occurs in an adhoc way or through resurveying targeted areas. The monitoring of vegetation is likely to become more efficient in the future as GIS and remote sensing technologies advance.

3.8 Interpretation and Education

Many of the individuals consulted expressed the need for education and training as they had a lack of resources and skills to understand and use the information. Many stated that they wanted to know what the data meant and how to interpret it. Questions like what percentage of a particular vegetation community should be conserved, where shall they focus their efforts and which areas do they zone 'environment protection' reveal the complexity of the information and comprehension required to make strategic planning decisions from the mapping.

Some mapping has previously been provided with different vegetation community classifications thereby making it difficult to use and compare previous documents without a thorough understanding of the species floristics. Eventhough the community descriptions have been compared in supporting interpretation documentation it results in these individuals requiring an ecological background.

Consultation also identified the need for modelling of threatened fauna habitat to assist in developing information for possible regional planning decisions, assess potential issues of corridors and flag issues for the case based assessments.

Questions over what the most appropriate flora species should be planted at a given location came up on a few separate occasions and it was thought that a map of the pre1750 distribution of communities could assist in providing advice to operational staff and interested members of the public.

Individuals recognised that they need to incorporate results of vegetation mapping into planning instruments but were unsure how to do it? They felt it would be easier to provide them with a map of areas that require special attention – that is an analysis of conservation values is provided to end users. Vegetation maps can provide assessments of vegetation communities and how they compare to conservation targets, location of endangered ecological communities (TSC Act) etc but the decisions on the most appropriate land use planning outcome needs to develop more specific objectives and targets from the land manager. Things to consider also include:

- Viability – the ecological information required to answer this question is most likely not available but general principles on size and shape can be applied. That is larger remnants are more viable and finger like fragments (higher edge to area ratios) are less viable. Mapping can provide the extent of these remnants to assist in this assessment.
- Connectivity – mapping can provide some of this information however the problems arise where fragments less that the minimum patch size being mapped are available for connectivity.
- Threats – development and landuse pressures, water quality issues, etc. Mapping does not provide an indication of threats but current landuse in association with vegetation mapping should assist in identifying the planning and management needs.

- Condition – the value of a particular remnant may also be affected by its condition, such as absence of understorey, weed growth etc. Information on remnants that support canopy cover only can be provided through the API process when developing the vegetation map. This information can be used to identify the level of regeneration required (if any).
- Presence of other values including threatened species and ecological processes will assist in identifying appropriate landuse planning outcomes.

3.9 Condition

A number of individuals consulted would like a variety of condition characteristics recorded by vegetation surveys. It was felt that this information could assist in regional planning and identifying priority areas for management activities.

Weeds

The approach to collecting information on weeds at survey sites may provide an indication of the types of weeds present in a particular vegetation community and landscape type but it does not provide an opportunity to model the regional distribution of weeds and relative condition across the whole landscape. The recording of weeds at survey sites provides raw data available to land managers (if they can access this information) on the types of species present in a particular area. It does not allow prioritisation of management resources and provides little assistance to case based assessments

To enable a regional approach to weed management the presence of woody weeds can be mapped from API. Prioritisation of weed management activities can then be based on information including conservation values and priorities of the vegetation/habitat, extent of weed invasion, etc and weigh that up with practical consideration of community support, access, likelihood of success, etc.

Understorey Characteristics

The presence or absence of an understorey can be mapped form API and would assist in the development of regional planning tools. Areas that represent a remnant canopy with an intact understorey offer vastly different habitat and corridor values for many species. Areas that support a remnant canopy but no intact understorey are likely to be more capable of regeneration for improved viability, connectivity and habitat diversity. It is more efficient to regenerate an area that has maintained a canopy than a totally cleared area.

Regionally based assessments can benefit from this information through providing an indication of potential regeneration areas that may improve connectivity and increase available habitat to focus landuse planning and management decisions.

Grazing and logging

Records of grazing and logging at survey locations provide additional condition data at the site but has limited use for the case based decisions in this format. Regional planning may use this information to identify threats and habitat condition but it would need to be provided at the regional scale to be of any use. Information on grazing and logging is difficult to obtain comprehensively across a region where there is a dependency on the modelling approach to mapping.

Regrowth
Identifying areas of regrowth indicates past disturbance and the possible removal of a threat. It provides an indication of areas offering rehabilitation potential. Recording regrowth provides an opportunity to monitor response of certain communities to disturbance if repeat survey work is undertaken (would need to know the exact location of the plot).

Evidence of Fire
Evidence of fire does not in itself affect conservation planning decisions except perhaps where there is an indication of the fire interval or threat. If an area is recognised as being at risk from increased fire intervals then developments can incorporate fire management planning principles in their developable footprint, such as locations, buffers, etc. Recent fire may alter the floristic structure and habitat of a site, but this is dependent on factors including the values of the site to begin with and the intensity of the fire. Evidence of what is resprouting or flowering following fire provides opportunities for long term monitoring of different species and vegetation communities' response to fire. Mapping fire history including time, extent and intensity of fires as they occur is useful for long term ecological management.

3.10 Minimum Patch Size

The question of what is the most appropriate minimum patch size to delineate from API work affects not just the scale of aerial photos required but has a significant impact on the validity of the data, what it can be used for and the amount of work involved.

Mapping remnants of 10 ha (100,000m^2) or larger provides a broad regional context for assessment of conservation value but there is likely to be insufficient information for many of the strategic regional planning processes (such as SLWCAs and RVMPs). API focusing on remnants of this size are likely to miss a number of vegetation communities and under sample pockets of vegetation that have specific ecological requirements (including rainforest gullies, fingers of riparian vegetation, etc). There is an argument that these specialised communities are likely to have higher conservation values and smaller remnants require greater strategic management attention.

Mapping remnants 2 ha (20,000m^2) or larger provides a more appropriate scale that could be used to identify regional context and strategic planning. More specific decisions on a local area are unlikely to be covered, particularly in highly fragmented areas that are subject to development/clearing pressures. Communities of conservation significance may still be under sampled although to a lesser extent than if a 10Ha minimum patch size was used. It still can be imagined that many of the issues to be addressed in a SLWCA or RVMP could involve remnants that are smaller than 2ha.

To map all vegetation remnants of a size of 0.5 ha (5,000m^2) or larger provides a map that classifies a larger proportion of the extant vegetation. In a landscape where there is considerable fragmentation, this provides more detail than limiting the mapping to larger remnants. The opportunity is there for the product to be more useful for a range of planning and management decisions.

Mapping with this minimum patch size provides comprehensive information at a scale that provides a regional context whilst facilitates most planning and management decisions down to a local level. It also provides an excellent framework for the smaller site specific and case based decisions by looking at connectivity, relative condition etc in the local area.

It is still important to recognise that a scale of 0.5 Ha will still miss small remnants that may provide important biodiversity values. Areas of weed infestation may still be missed using this scale. It is understood that mapping of condition is likely to require mapping to at least this scale.

The difficulty in mixing the minimum patch size used in the mapping across the landscape is that comparisons and assessments become difficult.

3.11 Scale of Aerial Photos

It has been shown that 1:16,000 provides sufficient scale to map 0.5 ha remnants and 1:25,000 for 2ha remnants or larger. Therefore to some extent the decision on patch size will dictate the most desirable API scale. (or vice-versa, if photos are already available). It is understood that the SCA is flying the entire hydrological catchments at 1:40,000.

3.12 Cover Abundance

Different vegetation surveys have used different classification systems for Braun-Blanquet cover abundance – usually either six or seven classes. The classification into six classes is preferred by NPWS and can compare with the seven classes approach by reclassification of these to six classes.

The primary aim of allocating cover abundance scores is to facilitate statistical analysis of species distributions at each site. This information becomes the basis of a pattern analysis that is used to identify vegetation communities based on species composition.

4. MAPPING CRITERIA

Based on the user requirements a number of consistent criteria and methods are recommended for the Hawkesbury - Nepean and Shoalhaven catchments vegetation mapping project. These have been classified in the context of their role in producing the final map. They include:

Data Audit

- Obtain existing survey site data
- Obtain most recent aerial photos
- Produce a GIS database of relevant environmental information

Aerial Photo Interpretation

- Minimum patch size of not greater than 0.5 Ha – consider mapping to a finer scale if information and resources are available
- Identify dominant canopy species and understorey characteristics
- Assign condition classes to remnant vegetation
- Map woody weeds
- Use most up to date aerial photos available
- Map non-forest communities eg. Grassland and wetlands
- Map other landscape features including rocky complexes and landuse (urban vs rural)

Field Survey

- Undertake an environmentally stratified systematic vegetation survey program that samples the full range of physiographic variables likely to be associated with floristic variation
- Maintain conventional plot sizes (0.04Ha) to enable comparison with existing data
- Survey full floristics and assign cover abundance values to individual species
- Record disturbance at each site
- Record physiographic details
- Record locational details of each site ensuring a high degree of spatial accuracy
- Take a photo of each site

Analysis

- Undertake a pattern analysis of species composition at each site to define community assemblages
- Allocate communities to each survey site
- Model the distribution of vegetation communities across the study area in relation to environmental variation

- Use this information to spatially interpolate pre1750 and extant community distributions
- Expert review and field validation of mapping products

Additional

- Map locations of threatened species, populations and EEC's
- Relate vegetation assemblages to those in neighbouring regions
- Identify communities that don't meet recognised targets
- Report on methodology, limitations and interpretation
- Consider the implementation of long term monitoring plots
- Develop the approach for data management, distribution and review prior to carrying out project

This methodology is consistent with the current methodology developed by David Keith and Michael Bedward of the NSW NPWS. This methodology has successfully been implemented on a variety of regional and locally based vegetation mapping projects. The main questions that arise in the development of the mapping criteria for the Hawkesbury - Nepean and Shoalhaven catchments relate to the selection of an appropriate minimum patch size (and resultant API scale). The four options put forward are:

Option A
A complete coverage of 0.5ha minimum patch size and using aerial photos at a 1:16000 scale.

Option B
A complete coverage of 2ha minimum patch size with 1:25,000 scale aerial photos.

Option C
A complete coverage of 10ha minimum patch size with 2ha on private land.

Option D
A coverage of 10ha minimum patch size on public land with 2ha in rare forest types and rainforest and 0.5ha in areas of high development/clearing threat.

Note: Option A will provide a level of detail that will ensure the highest level of usefulness of the final mapping product. As discussed earlier mapping at a larger scale will exclude many features and reduce the resolution of the final product thereby limiting its usefulness.

5. COMPILE EXISTING INFORMATION

This component focuses on gathering information currently available across the Hawkesbury - Nepean and Shoalhaven Catchments so as to review the data and establish a solid data resource to support future data acquisition and analysis.

5.1 Geographical Information System Environmental Database.

A Geographic Information System (GIS) environmental database has been compiled covering the Hawkesbury - Nepean and Shoalhaven Catchment areas. The Table in **Appendix B** lists and describes environmental data layers that have been compiled at a 25 metre grid cell resolution. These data layers were derived in the following way:

- Terrain variables including topographic position, roughness index, slope, aspect, solar radiation indices are derived from a 25m grid digital elevation model supplied by the NSW Land Information Centre.
- Climatic surfaces were derived using ESOCLIM (Hutchinson 1989). This produces layers describing mean annual figures as well as coldest, hottest, driest and wettest months. The Bureau of Meteorology provided rainfall and temperature data.
- Dominant Geological features were grouped from 1:250,000 Geological state wide mapping. These data layers were supplied by the Department of Mineral Resources.
- Other variables may be generated directly in the Arcview GIS system to provide a grid for easting and northing values and to generate layers indicating distance from features including streams and the coastline.

The use of an environmental database as part of a vegetation mapping project is twofold. Firstly, this information is used to develop an environmental stratification of the study area to aid in sampling the full range of environmental variation across the study area. Secondly, the data is used during the modelling phase to spatially interpolate the distribution of vegetation communities based on relationships to environmental variables.

5.2 Floristic Survey Data Sets.

An audit of all vegetation datasets available within the study area was undertaken, the results of which are included as **Appendix C**. Datasets that contain systematic survey sites were identified, analysed and are listed in the table below.

Reference:	Data Set Source	Quadrat_size	No.of plots	Floristics	Cover abundance
Bell, S.A.J. (1998b).	ALLWOLL	0.04ha	410	Full floristics	Braun-Blanquet C/A 1-6
Bell, S.A.J. (unpublished)	BELLEXTRA	0.04ha	8	Full floristics	Braun-Blanquet C/A 1-6
AMBS. (1997).	Bioind	0.04ha	299	Full floristics	Percentage Cover
Tozer, M. G. (199b).	CAMP	0.04ha	90	Full floristics	Unknown Braun-Blanquet C/A
Ann Clements (for Blue Mountains City Council)	CLEM99	Unknown	37	Full floristics	Unknown Braun-Blanquet C/A
NPWS (1999).	CRAHUN	0.04ha	291	Full floristics	Braun-Blanquet C/A 1-6
Helman, C.E. (1983).	CS_CLYDE	0.1ha	125	Full floristics	3 - level abundance rating (1=occasional, 2=common, 3=very common to abundant)
CSIRO (unpublished).	CS_JAP	0.1ha?	47	Full floristics	Unknown Braun-Blanquet C/A
Cohn, J.S. & Hastings, S.M (1993).	CUMB	0.04ha	112	Full floristics	Unknown Braun-Blanquet C/A
Clarke, P. J. (1989).	Clarke_coast	0.04ha	48	Full floristics	Unknown Braun-Blanquet C/A
Clarke, P.J. & Benson, D.H. (1986).	DHARUG	0.04ha	45	Full floristics	Braun-Blanquet C/A
Smith, P. & Smith, J. (2000).	DUFFYS	0.04ha	32	Full floristics	Braun-Blanquet C/A 1-6
Washington, H. (2001).	Gardensofstone	0.04ha - nested quadrat	82	Full floristics	Relative abundance
Wollongong City Council (unpublished).	ILLAWARRA	0.04ha	In progress (so far 131)	Full floristics	Braun-Blanquet C/A 1-7
Steenbecke, G. L. (1990).	Kowmung	0.04ha	150	Full floristics	Braun-Blanquet C/A
Binns, D. (1996).	MORREIS	0.1ha	146	Full floristics	Braun-Blanquet C/A 1-6
Bell, S.A.J. (unpublished).	Manobalai	0.04ha	23	Full floristics	Braun-Blanquet C/A 1-6
Bell, S.A.J. (unpublished).	Mount Piper	0.04ha	43	Full floristics	Braun-Blanquet C/A 1-6
Bell, S.A.J. (unpublished).	Myambat	0.04ha	22	Full floristics	Braun-Blanquet C/A 1-6
NPWS (2000b).	NP_DEUA	0.1ha	87	Full floristics	unknown (cover abundance)
NPWS (2000b).	NP_SCRA	0.04-0.1ha	680	Full floristics	Braun-Blanquet C/A
Bell, S., Vollmer, J. & Gellie, N. (1993).	NTHYENGO	0.04ha	92	Full floristics	Braun-Blanquet C/A 1-6
Nic Gellie (unpublished).	Nic Gellie	0.04ha	28	Full floristics	Braun-Blanquet C/A 1-7
Keith, D. A. (1994).	OHARES	0.04ha	56	Full floristics	Braun-Blanquet C/A1-7?
Bell, S.A.J. (1998a).	POPRAN	0.04ha	143	Full floristics	Braun-Blanquet C/A 1-6
Robert Payne (unpublished).	R PAYNE	0.04ha	27	Full floristics	Braun-Blanquet C/A 1-7
NPWS (2000a).	REMS	0.04ha	57	Full floristics	Braun-Blanquet C/A 1-6
NPWS (2000b).	SF_QFS	0.1ha	75	Full floristics	Unknown Braun-Blanquet C/A
Sydney Catchment Authority (unpublished).	SYDWATER	0.04ha	344	full floristics	Braun-Blanquet C/A
Tozer, M. G. (1999a).	WESTSYD	0.04ha	384	full floristics	Braun-Blanquet C/A 1-7
Tozer, M. G. (1999a) (additional).	WESTSYD2	0.04ha	19	Full floristics	Braun-Blanquet C/A 1-7
Wyong City Council (unpublished).	WYONG SHIR	0.04ha	86	Full floristics	Braun-Blanquet C/A 1-7
Baulkham Hills City Council (unpublished).	Baulkham	0.04ha	In progress (so far 60)	Full floristics	Unknown Braun-Blanquet C/A
Blue Mountains City Council (unpublished).	BMCC	0.04ha	In progress (so far 178)	Full floristics	Braun-Blanquet C/A 1-6
Benson, D.H (1992). Benson, D.H. & Howell, J. (1994a). Benson, D.H. & Howell, J. (1994b). Benson, D.H. & Howell, J. (1994c). Benson, D.H. & Keith, D.A. (1990). Fisher, M. & Ryan, K. (1994). Fisher, M. & Ryan, K. & Schaeper, L. (1994). Fisher, M., Ryan, K. & Lembit, R. (1995). Ryan, K. Fisher, M. & Schaper, L (1996). Keith, D.A. & Benson, D.H. (1988). K. Fisher, M. & Schaper, L (1996).	RBG 1:100k series	0.04 - 0.1 ha	371	Full floristics	Braun-Blanquet/Relative abundance/actual count

There are 4,637 individual systematic survey sites carried out by 36 different vegetation surveys that have been compiled into a single GIS data layer for this project. It includes information on the data source and methodology used. **Figure 2** indicates the location of the systematic survey sites across the study area.

5.3 Aerial Photo Interpretation.

An audit of vegetation coverage's including Aerial Photograph Interpretation (API) layers was undertaken across the study area. All vegetation coverage's were subject to general evaluations of parameters describing dominant canopy species, understorey characteristics, disturbance characteristics as well as minimum mapping unit, scale and date of imagery used (see below).

	Dominant canopy species classes	Understorey characteristics	Disturbance characteristics	Patch size	Scale of imagery	Date of imagery
Western Sydney	✔	✔	✔	0.5ha	1:16000	1997/1998
Illawarra COI (in progress)	✔	✔	✔	0.5ha	1:16000	2001
Southern Forest Ecosystem mapping (CRAFTI)	✔	✔	✔	10ha (2ha)	1:25000 (in some areas 1:50000)	not reported, most photos <2 yrs old, but some > 4 yrs old.
Sydney Catchment Authority Special Areas (in progress)	✔	✔	✔	10ha(2ha) In progress	1:25000 In progress	Unknown In progress
P5MA	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Blue Mountains City Council	Unknown	Unknown	Unknown	Unknown	1:16000	1998
Kowmung	✔	✖	✖	2 ha	1:50000	1972 &1977
Dharug NP	✔	✖	✖	Unknown	1:16000	1979
Jamison Valley	✖	✔	✔	N/A	1:25000	1994
Marramarra NP	✖	✖	✖	Unknown	Unknown	Unknown
Brisbane Waters NP	✖	✖	✖	Unknown	1:25000 (1:50000 published)	1976
Wollemi NP	✖	✖	✖	Unknown	1:25000	1982-1984
Blue Mountains Area	✖	✖	✖	Unknown	1:25000	Unknown
Nattai Vegetation coverage	✖	✖	✖	Unknown	Unknown	Unknown
Popran NP	✖	✖	✖	Unknown	Unknown	Unknown
Royal Botanic Gardens 100k series	✖	✖	✖	c. 10ha	1:40000Katoomba 1:16000 W"gong Moss Vale & Kiama, not stated 1:50000 Goulburn & Braidwood 1:25000 & 1:60000 Taralga 1:50000 Burragorang 1:40000 Penrith 1:25000 St Albans 1:40000 Walerawang	1979/80 1982 1969-1970, 1993 1991-1993 1990-1972, 1992 1981 1979, 1988, 1989 1991 1975

Of these only four provide dominant canopy species, understorey and disturbance characteristics. These 4 API layers have been reviewed against the recommended mapping criteria options defined above for patch size and API scale.

Mudgee
Singleton
Cessnock
Newcastle
Bathurst
Gosford
Sydney
Wollongong
Bowral
Goulburn
Canberra
Ulladulla
Batemans Bay
Moruya

0 20 40 60 Kilometres

Legend

- Site locations
- Towns
- Coastline
- Hawkesbury/Nepean & Shoalhaven Catchments
- National Parks & Wildlife Estate

Hawkesbury/Nepean &
Shoalhaven Catchments Scoping Study

Figure 2 - Existing Systematic Sites

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Scale 1 : 1, 250, 000

Printed by Conservation, Assessment & Data Unit, Central. June 2001

Vegetation coverage's selection criteria.

Coverage	Mapping criteria Option A	Mapping criteria Option B	Mapping criteria Option C	Mapping criteria Option D
Western Sydney	✔	✖	✖	✔
Illawarra COI (in progress)	✔	✖	✖	✔
Southern Forest Ecosystem mapping (CRAFTI)	✖	✖	✔	✔
Sydney Catchment Authority Special Areas (in progress)	✖	✖	✔	✔
Area covered (%)	2%	0%	23%	32%

Option A - A complete coverage of 0.5ha minimum patch size and using aerial photos at a 1:16000 scale.

Option B - A complete coverage of 2ha minimum patch size with 1:25,000 scale aerial photos.

Option C - A complete coverage of 10ha minimum patch size with 2ha on private land.

Option D - A coverage of 10ha minimum patch size on public land with 2ha in rare forest types and rainforest and 0.5ha in areas of high development/clearing threat.

The audit indicates that very few of the layers meet the recommended options for mapping criteria. It is also clear that very few are less than 10 years old and contain only general information. Two of the layers (Western Sydney & Illawarra) satisfy criteria under option A (0.5 ha patch size and 1:16000 API) covering approximately 2% of the total area of the Hawkesbury - Nepean and Shoalhaven catchments. There are no layers that satisfy criteria B (2ha patch size and 1:25,000 API). The Southern Forest Ecosystems mapping (CRAFTI) in combination with the Sydney Catchment Authority Special Areas Mapping (in progress) covers approximately 23% of the catchments, containing the information needed for criteria C (10ha patch size and 2ha on private land). A total of 32% of the study area is covered by the combined coverage's in criteria A and C satisfying the information needed for criteria D (0.5 ha patch size in areas of high development, 2 ha in rare forest types and 10ha on private land).

Several vegetation coverage's are available that partially cover the study area as shown in **Figure 3**.

6. LINKS WITH CONCURRENT MAPPING PROJECTS

A number of concurrent projects are already planned or under way within or adjoining the study area. It is fundamental that the methods of concurrent projects be compatible, across projects, so that data can be shared and reused avoiding the need to resurvey areas. The table below indicates projects that are planned or under way across the study area, as well as their individual percentage area overlap of the study area. The area covered by these projects is mapped in **Figure 3**.

Project	Custodian	Area (ha)	Percentage Area Overlap
Illawarra COI	Wollongong Council	71545	2%
Wingecarribee LGA	Wingecarribee Council	269093	9%
Blue Mountains LGA	Blue Mountains Council	143262	5%
Hornsby LGA	Hornsby Council	50669	2%
Baulkham Hills LGA	Baulkham Hills Council	40066	1%
SCA Special Areas	Sydney Catchment Authority	367849	13%
DLWC P5MA	Department of Land And Water Conservation	2629131	61%
Unsurveyed		1080018	37%

Mudgee
Singleton
Cessnock
Newcastle
Bathurst
Gosford
Sydney
Wollongong
Bowral
Goulburn
Canberra
Ulladulla
Batemans Bay
Moruya

0 20 40 60 Kilometres

Legend

- Coast
- Towns
- Hawkesbury/Nepean & Shoalhaven Catchments
- Illawarra COI
- Wingecarribee LGA
- SCA Special Areas
- Blue Mountains LGA
- Hornsby LGA
- Baulkham Hills LGA
- DLWC Priority 5 Mapping Area
- Vegetation Cover

Hawkesbury/Nepean &
Shoalhaven Catchments Scoping Study

Figure 3 - Current Vegetation Projects

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Scale 1 : 1, 250, 000

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7. NEW WORK REQUIRED

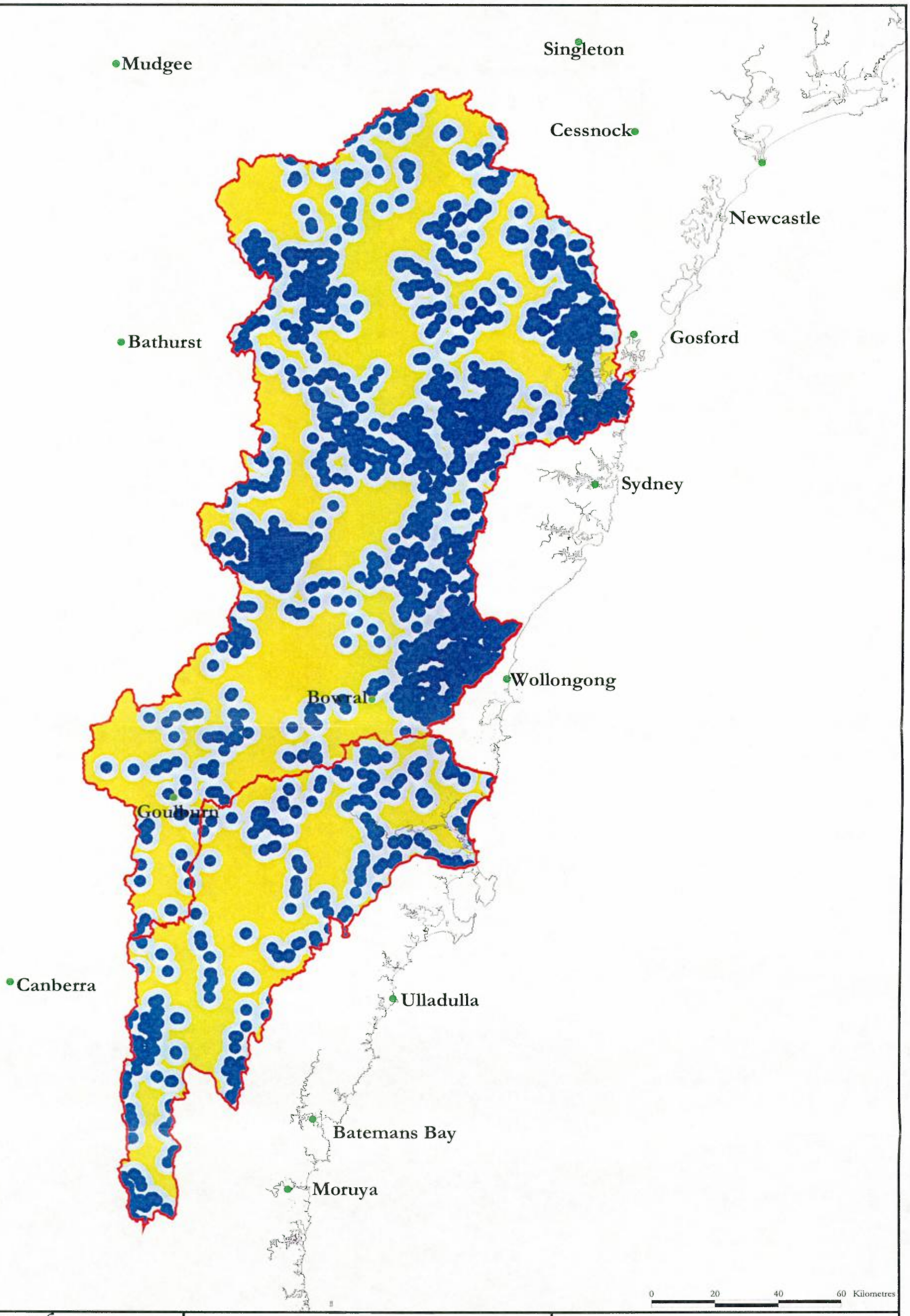
This section outlines additional work required to fill data gaps identified by the data audit process.

Floristic data
Systematic field survey enables the researcher to draw statistical conclusions about the presence and absence of species in different habitats and environments, enabling the extrapolation of species/vegetation communities across different types of environmental conditions. This approach seeks to sample the widest variation in plant communities present in the study area while having sufficient replication to explain them. A field survey program needs to be planned in order to sample major spatial and environmental gaps in site coverage across the study area.

There are several ways to identify and locate areas that are deficient in sampling. The first is to locate the sites spatially in the landscape and pick out the areas where sites don't occur (**Figure 4**). An alternative method is to environmentally stratify an area and perform analyses to highlight areas deficient in sampling. Development of the stratification and sampling regime needs to consider existing data, recent mapping, data objectives and financial resources.

To efficiently sample across the study area, the location of potential variations in vegetation communities is required. Factors most likely to affect plant distribution and abundance are moisture, nutrients, solar energy and fire, although this is not easily mapped (NPWS, 1997). Surrogates can be used to describe these factors using rainfall distribution maps, soil maps, aspect models, etc. Features within these digital layers can be combined to form parcels of the landscape which comprise similar groups of environmental characteristics (Neldner, 1995; Margules & Redhead, 1995). These parcels or 'strata' are assumed to represent features likely to support similar assemblages of plant species.

Before any surveys begin, a stratification needs to be developed to improve the efficiency in surveying and ensure an environmentally even spread of sites. Four environmental factors were selected for stratification for this study: aspect, elevation, rainfall and geology. These layers were combined to form a "strata" layer. Each "strata" has been given a unique five digit code. The first number in the series refers to the aspect class, the second refers to elevation, the third refers to rainfall class and the final two digit number refers to the geology class. The region contains 660 strata out of 1260 possible combinations. Some of the strata combinations do not exist spatially as certain substrates and environmental values don't overlap.



Legend

- Towns
- Coast
- Hawkesbury/Nepean & Shoalhaven Catchments

Distance Between Sites

- 0 - 100m
- 101 - 500m
- 501 - 2000m
- 2001 - 20000m
- Distance > 4000m between sites

Hawkesbury/Nepean &
Shoalhaven Catchments Scoping Study

Figure 4- Spatial Site Locations

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Scale 1 : 1, 250, 000

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Survey Stratification Categories.

Aspect	Elevation	Rainfall	Geology
1. Exposed	1. < 100m	1. < 700mm	01. Granite/Leucogranite
2. Intermedia te	2. 100 - 300m	2. 700 - 900mm	02. Coarse grained sediments
3. South	3. 300 - 500m	3. 900 - 1100mm	03. Fine grained sediments
	4. 500 - 700m	4. 1100 - 1400mm	04. Acid volcanics
	5. 700 - 1000m	5. > 1400mm	05. Quaternary alluvium
	6. > 1000m		06. Hawkesbury sandstone
			07. Intermediate/basic volcanics
			08. Narrabeen sandstone
			09. Shale
			10. Acid metamorphics
			11. Tertiary alluvium
			12. Quaternary sediments
			13. Calcareous sediments
			14. Quaternary sands

7.1 Identifying gaps.

All existing survey plots are compiled and queried against the strata to identify sampling levels in each strata classification. Under sampled strata are targetted for sampling by analysing the total hectares of each in relation to the total hectares of the study area and the total number of sites to be surveyed. For example a strata covering 5% of the study area would expect around 5% of the survey effort.

Figure 5 shows the unsampled strata while **Figure 6** shows undersampled strata. These areas include the Capertee valley, Central Wollemi, Megalong Valley, Southern Highlands, Goulburn, Lake Bathurst, Braidwood and the Shoalhaven areas, indicating the need for further survey.

The majority of areas highlighted occur on private land and targeting surveys towards private land must therefore be a priority. Targeting private lands minimises sampling gaps across the study area and reduces potential tenure bias.

Priority areas for survey:

Capertee Valley:

- Tenure: Private land; access constraints.
- Previous survey effort: Minimal; confined to NPWS estate surrounding area.
- Few roads/tracks to enable access to vegetation.
- Moderate clearing on private land.
- Not covered by current mapping projects.

Mudgee
Singleton
Cessnock
Newcastle
Bathurst
Gosford
Sydney
Wollongong
Bowral
Goulburn
Canberra
Ulladulla
Batemans Bay
Moruya

0 20 40 60 Kilometres

Legend

- Towns
- Coastline
- Hawkesbury/Nepean & Shoalhaven Catchments
- Unsampled Strata
- National Parks & Wildlife Estate
- Vegetation cover

Hawkesbury/Nepean &
Shoalhaven Catchments Scoping Study

Figure 5 - Unsampled Strata

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Scale 1 : 1, 250, 000

Printed by Conservation, Assessment & Data Unit, Central. June 2001

Mudgee
Singleton
Cessnock
Newcastle
Bathurst
Gosford
Sydney
Wollongong
Bowral
Goulburn
Canberra
Ulladulla
Batemans Bay
Moruya

0 20 40 60 Kilometres

Legend

- Towns
- Coast
- Hawkesbury/Nepean & Shoalhaven Catchments
- National Parks & Wildlife Estate
- Vegetation cover

Undersampled Strata
- Unsampled
- High
- Medium
- Low

Hawkesbury/Nepean &
Shoalhaven Catchments Scoping Study

Figure 6 - Undersampled Strata (Strata < 1 site per 500ha)

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Scale 1 : 1, 250, 000

Printed by Conservation, Assessment & Data Unit, Central. June 2001

Megalong Valley:
- Tenure: Majority private land, however small portion is State Forest.
- Previous survey effort: Minimal, less than 15 sites in area.
- Few roads/tracks however mostly confined to cleared areas.
- Heavily cleared.
- Covered by P5MA mapping.

Southern Highlands:
- Tenure: Approx 50% private and 50% NPWS estate.
- Previous survey effort: Minimal, majority confined to NPWS estate.
- Few roads/tracks causing difficulty accessing vegetation.
- Minimal clearing confined to private land.
- Covered by P5MA, with Wingecarribee and SCA special areas mapping covering approx 70% of region

Goulburn:
- Tenure: Private land; access constraints.
- Previous survey effort: Minimal. Non existent
- Heavily cleared with roads/tracks confined to cleared areas.
- Not covered by any current mapping.

Lake Bathurst:
- Tenure: Private land; access constraints.
- Previous survey effort: Minimal. Non existent.
- Moderately cleared with minimal roads/tracks.
- Approx 1/3 of region covered by P5MA mapping.

Braidwood:
- Tenure: Private land; access constraints.
- Previous survey effort: Minimal, majority confined to Tallaganda, Berlang and Monga state forests.
- Heavily cleared with minimal roads/tracks being confined to cleared areas.
- Covered by P5MA mapping.

Shoalhaven:
- Tenure: Majority is private with NPWS estate and state forests.
- Previous survey effort: Minimal, majority confined to public tenures.
- Heavily cleared in areas other than NPWS estate and State Forests.
- Covered by P5MA and approx 1/3 by Wingecarribee.

Central Wollem/Howes Valleyi:
- Tenure: Majority is NPWS estate with a small portion Private and State Forests.
- Previous survey effort: Minimal, sites confined to roads/tracks.
- Inaccessible country and lack of roads poses the idea of helicopter drops.
- Minimal clearing, confined to private land.
- Not covered by any current mapping.

8. PROJECT PLANNING

The Hawkesbury/Nepean and Shoalhaven Catchments cover a combined area of approximately 2.9 million hectares and cover whole or part of 31 Local Government Areas. Planning for a project of this size can be divided into two categories: Field Survey and Aerial Photograph Interpretation.

A. Field Survey.

Analyses were undertaken to determine the number of sites required to efficiently sample across the catchments. Local and regional vegetation projects covering small areas generally have a site density of 1 every 100 hectares, which is required to identify fine scale variation. Larger projects, such as the CRA forest ecosystem mapping, covering broader areas tend to have a site density of around 1 site to every 1000 hectares. From the compilation of existing sites, the maximum density of sites occurring anywhere within the study area is 1:14 ha. The table below indicates the number of sites required relative to the density at which sites would be located across the study area.

Density of sites (per hectare)	Number of sites required
1 : 14	202,822
1 : 100	26,216
1 : 250	9,138
1 : 500	3,704
1 : 750	2,074
1 : 1000	1,373

In order to calculate the number of sites required to fill areas deficient in sampling, it is imperative to know the number of sites that are to be surveyed by planned or current projects. The table below lists the number of vegetation sites planned by current mapping projects.

Project	No. of sites
Wingecarribee LGA	135
Hornsby LGA	40
Baulkham Hills LGA	131
SCA Special Areas	600
DLWC P5MA	1000
Total	1906

This project seeks to produce a detailed map over a large area, taking into account the information gathered and the aims of this project, a site density of 1:500ha or better is desirable. This site density produces detailed information that will satisfy the management and planning demands across the catchments. If this site density were selected approximately 1800 sites would be required to fill deficient sampling areas.

B. Aerial Photo Interpretation.

Aerial photo interpretation (API) across the study area is likely to be undertaken by four aerial photo interpreters. API involves detailed remote sensing and extensive field reconnaissance. The following table lists options for mapping criteria and their associated costs.

Reducing costs/Limitations

- Buy existing photos. Limitations with buying already flown photos is that:
  - you are confined to the year that the photos were flown, and
  - clearing of vegetation or extensive regeneration may have occurred In the interim
- Using existing data, in particular CRAFTI, for areas with reduced environmental planning needs that do not require finescale API (eg. Extensive areas of bushland such as Morton NP).

8.1 Project Timetable

This project would have a predicted timeframe of 5 years. The time required for each component task is estimated below.

Task	Time
API - Criteria A	28 months
- Criteria B	11 months
- Criteria C	9 months
- Criteria D*	18 months
Capture (based on Criteria D)*	24 months
Access arrangements	5 months
Field work (based on 4 teams)	12 months
Data Analysis	6 months
Mapping	6 months
Field validation	2 months
Map amendments	2 months
Report	8 months

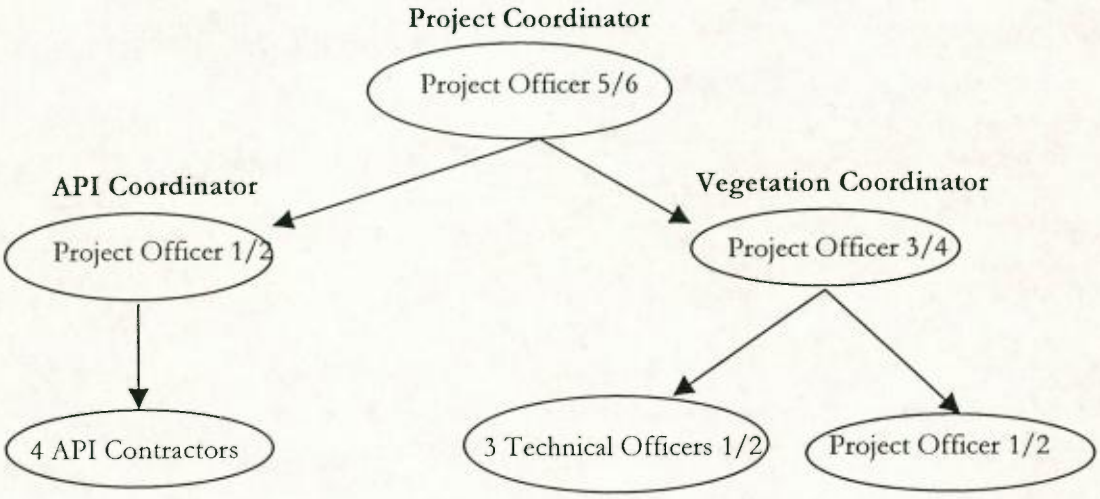
*the time taken to API and Capture may be reduced depending on the amount of existing information able to be used.

8.2 Project Team

Based on experience with projects of a similar size and nature a proposed staffing structure has been developed and is outlined below:

- A project co-ordinator - manage the project and report to the relevant agencies on the performance.
- An API co-ordinator – based on the recommendations proposed in the API mapping report for the Eden region (RACAC, 1999). This co-ordinator ensures consistent methods are undertaken by all API contractors, access can be arranged for field reconnaissance, management of photographs and general day to day queries.
- A vegetation co-ordinator - ensures the field survey component is undertaken smoothly, manages the vegetation survey database, the vegetation contractors, data analyses and the mapping component.

- Three technical officers and a project officer are required to assist the vegetation contractors, arrange access for survey, data entry, data capture, and support the vegetation co-ordinator.
- Vegetation contractors – expert field botanists to carry out the surveys.



8.3 Budget

Each of the mapping options has an itemised cost estimate provided below:

Option A (A complete coverage of 0.5ha minimum patch size and using aerial photos at a 1:16000 scale)

- API - Line work :Cost - $ 1,232,329
  - Capture : Cost - $ 867,578
- Photos : Cost - $ 196,000
- Staff : Cost - $ 2,378,810
- Contractors (4) : Cost - $ 168,000
- Cars (6) : Cost - $ 120,000
- Computers (4) : Cost - $ 20,000
- Hardware/Software : Cost - $ 15,000
- Sub total : $ 4,977,717
- GST : $ 497,771.7
- **Total: $ 5,475,488.7**

Option B (A complete coverage of 2ha minimum patch size with 1:25,000 scale aerial photos)

- API - Line work :Cost - $ 607,891
  - Capture : Cost - $ 415,417
- Photos : Cost - $ 100,000
- Staff : Cost - $ 2,378,810
- Contractors (4) : Cost - $ 168,000
- Cars (6) : Cost - $ 120,000

- Computers (4) : Cost - $ 20,000
- Hardware/Software : Cost - $ 15,000
- Sub total : $ 3,825,118
- GST : $ 382,511.8
- **Total: $ 4,207,629.8**

Option C (A complete coverage of 10ha minimum patch size with 2ha on private land)

- API - Line work :Cost - $ 468,082
  - Capture : Cost - $ 347,302
- Photos : Cost - $ 77,000
- Staff : Cost - $ 2,378,810
- Contractors (4) : Cost - $ 168,000
- Cars (6) : Cost - $ 120,000
- Computers (4) : Cost - $ 20,000
- Hardware/Software : Cost - $ 15,000
- Sub total : $ 3,594,194
- GST : $ 359,419.4
- **Total: $ 3,953,613.4**

Option D (A coverage of 10ha minimum patch size on public land with 2ha in rare forest types and rainforest and 0.5ha in areas of high development/clearing threat)

- API - Line work :Cost - $ 974,299
  - Capture : Cost - $ 593,911
- Photos : Cost - $ 121,000
- Staff : Cost - $ 2,378,810
- Contractors (4) : Cost - $ 168,000
- Cars (6) : Cost - $ 120,000
- Computers (4) : Cost - $ 20,000
- Hardware/Software : Cost - $ 15,000
- Sub total : $ 4,391,020
- GST : $ 439,102
- **Total: $ 4,830,122**

The cost estimates for each of the options are summarised below.

Project Options	Cost
Option A	$ 5,475,488.7
Option B	$ 4,207,629.8
Option C	$ 3,953,613.4
Option D*	$ 4,830,122

*may be reduced depending on how much existing information can be used.

Option A - A complete coverage of 0.5ha minimum patch size and using aerial photos at a 1:16000 scale.

Option B - A complete coverage of 2ha minimum patch size with 1:25,000 scale aerial photos.

Option C - A complete coverage of 10ha minimum patch size with 2ha on private land.

Option D - A coverage of 10ha minimum patch size on public land with 2ha in rare forest types and rainforest and 0.5ha in areas of high development/clearing threat.

It should be noted that these costs do not include analysis, interpretation and dissemination or education of the results.

9. CONCLUSIONS AND RECOMMENDATIONS

Recommendations include:

- The vegetation map is an essential tool for landuse planning and management, providing a regional context for case based decisions, assessing significance and developing conservation targets, monitoring rate of clearance and prioritising management activities. The vegetation map provides the basis for many other biodiversity questions such as identifying if conservation targets are met, modelling habitat of significant fauna and likely distribution of significant flora.

- There is a considerable lack of data to answer key landuse planning and management questions.

- Data is collected that provides a foundation for repeatable vegetation community identification.

- Complete aerial photo interpretation to accurately map extent of remnants and information on relative condition.

- Recommended mapping criteria and methodologies have been outlined in section 4 on data audit, aerial photographic interpretation, field survey and analysis to prepare the mapped product.

- The question of what is the most appropriate minimum patch size to delineate from API work affects not just the scale of aerial photos required but has a significant impact on the validity of the data, what it can be used for and the amount of work involved (and cost).

- The finer the scale mapped the more useful the final mapped product is for a wider variety of uses. As the scale becomes finer the more useful the mapped product is for local and site specific works. Planning products and day to day management decisions are tending towards the use of more accurate data. Products such as RVMPs and LEPs have attempted to provide as much local guidance and certainty of outcome as possible but rarely have adequate data. The SLWCAs are also attempting to provide more detailed local management planning and are likely to need detailed information.

- The main areas where physiographic variables are under sampled and are not being covered by proposed survey sites (or work in progress) include the Capertee Valley, Goulburn area, some of the Lake Bathurst area and Central Wollem/Howes Valley.

- The most common issue raised during the consultation was the need for interpretation of the data and mapping provided. Which communities and which areas are of conservation value and what are the relative priorities so that the necessary steps can be taken to implement its appropriate management. This means that once the data collection has been completed then some analysis and

interpretation is required. Education could assist by facilitating land managers interpreting the mapped product themselves for their specific roles.

- From discussions with land managers likely to use the data there is clearly a critical need for education and training programs on the outcomes of the mapping exercise, what the data means, how to use it and the limitations.
- Interpretation and education has not been costed into the proposal. These elements of the project need to be factored into the decision for mapping the catchments.
- Users of the data would be well served by presenting the data in a format that empowers them to add layers of site specific data or update information.
- Consider the application and approach to including long term monitoring or permanent plots as there are a number of users that this would benefit.

An assessment of the user requirements is provided in the table below and indicates what mapping option is likely to be able to provide sufficient biodiversity data to answer the landuse planning or management questions.

Role/Responsibility	Data Required	Option				Notes
		A	B	C	D	
Recovery Plans	Region	✔	X	X	✔	Dependent on the topic, area it covers.
Landuse Planning	Region to Precinct	✔	X	X	✔	LEPs, Masterplans etc. Dependent on scale. Options B and C may provide some guidance.
NPWS Reserve PoMs	Sub region	✔	✔	X	✔	Strategic planning documents.
Fire Management Plans	Sub region	✔	✔	X	X	Extent of vegetation communities, conservation priorities and presence of TSC Act species. Option D better than Option C.
SLWCAs	Sub region to local	✔	X	X	✔	Needs the regional framework for prioritisation and the local and possibly site specific information for detailed RAPs etc. Option A better than C.
RVMPs	Sub region to local	✔	X	X	✔	Needs the regional framework for priorities with more specific information for clearing applications, property plans, incentives etc. Option A better than C.
Council Reserve PoMs	Site specific or local	✔	X	X	X	Dependent on size of reserve and level of plan detail.
Monitor / Audit	Site specific to local.	✔	X	X	X	Dependent on what monitoring for. Option D could provide information for private lands.
Part 3A Permits	Site specific	X	X	X	X	Needs a local/regional context. Option A best achieves this then Option D.
Development Assessment	Site specific	X	X	X	X	Approvals, consent, concurrence. Dependent on scale of development. Focus on impact assessment. Needs a context. Option A best achieves this then D.
Pest/Weed Mgt	Site specific	X	X	X	X	Needs regional-local context for prioritisation. Based on conservation value and threat. Option A best achieves this then D.
Operations - Landscaping	Site specific	X	X	X	X	Identification of species to plant in a specific location/area. Modelling from region-sub region. All could provide some guidance – finer scale improves accuracy.
Operations - regeneration	Site specific	X	X	X	X	Needs regional and local for prioritisation. Option A best achieves this then D.
Veg clearance appn's	Site specific	X	X	X	X	Needs a local/regional context. Option A best achieves this then D.
Property plans, agreements, VCAs etc	Site specific	X	X	X	X	Needs a local/regional context. Option A is best to achieve this then D.
Tree Preservation Orders	Site specific	X	X	X	X	Condition, individual tree values. None will provide this.

Option A - 0.5ha minimum patch size and using aerial photos at a 1:16,000 scale.
Option B - 2ha minimum patch size with 1:25,000 scale aerial photos.
Option C - 10ha minimum patch size with 2ha on private land.
Option D - 10ha minimum patch size on public land, 2ha in rare forest types and rainforest and 0.5ha in areas of high development/clearing threat.

X – is not likely to provide sufficient information at this scale to answer the questions.
✔ - is likely to provide sufficient information.

It should be noted how dependent this is on scale and the topic of the individual task under question. For example a Recovery Plan on an endangered ecological community that occurs in the area may have sufficient info from the process but a threatened plant will not. Another example, is the size of the remnant within a council reserve and the distribution of the community being addressed for management actions.

Based on this analysis it can be seen that Option A, provides biodiversity data that is useful to the most users and planning/management roles. This is because it includes mapping of smaller remnants of 0.5 Ha in size and is therefore more likely to pick up the issues that need to be considered. Option A is also considered to provide the best contextual information for site specific decisions.

The smaller the remnants mapped the more likely it is that the specialised communities are to be picked up (such as riparian strips, gullies, etc). There is an argument that these specialised communities are likely to have higher conservation values and smaller remnants require greater strategic management attention.

Option D is the next preferred approach as it focuses the highest quality information in the area under threat from development, etc. In providing a finer scale for rare communities on public land it attempts to pick up the specialised communities. It is not known what problems will arise when carrying out analyses across data of different scale. It may be that given the consistency of landscapes across reserves versus private land that the issue will not be as great.

It is clear that the data can not answer all the questions.

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Appendix A: Consultation

Individuals consulted to ascertain biodiversity planning and landuse management needs include:

- Martin Beveridge, Strategic Planning of the ESD Unit of **Bankstown City Council** *.
- Ross Bradstock, Bushfire Research Unit, Biodiversity Research Group, **NPWS**.
- Daniel Connolly, Conservation Assessment and Data Unit, Central Directorate, **NPWS**.
- Rob Corby, Bushlands Officer of the ESD Unit of **Bankstown City Council** *.
- Paul Curley, M/Environment and Health, **Wingecarribee Shire Council** *.
- Scott Davidson, Strategic Planning Unit, **Liverpool City Council** *.
- Graham Douglas, Rural Fire Service.
- Tim Hager, Conservation Assessment and Data Unit, Central Directorate, **NPWS**.
- Gary Hopkins, Senior Environmental Planner of the Natural Resource Branch, **DUAP**.
- Arvind Lal, Environmental Management Unit **of Liverpool City Council** *.
- Robert McGuinness, Development Control, **SCA**.
- Frank Maloney, World Heritage Branch, **Environment Australia**
- Milan Marecic, Strategic Planning Unit, **Liverpool City Council** *.
- Jack Miller, Landscape Planner of **Goulburn City Council**.
- Mathew Napper, Environmental Management Unit **of Liverpool City Council** *.
- Ross Scott, World Heritage Branch, **Environment Australia**.
- Branden Haywood, Development Control, **SCA**.
- Mary Knowles, **SCA**.
- Julie Ravallion, Conservation Assessment and Data Unit, Central Directorate, **NPWS**.
- Alison Scobe, Environmental Officer of **Kiama and Shellharbour Councils**.
- Brad Staggs, Environmental Officer, **Wollondilly Shire Council**.
- Merron Tozer of the Sydney South Region, **DLWC**.
- Alex Williams, Strategic Planer, **Wollondilly Shire Council**. *

* - Based on existing projects involving the interpretation and application of existing vegetation mapping projects and biodiversity data.

Appendix B: Spatial Data Layers

(Available for use in vegetation modelling)

Altitude	Elevation above sea level (meters)
Slope	Inclination from horizontal (degrees)
Aspect	Deviation from grid north perpendicular to slope (degrees)
Aspect index	Categorical index of aspect (1: flat, 2: 301-30°, 3: 211-300°, 4: 31-120°, 5: 121-210°)
Geology	Major geological classes based on amalgamation of geologies from the 1:250k geological series.
Easting	Australian map grid
Northing	Australian map grid
Annual Mean Temperature	The mean of all the weekly mean temperatures.
Mean Diurnal Range	The mean of all the weekly diurnal temperature ranges.
Isothermality 2/7	The mean diurnal range divided by the Annual Temperature Range.
Temperature Seasonality (C of V)	The standard deviation of the weekly mean temperatures expressed as a percentage of the mean of those temperatures (i.e. the annual mean).
Max Temperature of Warmest Period	The highest temperature of any weekly maximum temperature.
Min Temperature of Coldest Period	The lowest temperature of any weekly minimum temperature.
Temperature Annual Range	The difference between the Max Temperature of Warmest Period and the Min Temperature of Coldest Period.
Mean Temperature of Wettest Quarter	The wettest quarter of the year is determined(to the nearest week), and the mean temperature of this period is calculated.
Mean Temperature of Driest Quarter	The driest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Mean Temperature of Warmest Quarter	The warmest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Mean Temperature of Coldest Quarter	The coldest quarter of the year is determined (to the nearest week), and the mean temperature of this period is calculated.
Annual Precipitation	The sum of all the monthly precipitation estimates.
Precipitation of Warmest Period	The precipitation of the warmest week or month, depending on the time step.
Precipitation of Driest Period	The precipitation of the driest week or month, depending on the time step.
Precipitation of Seasonality (C of V)	The Coefficient of Variation (C of V) is the standard deviation of the weekly precipitation estimates expressed as a percentage of the mean of those estimates (i.e. the annual mean).
Precipitation of Wettest Quarter	The wettest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Precipitation of Driest Quarter	The driest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Precipitation of Warmest Quarter	The warmest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Precipitation of Coldest Quarter	The coldest quarter of the year is determined (to the nearest week), and the total precipitation over this period is calculated.
Annual Mean Radiation	The mean of all the weekly radiation estimates.
Highest Period Radiation	The largest radiation estimate for all weeks.
Lowest Period Radiation	The lowest radiation estimate for all weeks.
Radiation of Seasonality (C of V)	The Coefficient of Variation (C of V) is the standard deviation of the weekly radiation estimates expressed as a percentage of the mean of those estimates (i.e. the annual mean).
Radiation of Wettest Quarter	The wettest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Radiation of Driest Quarter	The driest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Radiation of Warmest Quarter	The warmest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Radiation of Coldest Quarter	The coldest quarter of the year is determined (to the nearest week), and the average radiation over this period is calculated.
Neighbourhood Topographic Position (100)	Difference between altitude of a central cell and mean altitude of cells within a 1 x 1 neighbourhood
Neighbourhood Topographic Position (300)	Difference between altitude of a central cell and mean altitude of cells within a 3 x 3 neighbourhood
Neighbourhood Topographic Position (500)	Difference between altitude of a central cell and mean altitude of cells within a 5 x 5 neighbourhood
Neighbourhood Topographic Position (700)	Difference between altitude of a central cell and mean altitude of cells within a 7 x 7 neighbourhood
Neighbourhood Topographic Position (900)	Difference between altitude of a central cell and mean altitude of cells within a 9 x 9 neighbourhood

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Neighbourhood (100)	Topographic	Roughness	Standard deviation of altitude within a neighbourhood of 1 x 1 cells
Neighbourhood (300)	Topographic	Roughness	Standard deviation of altitude within a neighbourhood of 3 x 3 cells
Neighbourhood (500)	Topographic	Roughness	Standard deviation of altitude within a neighbourhood of 5 x 5 cells
Neighbourhood (700)	Topographic	Roughness	Standard deviation of altitude within a neighbourhood of 7 x 7 cells
Neighbourhood (900)	Topographic	Roughness	Standard deviation of altitude within a neighbourhood of 9 x 9 cells

Appendix C: Vegetation Survey Audit

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
Native Vegetation of the Cumberland Plain	Westsyd (2)	National Parks and Wildlife Service	Mark Tozer, NSW NPWS, PO Box 1967 Hurstville 2220, (ph.95856496)	ANZNS0208000073 .xls	0.5ha	Covers Cumberland Plain, 8% of P5MA in north. 1:100k maps: part Penrith, part Wollongong.	1997/1998	1:16000	Field Survey, analysis and modelling: 1999; Report and draft maps: April 2000	No	1:25,000, 25m pixel	Complete	Boundaries were delineated on drafting quality plastic film affixed to photographs and registered to the photo-fiducials. These boundaries were transferred to a polyester film using an artiscope re-scaling camera. Roads, streams and contour lines were printed on the polyester film to assist with aligning the individual photographs. Following edge-matching, the coverage was traced to another sheet for scanning. Scanning was performed at 15 pixels/mm to create a raster image which was then vectorised.
Floristics, Structure and Diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney	Ohares	National Parks and Wildlife Service	David Keith, NSW NPWS, PO Box 1967 Hurstville 2220, ph (02)95856498	ANZNS0263000002 .xls	1ha	O'Hares Creek Catchment, approximate area 9000 ha, centred on latitude 34o14'S and longitude 150o52'E, 45 km south-west of Sydney centre.	Wollongong 1:16000 Colour, Misc. 1320, May-July 1982	1:16000	Field Sampling/validation: 1984-1988; Map Publication 1994.	No	1:25,000	Complete	Polygons were transferred from aerial photographs to 1:25000 topographic maps and digitised using ERMS.

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (in hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
Native Vegetation of the Cumberland Plain	Field checking and aerial photograph comparisons have not been carried out	High level of accuracy.	Attribute coding has not been systematically checked.	Polygons were classified according to percentage crown cover projection density and dominant species.	There is extensive overlap with the Royal Botanic Gardens vegetation maps of the Penrith and Wollongong 1:100k map sheets.	0.04ha	523	full floristics	Braun-Blanquet C/A	Tree diameter, slope, aspect, geology, geomorphology and site disturbance	Plot position interpreted from 1:25000 topographic maps - precision estimated at 100m	Non-random stratified:Soil parent material (Wianamatta Shale, Mittagong Formation, Hawkesbury Sandstone, Holocene Alluvium (draining shale soils), Holocene Alluvium (draining sandstone soils), Tertiary Alluvium, Estuarine sediments and Aeolian Deposits), rainfall, temperature; supplemented by 'expert' selections	yes
Floristics, Structure and Diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney	Digital line work accuracy was checked through extensive field work. Spatial accuracy was not reported.	Not assessed	A comprehensive check of attribute coding was completed to eliminate all errors. Error rates were not reported.	Structural types mapped: forest (single-stemmed trees > 5 m tall and > 20% cover); woodland (single-stemmed trees > 5 m tall and < 20% cover); mallee (multi-stemmed trees); heath (shrubs < 5 m tall)	The Ohares Creek Catchment is included in the Royal Botanic Garden vegetation map of the Wollongong 1:100k map sheet.	0.04 ha (56 plots), 0.25 m2 (60 belt transects each with a frequency score calculated from 60 plots)	56	full floristics	Braun-Blanquet C/A	Vegetation structure, Species' growth form, stratum in which species occur (partial), physical site description (see example data sheet)	Plot position interpreted from 1:25000 topographic maps - precision estimated at 100m	Random selection with defined environmental strata: Soil parent material (Shale, Sandstone, Ironstone, Alluvium); Topography (slopes and gullies, plateau); Vegetation structure (dominant stratum)	Yes

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
Native Vegetation of the Cumberland Plain	1999	UPGMA cluster analysis of Bray-Curtis association matrix	N/A	There is extensive overlap with the Royal Botanic Gardens vegetation maps of the Penrith and Wollongong 1:100k map sheets.	Tozer, M. G. (1999). Native vegetation of the Cumberland Plain. NSW National Parks and Wildlife Service
Floristics, Structure and Diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney	1984 - 1988	UPGMA cluster analysis of Kulzcynski association matrix	N/A	The Ohares Creek Catchment is included in the Royal Botanic Garden vegetation map of the Wollongong 1:100k map sheet	Keith, D. A. (1994). Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney. Cunninghamia Vol. 3(3).

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
Forest Ecosystem Classification and Mapping for the Southern CRA Region	NP_SCRA; NP_DUEA	National Parks and Wildlife Service	Virginia Thomas, Natural Heritage Officer, NPWS Southern Conservation Programs & Planning Division, 6 Rutledge Street/PO Box 2115, Queanbeyan NSW 2620. Ph (02) 6298 9706.	Metadata statement contained in report: see CRA_rpt.DOC & CRA_app.DOC	10ha	Covers coast, escarpment & tableland area bounded by Kiama, Bermagui, Murray River, Gundagai, Crookwell, Kowmung, Robertson, 60% of P5MA in south-west. 1:100k maps: part Taralga, part Burragorang, part Goulburn, Moss Vale, Kiama, Braidwood, Ulladulla, Jervis Bay, Araluen, Batemans Bay.	Date of imagery was not reported. Most photos were less than two years old, but some were more than four years old.	Colour 1:25,000 colour aerial photography, except in Crookwell area 1:50,000 colour	Mapping/modelling: 1999	No	1:100,000, 25m pixel	Problems have been identified where forest types mapping (RN17) was joined to CRAFTI mapping. Edge mapping of data tiles (eg map boundaries) appears to be sound.	Polygon boundaries were traced on acetate overlay sheets and converted to a digital coverage by either digitising or scanning (followed by rectification and conversion to vectors).
An investigation into the Flora and Vegetation of the Middle Kowmung River Valley, Eastern NSW.	Kowmung	G. Steenbecke	G. Steenbecke	No	2ha	Kowmung River catchment. 100k maps: part Burragorang	Aerial photography 1972 & 1977	1:50,000	Map compiled 1990, thesis date 1990.	No	1:25,000	Complete	No
Water Catchment Land South of Sydney	Sydwater	Sydney Water Catchment Authority	Chris Chafer, Sydney Catchment Authority, PO Box 50 Appin 2560. Ph (02)46401000	No	As for RBG Wollongong 1:100k sheet	Woronora, Cataract, Cordeeaux, Avon River Catchments	As for RBG Wollongong 1:100k sheet	As for RBG Wollongong 1:100k sheet	Field Survey: 8/98 - 12/99; Analysis and map production in progress	No	Under consideration: 1:25000 - 1:100000	Analysis and map production in progress	Analysis and map production in progress

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (in hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
Forest Ecosystem Classification and Mapping for the Southern CRA Region	Line work and attribute coding were inspected by an independent interpreter to assess accuracy. Checks were made for errors in coding arising through transfer between media. Various accuracy statistics have been tabulated. Only limited field assessment of accuracy and reliability was performed.	External boundaries have high level of accuracy in general, but some remanants not mapped in fragmented landscapes. Linework artefacts present where different coverages are stitched.	Line work and attribute coding were inspected by an independent interpreter to assess accuracy. Checks were made for errors in coding arising through transfer between media. Various accuracy statistics have been tabulated. Only limited field assessment of accuracy and reliability was performed.	CRAFTI categories: see CRAFTI SOUTHERN REPORT A project undertaken as part of the NSW Comprehensive Regional Assessments November, 1999	Overlaps with Sydney 1:100k series (RBG) in north-west, Illawarra surveys in north-east and Coastal dune survey on eastern fringe, includes areas covered by Queanbeyan-Shoalhaven, Clyde Mtn, Clyde River, Southern Tableland TSRs and Abercrombie River surveys.	0.04-0.1ha	680	full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, obsevations on surface soil & disturbance	50m	non-random stratified: lithology, rainfall, temperature, topography; supplemented by 'expert' selections	yes
An investigation into the Flora and Vegetation of the Middle Kowmung River Valley, Eastern NSW.	N/A	Not evaluated	A comprehensive check of attribute coding was completed to eliminate all errors. Error rates were not reported.	Specht (1970) structural formations subdivided into map units of the Royal Botanic Gardens vegetation classification system	The Kowmung/Yerrander ie map is included in the Royal Botanic Garden vegetation map of the Burragorang 1:100k map sheet.	0.04 ha	150	full floristics	Braun-Blanquet C/A	Tree diameter, slope, aspect, geology, geomorphology and site disturbance	c. 250m	regular grid sampling	no
Water Catchment Land South of Sydney	Analysis and map production in progress	Analysis and map production in progress	Analysis and map production in progress	Specht (1970)	The Sydney Catchment Authority Area is partly covered by the Western Sydney Mapping Project and the Royal Botanic Gardens Wollongong 1:100k vegetation map sheet	0.04ha	344	full floristics	Braun-Blanquet C/A	Vegetation structure, dominant species and height for each stratum.	c.100m	Stratified by geology and fire history	yes

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
Forest Ecosystem Classification and Mapping for the Southern CRA Region	1998/99	UPGMA cluster analysis of Bray-Curtis association matrix	N/A	Overlaps with Sydney 1:100k series (RBG) in north-west, Illawarra surveys in north-east and Coastal dune survey on eastern fringe, includes areas covered by Queanbeyan-Shoalhaven, Clyde Mtn, Clyde River, Southern Tableland TSRs and Abercrombie River surveys.	Forest Ecosystem Classification and Mapping for the Southern CRA Region Volumes 1 & 2. A report undertaken for the NSW CRA/RFA steering committee, March 2000. CRAFTI SOUTHERN REPORT A project undertaken as part of the NSW Comprehensive Regional Assessments November, 1999
An investigation into the Flora and Vegetation of the Middle Kowmung River Valley, Eastern NSW.	1990	TWINSPAN	N/A	The Kowmung/Yerrandere map is included in the Royal Botanic Garden vegetation map of the Burragorang 1:100k map sheet.	Steenbecke, G. L. (1990). An investgation into the flora and vegetation of the middle Kowmung River valley, eastern NSW. BSc(Hons) thsis, University of Sydney.
Water Catchment Land South of Sydney	Field Survey: 8/98 - 12/99	UPGMA cluster analysis of Bray-Curtis association matrix	N/A	The Sydney Catchment Authority Area is partly covered by the Western Sydney Mapping Project and the Royal Botanic Gardens Wollongong 1:100k vegetation map sheet	None

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
The natural vegetation of the Sydney region 1:100k map series	RBG 100K series	Royal Botanic Gardens	Doug Benson, National Herbarium of NSW, Mrs Macquaries Rd Sydney. Ph (02) 92318148	ANZNS0263000009.xls, ANZNS0263000195.xls, ANZNS0263000010.xls	c.10ha	Northern 45% of P5MA. Katoomba, Penrith, Taralga (part), Burragorang, Wollongong (part), Moss Vale (part), Kiama (part) 1:100k map sheets	NSW Department of Lands 1979/80 black & white 1:40000 (Katoomba); 1982 colour 1:16000 (Wollongong); NSW Department of Lands 1969-1970, 1993 Landsat-5 TM (Moss Vale & Kiama); NSW Department of Lands 1991 colour, 1993 Landsat TM (Goulburn & Braidwood); NSW Department of Lands Colour 1990, Black and White 1972, 1992 Landsat TM (Taralga); Black and White 1981 (Burragorang); NSW Department of Lands Black and White 1979, 1988, 1989 (Penrith)	Katoomba 1:40,000; Woolongong 1:16,000; Taralga 1:25,000 & 1:60,000; Goulburn & Braidwood 1:50,000; Moss Vale & Kiama not stated; Burragorang 1:50,000; Penrith 1:40,000	Maps produced 1988-1996.	No	1:100,000	Some edge matching problems are apparent where map sheets are joined	Unknown - It is likely that the line work was digitised from the published 1:100k map sheets using ERMS.
Coastal Dune Vegetation of NSW	Clarke_coast	Department of Land and Water Conservation	Peter Clarke, Department of Botany University of New England, Armidale NSW 2351.	ANZNS0263000220.xls	N/A	No map	N/A	N/A	Report dated 1989	N/A	N/A	N/A	N/A
Clyde Mtn	CS_JAP	CSIRO	Mike Austin, Wildlife and Ecology, CSIRO, GPO Box 284, Canberra, ACT 2601. Ph (02)6242 1758	No	N/A	No map	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clyde River area	CS_CLYDE	CSIRO	Mike Austin, Wildlife and Ecology, CSIRO, GPO Box			50x20km area north	No reported, pre-		Thesis dated 1983.			N/A. Mapped on two	

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (ir hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
The natural vegetation of the Sydney region 1:100k map series	Digital line work accuracy was checked through extensive field work. Spatial accuracy was not reported.		A comprehensive check of attribute coding was completed to eliminate all errors. Error rates were not reported.	Specht (1970)	The Sydney Region Map Series overlaps with several other data sets including the WesternSydney Vegetation Mapping Project, Southern CRA Forest Ecosystem Maps, Sydney Catchment Authority Maps, Holsworthy Military Reserve and Kowmung Yerranderie.	0.04 ha	366	full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, landform, observations on surface soil & disturbance	c.100m	non-random expert selections	Partially
Coastal Dune Vegetation of NSW	N/A	N/A	N/A	N/A	Overlaps with Southern VCRA	0.04 ha	48	full floristics	Braun-Blanquet C/A	Data recorded from 3 zones (where vegetation was present): Incipient foredune, front face foredune, Backface foredune. Disturbance history and morphological characerisitics of the dunes system were recorded.	c. 100m	stratified transects to sample beach strand, foredune & hinddune at non-randomly selected locations	No
Clyde Mtn	N/A	N/A	N/A	N/A	Within Southern CRA	0.1ha?	47	full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, obsevations on surface soil & disturbance	unknown	stratified sampling	yes
Clyde River area	Not evaluated	Not evaluated	Two classes only,	aerial photos were interpreted to delineate two	Within the Southern				3 - level abundance rating (1=occasional,	Landform and topography; aspect, slope, horizon, soil	Plot position interpreted from	Random selection within defined environmental	

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
The natural vegetation of the Sydney region 1:100k map series	1975-1995	Intuitive	N/A	The Sydney Region Map Series overlaps with several other data sets including the WesternSydney Vegetation Mapping Project, Southern CRA Forest Ecosystem Maps, Sydney Catchment Authority Maps, Holsworthy Military Reserve and Kowmung Yerranderie.	Benson, D.H (1992). The Natural Vegetation of the Penrith 1:100,000 Map Sheet. Cunninghamia, 2(4), pp:541-596. Benson, D.H. & Howell, J. (1994a). Hawkesbury - Nepean Catchment Vegetation Mapping Explanatory Notes for the Wollongong 1:100,000 Map Sheet. Ecology Section, National Herbarium of NSW, Royal Botanic Gardens Sydney. Benson, D.H. & Howell, J. (1994b). Hawkesbury - Nepean Catchment Vegetation Mapping Explanatory Notes for the Moss Vale - Kiama 1:100,000 Map Sheets. Ecology Section, National Herbarium of NSW, Royal Botanic Gardens Sydney. Fisher, M. & Ryan, K. (1994). Hawkesbury - Nepean Catchment Vegetation Mapping Explanatory Notes for the Taralga and Oberon 1:100,000 Map Sheets. Ecology Section, National Herbarium of NSW, Royal Botanic Gardens Sydney. Fisher, M. & Ryan, K. & Schaeper, L. (1994). Hawkesbury - Nepean Catchment Vegetation Mapping Explanatory Notes for the Goulburn, Braidwood and Gunning 1:100,000 Map Sheets. Ecology Section, National Herbarium of NSW, Royal Botanic Gardens Sydney. Fisher, M., Ryan, K. & Lembit, R. (1995). The natural Vegetation of the Burragorang 1:100,000 M
Coastal Dune Vegetation of NSW	1989	TWINSPAN	N/A	Overlaps with Southern VCRA	Clarke, P. J. (1989). Coastal dune vegetation of New Soputh Wales. Technical Report 89/1. Coastal Studies Unit, University of Sydney and Soil Conservation Service, Sydney.
Clyde Mtn	1999	No classification	N/A	Within Southern CRA	CSIRO unpubl. Data
Clyde River area	1990-1993	UPGMA cluster analysis of Bray-	[illegible]	Within the Southern	Helman, C.E. (1983). Inventory Analysis of Southern NSW Rainforest Vegetation

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
Queanbeyan-Shoalhaven		CSIRO	Mike Austin, Wildlife and Ecology, CSIRO, GPO Box 284, Canberra, ACT 2601. Ph (02)6242 1758	No	N/A	No map	N/A	N/A	Report dated 1969	N/A	N/A	N/A	N/A
Blue Mountains City Council Vegetation Mapping Project	BMCC	Blue Mountains City Council	Frank Garafalow, Blue Mountains City Council, PO Box 189, Katoomba NSW 2780 ph. (02) 4723 5000	In preparation	Unknown	Blue Mountains City Council Area	Infra-red flown December 1998	Scale:1:6000	In progress	Yes	Map production in preparation	Map production in preparation	Map production in preparation
Vegetation Communities of Popran National Park	POPRAN	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	N/A	Popran National Park	Unknown	Unknown	Report dated ?	No	N/A	N/A	N/A
Vegetation Communities of Wollemi National Park	ALLWOLL	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	N/A	Wollemi National Park	1982-84	1:25000	Report dated ?	No	1:25000	Complete	Yes
Yengo National Park and Parr State Recreation Area: for use in fire management	NTHYENGO	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	N/A	Yengo National Park and Parr State Recreation Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vegetation Communities of Dharug National Park	DHARUG	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	Unknown	Dharug National Park	1979	1:16000	Report dated ?	No	1:16000	N/A	Yes
Vegetation Communities of Marramarra National Park	N/A	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	Yes	Unknown	Marramarra National Park	Unknown	Unknown	Report dated ?	No	Unknown	Complete	Yes
Vegetation Communities of Jamison Valley	N/A	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	Unknown	Jamison Valley in the Blue Mountains	1994	1:25000	1997	No	1:25000	Complete	Yes
Preliminary report on the vegetation of Yengo National Park and Parr	YENGO	National Parks and Wildlife Service	GIS Division NSW National Parks and	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (in hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
Queanbeyan-Shoalhaven	N/A	N/A	N/A	N/A	Within the Southern CRA	unknown	261	full floristics	presence/absence	Unknown	Unknown	Unknown	yes
Blue Mountains City Council Vegetation Mapping Project	Map production in preparation	Map production in preparation	Map production in preparation	Unknown	The Blue Mountains Council mapping is covered by the Royal Botanic Gardens Katoomba 1:100k vegetation map sheet	0.04 ha	Unknown - in progress	full floristics	Braun-Blanquet C/A	Unknown	c.100m	Unknown	Not at present
Vegetation Communities of Popran National Park	N/A	N/A	N/A	N/A	N/A	0.04ha	143	Full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from 1:25000 topographic maps - precision estimated at 100m	unknown	yes
Vegetation Communities of Wollemi National Park	Not evaluated	Not evaluated	Not Evaluated	Specht (1970)		0.04ha	410	full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	Unknown	yes
Yengo National Park and Parr State Recreation Area: for use in fire management	N/A	N/A	N/A	N/A	N/A	0.04ha	92	Full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	non-random stratified geology, aspect, topographic position; supplemented by 'expert' selections	yes
Vegetation Communities of Dharug National Park	Not evaluated	Not evaluated	Not evaluated	Specht (1970)		0.04ha	45	Full floristics	Braun-Blanquet C/A	Unknown	c. 100m	Unknown	yes
Vegetation Communities of Marramarra National Park	Not evaluated	Not evaluated	Not evaluated	Specht (1970)		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vegetation Communities of Jamison Valley	Not evaluated	Not evaluated	Not evaluated	Height classes and Canopy density		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Preliminary report on the vegetation of Yengo National Park and Parr	N/A	N/A	N/A	N/A		0.04ha	143	Full floristics	Braun-Blanquet C/A	Vegetation structure, substrate, slope, aspect, horizon azimuths,	Plot position interpreted from GPS & 1:25000	unknown	yes

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
Queanbeyan-Shoalhaven	1969	Not evaluated	N/A	Within the Southern CRA	Gunn, R.H., Story, R., Galloway, R.W., Duffy, P.J.B., Yapp, G.A. & Mc Alpine, J.R. (1969). Lands of the Queanbeyan-Shoalhaven area, ACT and NSW. Land Research Series No. 24.CSIRO, Melbourne.
Blue Mountains City Council Vegetation Mapping Project	1999 - ongoing	Analysis is awaiting field data collection	N/A	The Blue Mountains Council mapping is covered by the Royal Botanic Gardens Katoomba 1:100k vegetation map sheet.	None
Vegetation Communities of Popran National Park	1998				Bell, S.A.J. (1998a) Popran National Park Vegetation Survey: a Fire Management Document Eastcoast Flora Survey - Report To National Parks and Wildlife Service.
Vegetation Communities of Wollemi National Park	1993-97	Unknown	Unknown		Bell, S.A.J. (1998b) Wollemi National Park Vegetation Survey: A Fire management Document East coast Flora Survey - Report to the National Parks and Wildlife Service.
Yengo National Park and Parr State Recreation Area: for use in fire management	Unknown	Unknown	Unknown		Bell, S., Vollmer, J. & Gellie, N. (1993). Yengo National Park and Parr State Recreation Area: for use in fire management. Unpublished report for the N.S.W. National Parks and Wildlife Service.
Vegetation Communities of Dharug National Park	1986	Unknown	Unknown		Clarke, P.J. & Benson, D.H. (1986) Vegetation Survey of Dharug National Park. Royal Botanic Gardens Sydney.
Vegetation Communities of Marramarra National Park	N/A	N/A	N/A		None
Vegetation Communities of Jamison Valley	N/A	N/A	N/A		None
Preliminary report on the vegetation of Yengo National Park and Parr	1988				Sanders, J. Bedward, M. Leahy, B. Robinson, M. & Sheringham, P. (1988). Preliminary report on the vegetation of Yengo National Park and Parr State Recreation

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
Forest Ecosystem Classification and Mapping for the Hunter Sub-Region in the Lower North East Comprehensive Regional Assessment	CRAHUN	National Parks and Wildlife Service	Department of Urban Affairs and Planning. Govenor Macquarie building Bridge St, Sydney.	No	N/A	Hunter sub-region in the Lower North East CRA region	N/A	N/A	1999	No	N/A	N/A	N/A
Vegetation Survey, Classification and Mapping: Lower Hunter and Central Coast Region	REMS	Lower Hunter & Central Coast Regional Environmental Management Strategy	Sophie Powrie, PO Box 1906 Hunter Region Mail Centre NSW 2310 ph: (02) 49262566	Yes	5,6	Covers LGA's of Gosford, Wyong, Lake Macquarie, Newcastle, Port Stephens, Maitland and Cessnock.	Various :						
Forest Survey of the Warragamba Inner Catchment Area	N/A			No	Unknown		1956	Unknown	Unknown	No	20 chains to an inch (approx 1: 15840)		Yes
Survey of the Duffys Forest community	Duffys	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vegetation Survey of Gardens of Stone NP	Gardensofstone	National Parks and Wildlife Service	GIS Division NSW National Parks and Wildlife Service	No	Unknown	Gardens of Stone National Park	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Illawarra COI	Illawarra	Wollongong City Council	?	No		Wollongong Local Government Area	2001	1:16000	2001	No	1:16000	in progress	in progress
Flora Survey, Morrisset Forestry District	Morreis	NSW State Forests		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (in hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
Forest Ecosystem Classification and Mapping for the Hunter Sub-Region in the Lower North East Comprehensive Regional Assessment	N/A	N/A	N/A	N/A		0.04ha	291	Full floristics	Braun-Blanquet C/A 1-6	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	non-random stratified : lithology, rainfall, temperature, aspectbroad vegetation structure and supplemented by 'expert' selections	yes
Vegetation Survey, Classification and Mapping: Lower Hunter and Central Coast Region						0.04ha	57	Full floristics	Braun-Blanquet C/A 1-6	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	Non-random stratified:soil landscapes, aspect and supplemented by 'expert' selections	Yes
Forest Survey of the Warragamba Inner Catchment Area	Not evaluated	Not evaluated	Not evaluated	Height classes and Canopy density		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Survey of the Duffys Forest community	N/A	N/A	N/A	N/A	N/A	0.04ha	32	Full floristics	Braun-Blanquet C/A 1-6	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	Expert selection	No
Vegetation Survey of Gardens of Stone NP	N/A	N/A	N/A	N/A	N/A	0.04ha - nested quadrat	82	Full floristics	Relative abundance		Plot position interpreted from 1:25000 topographic maps - precision estimated at 100m		
Illawarra COI	unknown	unknown	unknown	Dominant Canopy species		0.04ha	In progress (so far 131)	Full floristics	Braun-Blanquet C/A 1-7	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	non-random stratified : soil landscape and aspect	yes
Flora Survey, Morrisset Forestry District	N/A	N/A	N/A	N/A		0.1ha	146	Full floristics	Braun-Blanquet C/A 1-6	Slope, altitude, aspect, topographic position, drainage, percentage cover and particle size of surface rock and cover of outcropping bedrock		non-random stratified : lithoogy, altitude and topographic exposure	yes

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
Forest Ecosystem Classification and Mapping for the Hunter Sub-Region in the Lower North East Comprehensive Regional Assessment	1998-99				NPWS (1999). Forest Ecosystem Classification and Mapping for the Hunter Sub-Region in the Lower North East Comprehensive Regional Assessment: A Report undertaken for the NSW CRA/ RFA Steering Committee
Vegetation Survey, Classification and Mapping: Lower Hunter and Central Coast Region	1999				NPWS (2000a) Vegetation Survey, Classification and Mapping: Lower Hunter and Central Coast Region. A project undertaken for the LHCC Regional Environmental Management Strategy. NSW National Parks and Wildlife Service.
Forest Survey of the Warragamba Inner Catchment Area	N/A	N/A	N/A		
Survey of the Duffys Forest community	1999-00				Smith, P. & Smith, J. (2000). Survey of the Duffys Forest Vegetation Community. A report to the NSW National Parks and Wildlife Service and Warringah Council.
Vegetation Survey of Gardens of Stone NP	2001				Washington, H. (2001) Vegetation Survey of Gardens of Stone National Park. A report to the NSW National Parks and Wildlife Service, Blue Mountains Region.
Illawarra COI	2001				in progress
Flora Survey, Morrisset Forestry District	1993-94				Binns, D. (1996). Flora survey, Morisset Forestry District, Central Region New South Wales. Morisset Forestry District EIS. Supprting document No. 3. Research division, State Forests of New South Wales, Sydney.

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
Manobalai	Manobalai	Stephen Bell		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mt Piper	Mount piper	Stephen Bell		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Myambat	Myambat	Stephen Bell		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nic Gellie	Nic Gellie	Nic Gellie		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Robet Payne	R Payne	Robert Payne		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vegetation Survey of the Wyong Shire	Wyong shire	Wyong City Council		No	Unknown	Wyong Local Govrenment Area	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)
Vegetation Survey of	Baulkham	Baulkhan Hills City					Unknown (in	Unknown (in	Unknown (in	Unknown (in	Unknown (in	Unknown (in	Unknown (in

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (in hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
Manobalai	N/A	N/A	N/A	N/A		0.04ha	23	Full floristics	Braun-Blanquet C/A 1-6		Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	non-random stratified : geology, aspect, broad veg structure, topographic position and supplemented by 'expert' selections	
Mt Piper	N/A	N/A	N/A	N/A		0.04ha	43	Full floristics	Braun-Blanquet C/A 1-6		Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	non-random stratified : geology, aspect, topographic position and supplemented by 'expert' selections	
Myambat	N/A	N/A	N/A	N/A		0.04ha	22	Full floristics	Braun-Blanquet C/A 1-6		Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	non-random stratified : geology, aspect, broad veg structure, topographic position and supplemented by 'expert' selections	
Nic Gellie	N/A	N/A	N/A	N/A		0.04ha	28	Full floristics	Braun-Blanquet C/A 1-7	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	c. 100m	random	yes
Robet Payne	N/A	N/A	N/A	N/A		0.04ha	27	Full floristics	Braun-Blanquet C/A 1-7	Partial sites with vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from 1:25000 topographic maps - precision estimated at 250m	Random	yes
Vegetation Survey of the Wyong Shire	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)	Unknown (in progress)		0.04ha	86	Full floristics	Braun-Blanquet C/A 1-7	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	Non-random stratified:soil landscapes, aspect and supplemented by 'expert' selections	yes
Vegetation Survey of	Unknown (in	Unknown (in	Unknown (in	Unknown (in		0.04ha	In progress (so far	Full floristics	Unknown Braun-	unknown	Plot position interpreted from GPS & 1:25000		

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
Manobalai					none
Mt Piper					none
Myambat					none
Nic Gellie	1985-95				none
Robet Payne	1995				none
Vegetation Survey of the Wyong Shire	2000				in progress
Vegetation Survey of					

Dataset Name + Description	Survey Id	Custodian	Contact Person/s	Metadata statement obtained ? To ANZLIC standard ?	Minimum Map Unit (area in hectares)	Coverage (Description of map extent)	Date of ImageryUsed	Scale of mapping imagery used	Dates of mapping	Aerial photos scanned and rectified ?	Scale of map	Edge Matching	Line work digitised
Bioindicators	Bioind			No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stephen Bell	Bellextra	Stephen Bell		No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Campbeltown shale-sandstone transition vegetation survey	Camp			No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
The conservation of natural vegetation remnants in southern Hawkesbury City Council Local Governmnet Area	Cumb			No	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A

Dataset Name + Description	Quality control - Line work	Line Work Reliability and Obsolescence	Quality control - attribute coding	Method of Vegetation Classification by API (Walker & Hopkins structural/floristic or other ?)	Data overlap	Plot Size / Dimensions (in hectares or metres)	Number of plots surveyed	Plot Data Content full floristics ?	Plot Data Content Braun-Blanquet cover/abundance ?	Other site data collected ? eg. veg. structure, canopy cover, sp. abundance, biomass, veg. condition	Precision of Plot Location (georeferencing)	Method of plot selection (e.g. random, stratified random etc.)	Plot data available digitally ?
Bioindicators	N/A	N/A	N/A	N/A	N/A	0.04ha	299	Full floristics	Percentage Cover	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	unknown	Selection within idelalised sampling unit of a sub-catchment	yes
Stephen Bell	N/A	N/A	N/A	N/A	N/A	0.04ha	8	Full floristics	Braun-Blanquet C/A 1-6	Vegetation structure, substrate, slope, aspect, horizon azimuths, landform, observations on surface soil & disturbance	Plot position interpreted from GPS & 1:25000 topographic maps - precision estimated at 100m	unknown	yes
Campbeltown shale-sandstone transition vegetation survey	N/A	N/A	N/A	N/A	N/A	0.04ha	90	Full floristics	Braun-Blanquet C/A ?	Vegetation structure, slope, aspect, horizon azimuths, landform, disturbance	Plot position interpreted from 1:25000 topographic maps - precision estimated at 100m	unknown	yes
The conservation of natural vegetation remnants in southern Hawkesbury City Council Local Governmnet Area	N/A	N/A	N/A	N/A	N/A	0.04ha	112	Full floristics	Unknown Braun-Blanquet C/A	Substrate, slope, aspect, altitude, topographic position	Plot position interpreted from 1:25000 topographic maps - precision estimated at 100m	unknown	yes

Dataset Name + Description	Date/s of plot data collection	Method of Vegetation Classification	Environmental Variables used in classification	Data Overlaps	Publication
Bioindicators	1996				AMBS. (1997). Blue Mountains District Bio-indicators Survey and Research Project, NSW National Parks and Wildlife Service Blue Mountains District.
Stephen Bell	1998-99				None
Campbeltown shale-sandstone transition vegetation survey	1999				
The conservation of natural vegetation remnants in southern Hawkesbury City Council Local Governmnet Area					Cohn, J.S. & Hastings, S.M (1993) The conservation of natural vegetation remnants in southern Hawkesbury City Council Local Government Area. Save the Bush Project No. MZ08, Australian Nature Conservation Agency.