Regional Biodiversity Survey & Assessment Guidelines

Draft for comment

April 2001

Prepared by the NSW National Parks and Wildlife Service and SMEC Australia

1 APPENDIX A: DOCUMENTS REVIEWED

Guideline Name	Prepared By
A Framework for Public Environmental Reporting, An Australian Approach	SMEC & Australian Industry Group for Environment Australia, 2000
Animal Research Authority Guidelines 1, 5, 6, 7 and 10	NSW Agriculture, 1994, 1996, 1998, 1999, 2000a
Assessment of Terrestrial Ecosystems, Draft 4, EIS Manual	DUAP 1997
Assessment of Aquatic Ecology in EIA - DUAP	Lincoln Smith (1998)
Australian Code of Practice for the care and use of animals for scientific purposes. 6th Edition	NHMRC, 1997
Biodiversity Planning Guide for Local Government	Fallding et al., 2001
Bush Fire Risk Management Plans and Guidelines	NSW Bush Fire Coordinating Committee (1998 & 1999)
Community Biodiversity Survey Manual	Carlton (1998)
Conservation Value Assessment Guidelines (Site specific).	NPWS, 1997b
Environmental Assessment Guidelines - Flora and Fauna	NPWS Western Zone, 1998
Flora and Fauna Guidelines for Development – Wyong Shire Council	Wyong Shire Council, 1999
Flora and Fauna Survey Guidelines - Lake Macquarie City Council	Forest Fauna Surveys, EcoPro P/L, Fly By Night Bat Surveys P/L, 1997.
General Guidelines for Impact Assessment	NPWS, 1998a
Guide to Native Vegetation Survey (Agricultural Region) using the Biological Survey of South Australia Methodology	SA Department of Housing & Urban Development, 1997
Guideline for the Preparation of Environmental Assessment Reports, Edition 1	DPWS Project Management Group, 2000
Guidelines and Application Form for Clearing Vegetation under the NVC Act	DLWC, 1999a
Guidelines for Assessment of Aquatic Ecology in EIA (Draft)	DUAP, 1998
Guidelines for Clearing Fauna Habitat - RTA	Sinclair Knight Mertz, 1999
Guidelines for Koala Habitat Assessment	Australian Koala Foundation, 1999
Guidelines for Natural Heritage Conservation Assessment of Lands (Draft)	NPWS, 1997a
Guidelines for Protecting Urban Bushland and other Natural Areas (Draft)	DUAP, 1999a

Interim Procedures for Targeted and General Flora and Fauna Surveys and Reports under the *Native Vegetation Conservation Act 1997*.	DLWC, 1999b
Internal Guidelines – Threatened Species	DUAP, 2000
Local Greening Plans - a guide for vegetation and biodiversity management.	Greening Australia, 1995
Native Vegetation Handbook 1 - support package for regional vegetation committees (Draft)	DLWC, 1998
NSW Comprehensive Regional Assessments, Vertebrate Fauna Surveys 1996-1997 - Summer Survey Season Field Survey Methods	NPWS, 1997c
SEPP 44 – Koala Habitat Protection, DUAP Circular B35	DUAP, 1995
Staff Guidelines for the assessment of clearing applications under the NVC Act	DLWC, 1997
Survey Design for Biodiversity: Bryophytes - Literature review (Draft)	Author unknown
Terms of licence under the TSC Act, State Forests, Lower North East. Appendix B	NPWS, 1999
Terrestrial Flora and Fauna Survey Guidelines (Draft)	DUAP, 1999b
Threatened Species Assessment Manual, Development Services Division	Shoalhaven City Council, 2000
Threatened Species Conservation Act 1995 – Information Circular No.1	NPWS, 1996b
Threatened Species Management Information Circular No. 2 8 Part test of significance	NPWS, 1996a
Threatened Species Management Information Circular No. 5 - Species Impact Statements	NPWS, 1998b
Threatened Species Management Information Circular No. 6 Policy for Translocation of Threatened Fauna in NSW	NPWS, 1998c
Vegetation Mapping Guidelines for Reserve and Conservation Planning (Draft)	NPWS, 1997d

2 APPENDIX B PARTICIPATING ORGANISATIONS

The guidelines were developed following extensive industry consultation throughout NSW. The following organisations participated in the consultation program conducted by SMEC with the assistance of NPWS.

Additions to be made after the 2nd workshop

Actinotus Flora Consultants

Alan Stewart & Associates

Andrews Neil

Arbec Garden and Parks Design

Armidale City Council

Arnhem Environmental Impact Assessors

Australian Nature P/L

Avifauna Studies

Ballina Shire Council

Bankstown City Council

Bathurst City Council

Baulkham Hills Shire Council

Bega Valley Council

BioDesign

Biosis Research P/L

Biosphere Environmental Consultants Pty Ltd

Blue Mountains City Council

Blue Mountains Wilderness Trust

Bushcare

Byron Council

Campbelltown City Council

Central Coast Regional Catchment Committee

Coal & Allied

Conarcher & Travers

Cooma-Monaro Shire Council

CSIRO Wildlife & Ecology

Cygnet Surveys and Consultancy

Department of Land & Water Conservation

Department of Urban Affairs & Planning

Ecological Surveys and Management

Education & Environment Services Pty Ltd

Environment ACT

Environmental Research & Information Consortium

ERM Australia
Eurobodalla Shire Council
Evans Shire Council
Forest Fauna Surveys
Geoff Butler & Associates
Geoff Cunningham Natural Resource Consultants P/L
GeoLINK Group
Greater Taree City Council
Greenloaning Biostudies Pty Ltd
Greg Daly Environmental Consultant
Greg Richards & Associates P/L
Gunninah Environmental Consultants
Holroyd City Council
Hornsby Shire Council
Hunter Catchment Management Trust
Hunters Hill Council
James Warren & Associates
Kendall & Kendall Ecological Services P/L
Land & Environment Planning
Lane Cove Council
Lemington Coal Mines Pty Ltd
LesryK Environmental Consultants
Liverpool City Council
Loftus Bushcare
Macquarie University
Maitland City Council
Mosman Council
Mount King Ecological Surveys
National Parks Association of NSW
Nature Conservation Council of NSW
North Coast Forestry and Environmental Consultants
NSW Aboriginal Land Council
NSW Agriculture
NSW Minerals Council
P & J Smith Ecological Consultants
Parramatta City Council
Penrith City Council
Pittwater Council
Powercoal P/L
Rangott Minerall Exploration P/L
Robert Clifton Consulting

RTA
Rural Fire Service
RZM Pty Ltd
Shellharbour City Council
Shire of Nambucca
State Forests of NSW
Strathfield Municipal Council
Sutherland Shire Council
Sydney Water Corporation
Tallaganda Shire Council
Terra Consulting (NSW) Pty Ltd
Threatened Species Network NSW
Tree Wise Men Australia P/L
Ulan Coal Mines Ltd
Ulmarra Council
Umwelt (Aust.) Pty Ltd
University of Wollongong
Urban Bushland Management Consultants P/L
Walgett Shire Council
Warringah Shire Council
WBM Oceanics Australia
Wellington Council
Wingecarribee Shire Council
Wirrimbirra Consultants
Woollahra Council
Yass Shire Council

3 APPENDIX C LEGISLATION

3.1 STATUTES

3.1.1 EPBC Act

Environment Australia administers the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) which commenced in July 2000. The EPBC Act provides Commonwealth leadership to the States and Territories on the environment to enable a national scheme of environmental protection and biodiversity conservation to be achieved. The Act (Environment Australia 2000):

- focuses Commonwealth interests on matters of national environmental significance;
- puts in place a streamlined environmental assessment and approvals process; and
- establishes an integrated regime for biodiversity conservation and management of important protected areas.

The EPBC Act applies to matters of national environmental significance, the environment on Commonwealth land or (if taken in a Commonwealth area or by the Commonwealth) on the environment (Environment Australia 2000). There are four matters of national environmental significance in the EPBC Act which need to be considered in regional-scale biodiversity assessments:

a) World Heritage Properties;
b) Ramsar wetlands of international significance;
c) Nationally threatened species and ecological communities and key threatening processes;
d) Migratory species protected under:
    - Japanese and Australian Migratory Bird Agreement (JAMBA),
    - China and Australian Migratory Bird Agreement (CAMBA) and
    - the Bonn Convention.

These matters are detailed below.

i World Heritage Properties

At the present, there are only two World Heritage properties located in NSW. These are the Central Eastern Rainforest Reserves (extending from Barrington Tops in the south, to Border Ranges NP on the Queensland border), Wilandra Lakes Region (located in southwestern NSW) and Blue Mountains NP (located west of Sydney).

ii Ramsar Wetlands

The Convention on Wetlands of International Importance, commonly referred to as the Ramsar Convention was ratified in 1975. This intergovernmental treaty aims to halt the loss of wetlands and to conserve the remaining wetlands. Australia has approximately 49 sites listed under the Convention, of which six are in NSW. To obtain locations of Ramsar sites, refer to Chapter 4 of these Guidelines.

iii Nationally Threatened Species and Ecological Communities and Key Threatening Processes

The EPBC Act includes a list of nationally threatened species, threatened ecological communities and key threatening processes. These were previously listed on the *Endangered Species Protection Act 1992*, which is replaced by the new Act. Refer to Chapter 4 of these Guidelines for access to these species lists.

iv Migratory Species

Australia has international agreements under the Bonn Convention, which deals with all migratory species, and JAMBA and CAMBA, which deal only with birds.

JAMBA and CAMBA ensure that the Australian, Japanese and Chinese Governments recognise the value of migratory birds by protecting those that migrate between their countries. These bilateral agreements reinforce the Ramsar Convention. The Agreements define migratory birds as those birds which migrate between Australia and Japan and Australia and China and include shorebirds, seabirds and some species of swallow and wagtail.

The Bonn Convention (also known as Convention on the Conservation of Migratory Species of Wild Animals - CMS) aims to conserve terrestrial, marine and avian migratory species and their habitats on a global scale. There are approximately 66 countries that are members of the CMS from Africa, Central and South America, Asia, Europe and Oceania.

To obtain more information and a list of migratory species on the EPBC Act, visit: www.environment.gov.au/bg/wildlife/lists/migratory/index.html.

3.1.2 EP& A Act

The NSW *Environmental Planning & Assessment Act 1979* (EP&A Act) is administered by the NSW Department of Urban Affairs & Planning. Most of the provisions dealing with what can and cannot be done on land in NSW are found in legislation or planning instruments made under this Act (Farrier *et al* 1999). Environmental planning involves two major processes:

1. the preparation of environmental planning instruments (State Environmental Planning Policies (SEPPs), Regional Planning Policies (REPs) and Local Environmental Policies (LEPs)) under Part 3 of the EP&A Act; and
2. the making of decisions about development and activities under Parts 4 or 5 of the EP& A Act.

The EP&A Act links the environmental planning process to the protection of environmental values as it seeks to:

> "*encourage the protection of the environment, including the protection and conservation of native animals and plants including threatened species, populations and ecological communities*" (s.5(a)vi).

With regard to regional-scale biodiversity assessments, consideration needs to be given to Environmental Planning Instruments – SEPPs, REPs, LEPs, which are made under the EP&A Act. Section 2.1.2 discusses the relevant SEPPS, which apply to terrestrial biodiversity conservation in NSW.

3.1.3 TSC Act

The NSW *Threatened Species Conservation Act 1995* (TSC Act) is administered by the NPWS. It aims to protect all threatened wildlife that is native to NSW, excluding most marine life. The Act relates to 'species', 'populations', 'ecological communities', 'habitats' and 'threatening processes'. The *National Parks and Wildlife Act 1974* further protects all flora and fauna in NSW.

The TSC Act protects threatened flora and fauna and their habitats by:
- creating a range of offences;
- giving the NPWS and the Minister for the Environment the power to issue certain orders which can help to protect threatened wildlife in the short term;
- requiring that the planning and development approval process for developments and activities have regard to the potential for adverse impacts; and
- requiring the NPWS and others to take long-term actions.

One of the main features of the TSC Act is the integration of the conservation of threatened species into the development control processes under the *Environmental Planning and Assessment Act 1979*. Amendments made to this Act set out eight factors to be considered in deciding whether there is likely to be a significant effect on threatened species, populations and ecological communities and whether a Species Impact Statement is required. These eight factors are refereed to as a Section 5A Assessment of Significance or more commonly an Eight-part Test.

3.1.4 NPW Act

The NSW *National Parks & Wildlife Act 1974* (NPW Act) established the National Parks and Wildlife Service (NPWS). The main functions of the NPWS are to administer national parks and other lands under the NP&W Act and the *Wilderness Act, 1987,* and to manage threatened species under the *Threatened Species Conservation Act, 1995.* Under the NP&W Act, the Director General of the NPWS can issue a stop work order in relation to an area if they consider that an activity is likely to significantly affect native flora and fauna, or their environment.

3.1.5 NVC Act

The Department of Land & Water Conservation administers the NSW *Native Vegetation Conservation Act 1997* (NVC Act). The NVC Act was enacted to protect and conserve the remaining native vegetation in New South Wales. It repeals *State Environmental Planning Policy No 46 - Protection and Management of Native Vegetation* and replaces the protected land provisions of the *Soil Conservation Act, 1938.* The Act also provides for communities to develop regional solutions to native vegetation management by preparing Regional Vegetation Management Plans (RVMPs).

The NVC Act creates a system whereby development consent is required to clear native vegetation or to clear vegetation on protected land. These development consents are dealt with as if they were required under Part IV of the *Environmental Planning & Assessment Act, 1979.*

3.1.6 State Environmental Planning Policies

i SEPP 14 - Coastal Wetlands (12 December 1985)

SEPP 14 is designed to ensure that coastal wetlands are preserved and protected in the environmental and economic interests of NSW. The policy applies to developments that have the potential to damage or destroy wetlands. The policy maps the wetlands to which the provisions of the policy apply. Land reserved or dedicated under the National Parks and Wildlife Act are excluded from the provisions of this policy. In deciding whether to give concurrence to development, the Director of Planning has to take a number of factors, including habitat conservation, the representations of the Director General of NPWS and any feasible alternatives to the proposal.

ii SEPP 19 - Bushland in Urban Areas (24 October 1986)

State Environmental Planning Policy 19 – Bushland in Urban Areas (SEPP 19) is designed to protect bushland in public open space zones and reservations, as part of preservation for natural heritage, or for recreational, educational and scientific purposes. It ensures that bush preservation is given a high priority when local environmental plans for urban development are prepared. Under SEPP 19 'bushland' means land on which there is vegetation that is either a remainder of the natural vegetation of the land or, if altered, is still representative of the structure and floristic of the natural vegetation. It offers protection to bushland on areas zoned or reserved for public open space purposes, but it only applies to local government areas listed in the Schedule.

iii SEPP 26 – Littoral Rainforests (5 February 1988)

SEPP 26 aims to provide a mechanism for assessing the impact of development on areas of littoral rainforest, with a view to their preservation. Littoral rainforest is a distinct type of rainforest especially adapted to coastal conditions. SEPP 26 applies to certain mapped areas as well as a buffer zone of 100 metres surrounding them, except for areas protected under the NPW Act. A range of activities in these areas requires the consent of Council and the concurrence of the Director of Planning (or the Minister where development by public authorities is involved). This policy complements the NPWS's efforts to conserve littoral rainforests that are not yet protected by the NPWS.

iv SEPP 44 – Koala Habitat Protection (13 February 1995)

SEPP 44 aims to encourage the conservation and proper management of areas of natural vegetation that provides habitat for Koalas. This is to ensure permanent, free-living populations over their present range and to reverse the current trend of population decline. The policy requires the identification of "potential koala habitats' and "core koala habitats" in lands subject to development applications, as well as preparation of plans of management for areas of identified core koala habitats. SEPP 44 also requires council to survey and identify potential and core koala habitat in local environmental planning instruments. Whilst the policy primarily aims to conserve the koala, the conservation of natural vegetation also complements the efforts of conserving potential wildlife corridors.

3.1.7 Agreements

i Voluntary Conservation Agreements

Voluntary Conservation Agreements under the NPW Act are joint agreements between a landholder and the Minister for the Environment, which allows a landholder to conserve the natural, cultural and/or scientific values of an area of land. The agreements contribute to the conservation of the State's heritage by providing permanent protection for the special features of an area such as aboriginal sites, threatened species, and unique geological features. An agreement can be entered into with owners of freehold land, lessees of Crown land, and local councils.

For further information, access the NPWS website at:
http://www.npws.nsw.gov.au/wildlife/vca/htm.

3.1.8 Environmental Strategies

i The National Strategy for Ecologically Sustainable Development (NSESD)

Ecological Sustainable Development (ESD) is development that meets the needs of the present, without compromising the ability of future generations to meet their needs (Commonwealth Government 1992). The integration of economic and environmental considerations is the foundation of the decision making process, and requires the application of the following key principles:

1. Precautionary principle: avoiding serious or irreversible damage to the environment;
2. Intergenerational equity: ensuring the health of the environment is maintained for the benefit of future generations;
3. Conservation of biological diversity: conservation of biological diversity and ecological integrity; and
4. Environmental economic valuation: the true cost of environmental impacts should be factored into valuation of assets and services.

ii The National Strategy for the Conservation of Australia's Biological Diversity

The Commonwealth, States and Territories ratified the National Strategy for Conservation of Australia's Biological Diversity (DESP 1996) in 1996. Its goal is to protect biodiversity and maintain ecological processes and systems. The States and Territories are committed to the development of their own detailed biodiversity conservation strategies, such as the NSW Biodiversity Strategy (outlined below).

The National Strategy recognises and adopts the principles of ecologically sustainable development. It recognises six key areas: conservation of biological diversity within and outside protected areas; integration of biological diversity conservation with natural resource management; managing threatening processes; improving our knowledge; involving the community; and meeting our international commitments.

iii The NSW Biodiversity Strategy (NPWS 1999);

One of the proposed actions in the National Strategy for Conservation of Australia's Biological Diversity (DESP 1996) is the development of complementary State and Territory Biodiversity Strategies. The NSW Biodiversity Strategy developed by the NPWS contains programs aimed at addressing key threatening processes in the State that could be implemented through the legislative and policy framework in NSW. This guideline contributes to the State Biodiversity Strategy by providing the assessment process that could be used to determine the biodiversity of a particular site in NSW.

4 APPENDIX D POTENTIAL KEY STAKEHOLDERS AND DATA SOURCES

Agency or Organisation	Administering Legislation	Information available	Web Address or other form of contact
Australian Government Printing Service (AGPS)		Government acts, policies and publications	
Australian Heritage Commission (Division of the Commonwealth Dept of Environment & Heritage)	*Australian Heritage Commission Act 1975*	Register of the National Estate (listings of natural sites).	www.environment.gov.au/heritage/
Australian Museum		Australian Museum database Specimen library Taxonomic experts	www.austmus.gov.au
Birds Australia		Atlas of Australian Birds Birds counts in Australia Species information (habitat, distribution, ecology)	www.birdsaustralia.com.au
Bureau of Meteorology	*Meteorology Act 1955*	Weather data (rainfall, temperature, wind)	www.bom.gov.au/climate/

Agency or Organisation	Administering Legislation	Information available	Web Address or other form of contact
Commonwealth Scientific Industrial Research Organisation (CSIRO)		Biodiversity research, including threatened species Feral animal control research; CSIRO publications on biodiversity; EUCLID – computer guide to identifying eucalypts; Interactive plant identification tools	www.csiro.au
Environment Australia	*Environment Protection Biodiversity Conservation Act 1999*	EPBC Act listings (Threatened species, JAMBA & CAMBA, Bonn convention). Databases: Directory of Important Wetlands, Eucalypt Data Project, Species Mapper; IBRA and EnviroMaps. Biodiversity Publications	www.environment.gov.au
Environmental Consultants		Environmental Reports Flora and Fauna Reports	Search DUAP library database to find relevant reports

Agency or Organisation	Administering Legislation	Information available	Web Address or other form of contact
Council	*Local Government Act 1993* *Local Environmental Plans*	Zoning, land use and heritage information Flora and fauna consultant reports State of the Environment Reports Flora and fauna guidelines	Contact relevant councils
National Heritage Trust		Funding for major natural heritage programs including wetlands, landcare and rivercare	www.nht.gov.au
Nature Conservation Council of NSW		Non-government environmental information from a range of sources Code of Conduct for Ecological Consultants	www.nccnsw.org.au
NSW Agriculture	*Animal Research Act 1985* *Animal Research Regulations 1985*	Feral plant and animal information Land use features Animal Research Authority inquiries	

Agency or Organisation	Administering Legislation	Information available	Web Address or other form of contact
NSW Department of Land and Water Conservation	*Catchment Management Act 1989* *Native Vegetation Conservation Act 1997* Regional Vegetation Management Plans	NSW Natural Resources Data Directory (NRDD) Aerial photographs and satellite images; Land tenure and land capability; Regional Vegetation Management Plans Maps, reports and GIS data on vegetation, topographic features, soil, geological and others	DLWC: www.dlwc.nsw.gov.au NRDD: www.nrims.nsw.gov.au
NSW Department of Urban Affairs and Planning	*Environmental Planning & Assessment Act 1979* *Heritage Act 1977* *State Environmental Planning Policies* *Regional Environmental Planning Policies*	EIS Guidelines (DUAP, 1996) Library resources – Flora and Fauna Reports, Regional studies.	www.duap.nsw.gov.au

Agency or Organisation	Administering Legislation	Information available	Web Address or other form of contact
NSW National Parks & Wildlife Service	*National Parks and Wildlife Act 1974* *Threatened Species Conservation Act 1995*	NPWS Wildlife Atlas Database Threatened species and reserve information Recovery Plans and Threat Abatement Plans Biodiversity Research	http://www.npws.nsw.gov.au
Royal Botanic Gardens, Sydney		Royal Botanic Gardens Database (online); National herbarium; Expert taxonomic information; Botanical library and bookshop (vegetation maps, flora identification books, and scientific journals);	www.rbgsyd.gov.au
State Forests of NSW		Flora and fauna records and reports	
Universities		Library resources Research programs	
Zoological Parks Board, NSW		Native fauna research	Taronga Zoo, Sydney Western Plains Zoo, Dubbo

5 APPENDIX E REPORTING CHECKLIST

Refer to:	Element	What it does	Importance	Sufficiency of Report			
				n/a	low	med	high
Section 3.3	Licensing for all field workers	Discloses the following information for all field workers associated with the survey: • NPWS Scientific License; • Animal Research License number (NSW Agriculture); and • Animal Care and Ethics Committee Approval.	Essential				
Section 7.1	Physical Profile of the region	Describes the physical nature of the land and past disturbances that have affected it.	Essential				
Appendix C	Regulatory profile of the region	Describes the environmental planning instruments at the federal, state and local level that apply to the biodiversity of the region.	Essential				
Section 7.1.1	Map of the Region	Displays the locality of the region, remnant vegetation present and extent of development.	Desirable				
Chapter 4	Data sources	Outlines all the data sources used to obtain background information and identify any limitations.	Essential				
Chapter 5	Survey design	Outlines the field survey techniques used, timing of surveys, the amount of effort implemented.	Essential				
Section 5.2	Survey locations	Identifies the location of survey sites and where photographs were taken. This information should be mapped.	Essential				
Section 5.1.2	Limitations and assumptions	Recognises the limitations and shortcomings of the study and the assumptions used in interpreting the data.	Essential				

Refer to:	Element	What it does	Importance	Sufficiency of Report			
				n/a	low	med	high
Section 6.5	Flora inventory	Lists all tree shrub, ground cover and aquatic species, including: • species which are protected or threatened at a regional, state and federal level; • introduced species; • protected or threatened species which have specific habitat requirements found within the region;	Desirable				
Section 6.5	Vegetation community description	Describes the vegetation communities present in the region by: • structure (in terms of scientifically accepted classification system); • spatial distribution (i.e. plant densities and patterning); • condition and integrity; • likely original vegetation communities (pre- or at early settlement); The vegetation communities of the region should be mapped to display the extent of each type.	Desirable				
Section 6.5	Hydrology	Describes the hydrology of the area and how this relates to the dynamics of vegetation communities.	Desirable				
Section 6.6	Fauna inventory.	Lists all known and likely terrestrial and aquatic fauna species. This should include: • species which are protected, threatened or listed under any international agreements; • introduced species; • species known or likely to breed in the area; and • any species which have specific habitat requirements found within the region.	Desirable				

Refer to:	Element	What it does	Importance	Sufficiency of Report			
				n/a	low	med	high
Section 6.6	Fauna habitat description	Describes the fauna habitat types present in the region and their importance as corridors, migratory routes or drought refuges.	Desirable				
Section 7.1.2	Biodiversity significance	Assesses the significance of the biodiversity in the region. This should consider: • vegetation condition; • conservation status of species, populations and ecological communities; • connectivity of habitat; • biodiversity richness/uniqueness; • migratory species; and • isolated and disjunct populations.	Desirable				
Section 7.1 and 7.3	Strategic Planning	Identify strategic planning options with regard to conservation status utilising a hierarchy to determine areas of outstandingly high biological diversity and threatened species diversity or abundance.	Desirable				
Section 7.1.6	Recommendations	Suggest recommendations with regard to conservation values found in the region	Desirable				
Section 3.2.1	References	Lists all references cited in the study	Essential				

6 APPENDIX FBIODIVERSITY DATABASES

1. **The Atlas of NSW Wildlife** is administered by the NPWS and contains native flora and fauna records in NSW, both historical and current. Records are obtained from field surveys conducted by NPWS and other organisations, specimens and records of herbariums, private collections and museums, scientists, reports and journals, and the general public. To obtain data from this resource, contact the Data Exchange Officer at NPWS and order historical flora and/or fauna records per 1:100,000 map sheet. The Wildlife Atlas is available at http://www.npws.nsw.gov.au.

2 **CANRI** includes the NSW Natural Resources Atlas and Data Directory, as well as websites tailored for coastal management, rivers, soils, environmental reporting and wildlife. It provides information on biodiversity, salinity, Landcare, vegetation landscape management, and regional planning. Website: www.canri.nsw.gov.au.

3 **Australian Museum Fauna Database** is Australia's largest comprehensive voucher specimen collection. To obtain database records, contact Australian Museum Business Service's (AMBS) general office. Data is available for a fee, and records include location. Voucher collections from most taxonomic groups are contained at the Sydney Museum premises, and positive identifications can be made if specimens are preserved and sent to AMBS with notification. Voucher collections are maintained for all functional groups including aquatic and terrestrial fauna (vertebrates and invertebrates).

4 **Atlas of Australian Birds** is a database produced by Birds Australia. It contains records of birds throughout Australia, including rare and threatened birds, which have been recorded by volunteers. The methods for searching the database can either be by a specified area or incidental searches for individual species or groups. Maps of species distributions are also available. Website: www.birdsaustralia.com.au.

5 **NSW data** is administered by the Royal Botanic Gardens and contains records of botanical specimens, including rare and threatened plants throughout NSW. To order a search of an area, contact the Royal Botanic Gardens, Sydney. Website: www.rbgsyd.nsw.gov.au

6 **PlantNet** is a taxonomic database administered by the Royal Botanic Gardens, Sydney. The database currently provides a comprehensive listing of indigenous plants, potentially dangerous weeds and information on rare and threatened plants in NSW. Each entry includes the scientific name of the plant with common and misapplied name/s and a distribution map. The database is being expanded to give diagnostic and possibly specimen records in the future. Website: http://plantnet.rbgsyd.gov.au.

7 **FaunaNET** is the Australian Museum's Website which includes the Master Names List of NSW fauna (taxonomic database), has mapping capabilities using GIS Software, and contains interactive diagnostic keys (eg the Dung Beetles of NSW). Website: to be announced

8 **EPBC Act Database** is an on-line database managed by Environment Australia. The database contains relevant information for the EPBC Act, including all of the current listings for threatened species and ecological communities, migratory species, Ramsar

sites, world heritage areas, and nature conservation reserves. The database supplies records from predictive modelling rather than actual records and can be found at Website: www.environment.gov.au/epbc/db/index.html

9 **Eucalyptus Data Project** is another database managed by Environment Australia, containing specimen locality records of Eucalyptus, Angophora and Corymbia species in Australia. It is a collaboration project of Australian Herbaria and Conservation Agencies and the Environmental Resources Information Network. Website: www.dest.gov.au/database/euc-data/euc.html

10 **Other Environment Australia databases** are available on-line through the Environment Australia website at http://www.environment.gov.au/search/databases.html. These may assist in both gathering and interpretation of biodiversity data. Examples of other on-line databases include the Australian Bird and Bat Banding Scheme.

11 **Other Herbariums** exist in various institutions around NSW. Examples regional herbariums include Canberra (Southern Coast Tablelands), Queensland Herbarium (North Coast), University of New England (North Tablelands/Coast).

12 **Local Government Databases** to request on a project by project basis by contacting the local Council. eg. Lake Macquarie Council Wildlife Database.

7 APPENDIX G PROFORMAS FOR FIELD SURVEYS

FIELD DATA SHEETS ARE IN PREPARATION FOR THE FOLLOWING TYPES OF SURVEY DATA:

Plant survey:

1. Vegetation survey: general data about survey sites
2. Vegetation survey: structural data
3. Vegetation survey: floristic data
4. Threatened plants

Animal survey:

5. Amphibian and reptile survey
6. Diurnal bird census
7. Nocturnal Call Playback census
8. Elliott and cage trapping for small mammals
9. Hair tubes and scats
10. Spotlighting
11. Bat ultrasonic call detection
12. Harp trapping
13. Opportunistic records
14. Collection of voucher specimens

General:

15. Check list of survey activities
16. Site attributes

DRAFT

Prepared by the NSW National Parks & Wildlife Service and SMEC Australia for the Biodiversity Survey Program, an initiative of the NSW Biodiversity Strategy.

This is a draft for comment only. It should not be cited or quoted in any form.

Comments on the *Draft Regional Biodiversity Survey & Assessment Guidelines* are welcomed and should be addressed before the 25 May 2001 to:

biodiversity.survey@npws.nsw.gov.au

DRAFT

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Acronyms

AGD	Australian Geodectic Datum
AMG	Australian Map Grid
AR Act	Animal Research Act 1985
CAMBA	China-Australia Migratory Bird Agreement
CANRI	Community Access to Natural Resources Information
CV	Curriculum Vitae
DLWC	Department of Land and Water Conservation
DUAP	Department of Urban Affairs and Planning
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
EPI	Environmental Planning Instrument
ESD	Ecological Sustainable Development
FM Act	*Fisheries Management Act 1994*
GDA	Geocentric Datum of Australia
GIS	Geographic Information System
GPS	Global Positioning System
IBRA	Interim Biogeographic Regionalisation of Australia
JAMBA	Japan-Australia Migratory Bird Agreement
LES	Local Environment Study
NPW Act	National Parks and Wildlife Act 1974
NPWS	NSW National Parks and Wildlife Service
NVC Act	*Native Vegetation Conservation Act 1997*
POEO Act	*Protection of the Environment Operations Act 1997*
POM	Plan of Management
REP	Regional Environmental Plan
RES	Regional Environmental Study
RVMP	Regional Vegetation Management Plan
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
SMEC	Snowy Mountains Engineering Corporation
TSC Act	*Threatened Species Conservation Act 1995*

1 INTRODUCTION

1.1 WHY CONDUCT REGIONAL SCALE BIODIVERSITY PLANNING?

The NSW Biodiversity Strategy (NPWS 1999a) identifies the values of biodiversity (ecological, cultural and financial) and the need for their protection. Maintaining the values of biodiversity can only be achieved through a combined effort by the community and government. A way in which this can be achieved is by planning for future development and conservation on a broad scale across the landscape.

At this strategic level biodiversity conservation becomes a collective partnership between individual landholders, community groups, and local and state government. This integration of biodiversity values into landscape-scale planning requires establishing guidelines to assist the process of surveying and assessing biodiversity.

1.2 WHAT IS THE PURPOSE OF THE GUIDELINES?

The aim of the Guidelines is to provide a coordinated, transparent and consistent approach to biodiversity survey and assessment. Such an approach not only helps to address some immediate needs in regional planning, but also provides the foundations for assembling information required to see long-term trends in landscape conservation and biodiversity distribution and abundance.

The Guidelines will assist those undertaking regional surveys to:

- understand the process of such work and their role within that process, as well as points at which other stakeholders should be involved;
- formulate appropriate aims and objectives for their study;
- employ appropriate survey techniques and survey designs for different taxonomic groups and different biotic environments;
- adopt a common approach to data collection and reporting, so that results are applicable to future studies and studies conducted in other bioregions;
- assist in the interpretation of survey results in a regional context so that studies are applied appropriately in environmental planning.

The Guidelines will also assist organisations that assess biodiversity surveys by providing benchmarks for assessing the standard of survey work, and by encouraging a higher standard of consistency and detail in survey reporting.

These guidelines also aim to be broadly relevant to most biodiversity survey needs. They can be adapted to suit survey in a range of regional environments within NSW, and to suit the survey requirements of projects with a diversity of regional planning and environmental management aims.

1.3 HOW HAVE THE GUIDELINES BEEN PREPARED?

The NSW National Parks and Wildlife Service (NPWS) in conjunction with SMEC Australia prepared these guidelines. The process has been coordinated and directed by representatives from NPWS, the Department of Land and Water Conservation (DLWC) and the Department of Urban Affairs and Planning (DUAP).

The process of guidelines preparation involved an extensive review of current literature (**Appendix A**) and two rounds of state-wide consultation workshops with stakeholders from local government, state agencies, ecological consultants, and non-government conservation groups (**Appendix B**).

1.4 APPLICATION OF THE GUIDELINES

1.4.1 Who are the Guidelines aimed at?

The Guidelines are primarily aimed at three groups:

Regional planning bodies	Those who are required to develop regional conservation plans or apply environmental planning legislation at the regional scale, including Local Government, Catchment Management Committees, and Regional Vegetation Management Committees.
Investigators	Those who conduct and report on regional scale biodiversity surveys and assessment. This can be either ecological consultants or the regional planning body themselves.
Reviewing authorities	Those consent/determining authorities which are responsible for assessing biodiversity surveys for the purpose of strategic land use decision making, such as NPWS, DLWC, DUAP and Environment Australia.

1.4.2 The Guidelines and regional planning instruments

The Guidelines provide principles and generic information that is applicable to a range of planning instruments such as:

- Regional Environmental Plans (REPs);
- Local Environmental Plans/Studies (LEPs/LESs);
- Regional Vegetation Management Plans (RVMPs);
- Regional Forest Assessments;
- Bush Fire Risk Management Plans under the Rural Fires Act;
- Catchment management planning under the *Total Catchment Management Act* or the Healthy Rivers policy initiatives;
- Water Reform Committees;
- Plans of Management (POMs).

These Guidelines provide advice on gathering data on the distribution and diversity of animals, plants, vegetation communities and potential habitats, data that contributes to most types of regional conservation planning irrespective of the planning instrument which is used to implement it. A planning instrument may have specific aims or purposes that will influence the choice of survey design or methods, perhaps through greater emphasis on gathering certain types of data, and these guidelines are intended to be adapted to those needs by users.

1.5 SCOPE AND LIMITATIONS OF THE GUIDELINES

The Guidelines are not intended to provide a comprehensive guide to the conduct of regional planning. Rather, they provide advice on the process of gathering biodiversity survey data required for regional planning aimed at biodiversity conservation. They also provide guidance for interpreting that data in a regional conservation context.

Hence, the information, general principles and points of consideration presented in the Guidelines are intended to be tailored to suit a range of regional planning instruments and aims, and to the diversity of land types found in NSW. The Guidelines represent current practice in survey, and may be subject to periodic review to ensure they remain so.

These Guidelines are complemented by:

- *Threatened Species Survey and Assessment: Guidelines for Developments and Activities* (NPWS and SMEC, 2001) which address impact assessment at the scale of individual land developments;
- Profiles commissioned by the NPWS which will provide detailed ecological information to assist in the survey and assessment of particular threatened species.
- *Biodiversity Planning Guide for Local Government* (Fallding *et al.* 2001) which provide a broad framework for regional planning in NSW.

1.6 CONTENTS OF THE GUIDELINES

The Guidelines have been divided into six main areas, as outlined below.

Chapter 2	***The Process* –** describes a typical chronological process for conducting regional-scale biodiversity surveys and assessment, and the roles and functions of the regional planning body, investigator, and reviewing authority.
Chapter 3	***The Investigator* –** provides suggestions for selecting an investigator through tender, the qualifications and experience which are necessary, and licenses and permits required by investigators conducting biodiversity surveys within NSW.
Chapter 4	***Data* –** outlines major sources of data and the use of this information in defining aims, scope, design and methods of study at the pre-survey, survey, and post survey stage. It also provides suggestions for the management of data.
Chapter 5	***Survey Design* –** provides principles and points of consideration for planning field survey, and the design and layout of survey sites.
Chapter 6	***Survey Methods* –** provides guidance on field survey techniques and the level of effort required, including assessment of flora and fauna habitat, and consideration of cultural significance in the process.
Chapter 7	***Interpretation, Reporting & Implementation* –** provides suggestions about the interpretation of results, how information should be structured to facilitate understanding and informed decision-making about the conservation of biodiversity within the region, and how the study should be reported to maximise its value and make it easier for readers to understand.

2 THE PROCESS OF BIOREGIONAL SURVEY & ASSESSMENT

This section discusses nine steps in surveying and assessing biodiversity at a regional-scale. Each step suggests activities that need to be considered by regional planning bodies, investigators, and reviewing authorities. The steps are applicable to most types of regional-scale biodiversity surveys and assessment regardless of size or complexity.

The overall process is cyclical, with each of the steps involving information gathering and consultation also involve feedback and revision. A diagrammatic representation of the Guidelines nine step process is presented in Figure 2.1.

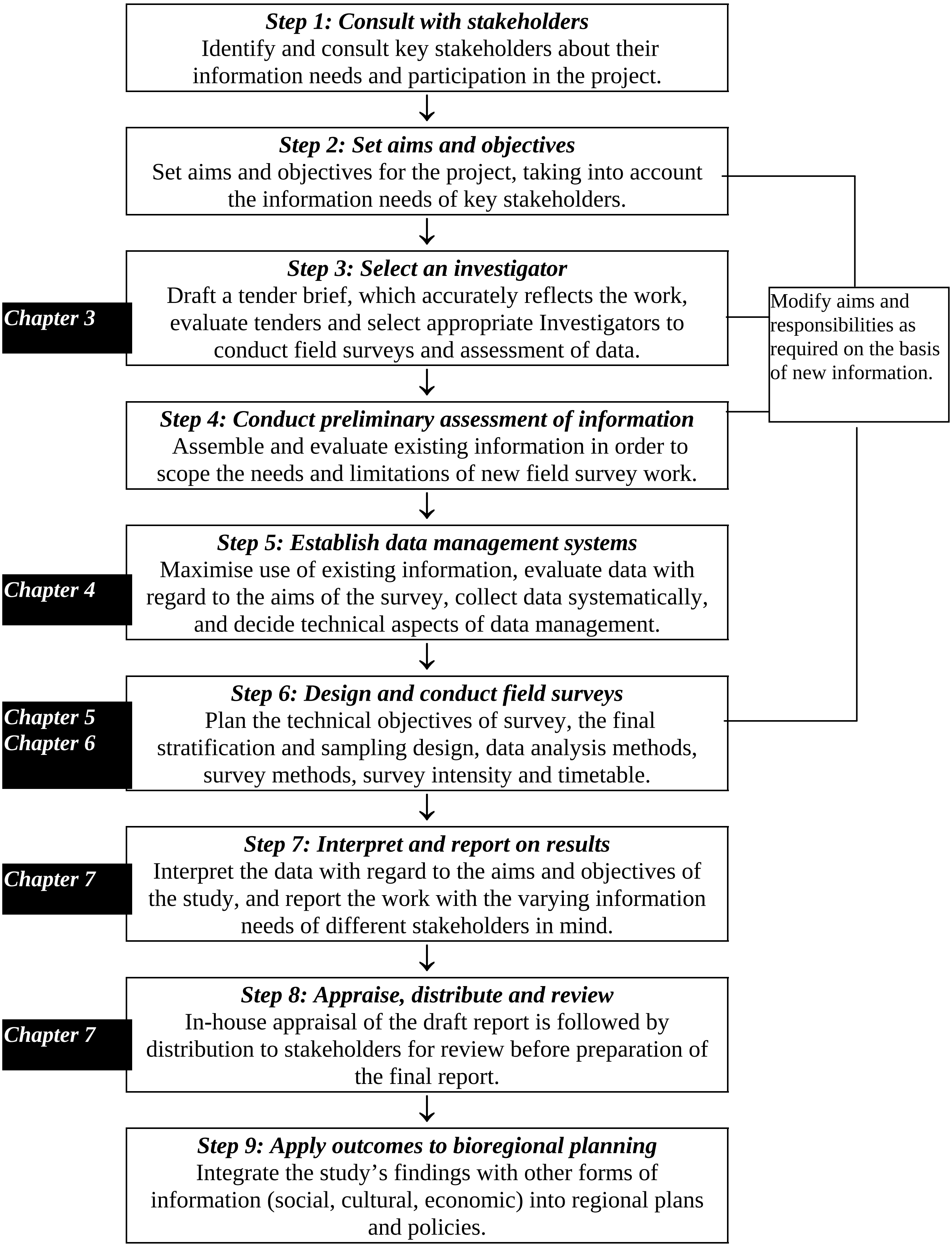
STEP 1: CONSULT WITH STAKEHOLDERS

- identify the intended audience for the study – the stakeholders
- consult with stakeholders regarding:
  - the outcomes they wish to see from the project;
  - the contributions they wish to make to the project.

Identifying and consulting with a wide range of stakeholders is crucial to the study's success. In particular, key stakeholders will assist to:

- clarify the aims and objectives of the study;

Figure 2.1: The general process of conducting bioregional survey and assessment



- determine the technical levels at which reporting should be pitched and the report formats (for example, a detailed written report, a brochure summary, a video report);
- provide information or data relevant to the study;
- review proposed methods, and final results and outcomes;
- implement the study's findings.

2.1.1 Identify intended audience

Potential key stakeholders to a regional-scale biodiversity study and assessment include:

- suppliers of information and data;
- owners of land;
- users of land;
- regulatory and planning authorities such as DLWC, DUAP and NPWS;
- regionally- based organisations involved in planning such as Catchment Management Committees;
- community interest groups such as bush regeneration groups and local natural history clubs.

2.1.2 Consultation

Stakeholders should be consulted at the outset of the study and at other key points in the study process. Those key points will be determined by the interests of the stakeholders themselves.

i Provide information about the study

During the initial consultation, stakeholders should be provided with information about:

- the overall purpose of the project;
- the background to the study, including any information which contributes to decisions about the overall purpose;
- the bodies who are managing and funding the project;
- the proposed process for conducting the study, including time frames and points where they may wish to participate.

ii Identify stakeholder needs and expectations

Stakeholders should be invited to state their needs in terms of the potential outcomes of the study that they would find useful for their work. Those needs may be for data, for example the location of threatened species, or a map of vegetation communities, or the level of disturbance of native vegetation. Alternatively, it may be in the form of recommendations, for example areas recommended for some form of reservation because they contain many threatened species, or areas recommended for revegetation because they provide the best corridors between existing bushland.

Different stakeholder groups are likely to have differing views on the aims of the study, the methods by which it should be conducted, and the potential outcomes that should arise from it. Their differing views will be formed by the different relationship they have to the study area, and the philosophies underlying those relationships.

It will not always be possible to accommodate the views and needs of all stakeholders in the final design and implementation of the study because of financial, technical or time constraints, or simply because those needs may be mutually exclusive. Stakeholders should be made aware of this, and kept informed of the study's progress, so that their expectations of the project are realistic.

iii Invite stakeholder participation

Stakeholders should be invited to participate in the study in a range of ways, and at a number of different points, which may include:

- participation on a steering or advisory committee throughout the study process;
- supply of information or data;
- participation in field surveys;
- reviewing proposed methods, results or draft reports;
- implementing outcomes when the study has been completed.

iv Tools for consultation

Tools that may be used to seek input from stakeholders include:

- meetings and workshops;
- surveys and questionaries;
- open communication channels such as telephone or e-mail links;
- invitations to comment on written documents, including draft reports.

Of particular importance is consultation with natural resource bodies, especially if the Regional Planning Body is not a natural resource body; and local Aboriginal communities to address culturally significant species. Consultation with these bodies is discussed below.

v Consultation with natural resource agencies

Discussions with natural resource agencies may help to :

- identify areas, communities and species of conservation concern or important habitat features in the study area or in adjoining areas;
- provide information about similar studies already conducted in the region which may direct the methods of the current study;
- identify previously unknown sources of existing information in databases or unpublished literature.

Natural resource bodies that should be considered for consultation are NPWS, DLWC, DUAP, State Forests, Environment Australia and Greening Australia.

vi Consultation with Aboriginal groups

Certain native species of plants and animals are culturally significant to Aboriginal groups, particularly through their utilisation for food and medicine and the role that utilisation plays in expressing aboriginal people's association with the land (English & Brown 2000). Local Aboriginal Land Council and any other Aboriginal groups should be consulted regarding the presence of culturally significant species in the region, and the results of this consultation should be taken into account in both the survey design and in the report. The Regional Directorate offices of NPWS can provide contact details for local Aboriginal groups and land councils.

Consultation with NSW Aboriginal people during regional-scale biodiversity studies has not been conducted widely, but should be a standard practice for future studies. Regional planning bodies and investigators should check with NPWS for any recent guidelines for Aboriginal consultation.

English & Brown (2000) provides background on the cultural values of biodiversity to Aboriginal people, and Smart *et al*. (2000) and NPWS (2000a) provide some examples of the incorporation of Aboriginal cultural values into bioregional studies.

The intellectual property rights of Aboriginal people must be respected and traditional Aboriginal knowledge must be treated with confidentiality unless otherwise agreed by the traditional owners.

STEP 2: SET AIMS AND OBJECTIVES

- set broad aims for the study
- devise a series of technical objectives to meet the aims
- consider potential constraints on meeting objectives
- consider an adequate timeframe for the study

Aim – is a general statement of what outcome or achievement is desired. For example: identify areas of high biodiversity value in the Local Government Area in order to protect these areas.

Objective – is a specific statement of what output or technical achievement is desired. For example: collect and map biodiversity data in the Local Government Area in order to make possible the identification of areas of high biodiversity value.

An important starting point in any biodiversity study is to define the aims and objectives of the study. The objectives set the technical framework for attaining the ultimate aims of the study and need to be specific and measurable. Objectives can be stated both in terms of methods (the techniques that will be used) and outputs (the physical products that will be made, such as maps or reports).

Defining the aims and objectives assists in:

- providing a clearly defined statement of purpose to stakeholders, investigators and project managers;
- determining which needs of stakeholders (step 1) can be addressed by the study;
- identifying priorities and limitations;
- determining the types of investigations required;
- relating technical needs to land management and planning needs, and vice versa.

As the study advances and more information is gathered about the region, the aims and objectives of the study may need to be refined. The regional planning body and the investigator should regularly revisit the aims and objectives to ensure that the initial direction of the study is maintained and the outcomes are met.

2.1.3 Set study aims

Setting the aims of the study should be the responsibility of the regional planning body, in consultation with reviewing authorities and key stakeholders. Factors that should be considered include:

- consistency with any legislative requirements (Appendix C);
- existing biotic information about the region;
- the needs of stakeholders;
- technical, financial or time constraints which limit the ability of the study to meet some potential aims;
- existing regional planning strategies, settlement strategies or regional priorities;
- compatibility with other studies done in the same or other bioregions.

The sample goals for Council management plans and strategies as set out in Part 10 of *Biodiversity Planning Guide for Local Government* (Fallding *et al.* 2001) are a useful guide for setting aims.

2.1.4 Set study objectives

Development of technical objectives that fulfil the study's overall aims may be the responsibility of the investigator, the regional planning body, or both. These objectives should be well defined prior to embarking on the design of field survey, and should be appropriate to the region under consideration. Some factors that should be considered in framing objectives are:

- The general methods required to achieve the objective;
- The outputs of the objective and their forms (e.g. digital, spatial, electronic, paper);
- The types of data and level of interpretation of that data that will be required to meet the objective;
- The intended audience for the work.

Section 5.1.2 further discusses setting technical objectives.

Objectives should be evaluated both by the investigator and the regional planning body to ensure that they will meet the aims of the project. Fallding *et al.* (2001) provide a useful checklist for evaluating objectives:

- Is the objective ambiguous or open to interpretation?
- Is there conflict or overlap with other objectives or policies?
- Can the objective be clearly understood?
- Should the objective take priority over others? If so, is this clear?
- How might the objective be interpreted in a legal dispute?
- Can the same idea be expressed more succinctly?
- Is the objective realistic or achievable?
- Is the objective measurable?
- Is there a good reason for including the objective in the plan?
- Are there provisions within the plan that provide a mechanism for achieving the objective?
- Is the objective appropriate to the type of plan and the ecological setting of the area?
- Is the objective linked to identified indicators or targets for environmental reporting purposes?

2.1.5 Recognise potential limitations

Many potential limitations on the study can be recognised from the outset, such as time frames which prevents field survey in some seasons. Others may become apparent only further into the study, such as landholders that will not permit survey on their land. Constraints that limit the intensity and spatial extent of field sampling may restrict the level of analysis that is possible, and consequently limit the aims which can be met by the study.

Limitations on the study should be acknowledged at all stages, including in tender briefs and final reports. Attempts to disguise limitations may make the study appear to be poorly designed. Potential limitations to a biodiversity study may include:

- restrictive budget and time-frame
- availability and reliability of information
- disturbances prior to or during the survey such as bushfire
- access to lands
- seasonal or vagrant species
- obtaining appropriate survey personnel
- achieving an adequate survey effort
- species that are difficult to survey
- changing weather conditions

2.1.6 Set timeframe

An adequate timeframe does not heavily limit the type of technical objectives that can be set. Of most importance is that enough time is allowed for an adequate sampling effort to be made, in order to ensure the study has a sound statistical basis and reliable results.

Issues to consider when drawing up a time line for a biodiversity study include the following:

- field surveys should be conducted in seasons which are appropriate for detecting those taxa, and over an adequate length of time;
- voucher specimens, scats, hair samples, and bat call recordings will need to be identified by a specialist before they can be used as data;
- weather conditions may affect the success of some survey techniques, and surveys may need to be repeated when the weather is more suitable.

CHAPTER 3

STEP 3: SELECT AN INVESTIGATOR

- the contents of a tender brief;
- qualifications and experience of investigators;
- selecting successful tenderers;
- authorities to conduct field work.

Selecting an appropriate investigator with the relevant skills and authorities to conduct field work is an important component of the process as it can ensure the quality and success of the study. Providing a detailed and comprehensive brief can be a valuable tool in finding an appropriate investigator.

Factors to consider when selecting an Investigator are:

1. **Preparing a tender brief** that provides enough detail for investigators to accurately cost the work and identifies the types of information required in the investigator's response in order for the planning body to assess its merits (Section 3.1.1);
2. **Determining the successful tenderer** by developing criteria for assessing tender bids at the same time that the tender brief is developed (Section 3.1.2);
3. **Qualifications and experience of Investigators** to ensure that Investigators undertaking surveys are suitably experienced and trained (Section 3.2);
4. **Authorities to conduct field work** including NPWS Scientific Licences, Special Purpose Permits and Animal Research Authorities (Section 3.3).

STEP 4: CONDUCT PRELIMINARY ASSESSMENT

- the value of a preliminary assessment
- the stages involved
- the expected outcomes

This valuable tool should be conducted at the earliest stage possible. If expertise to conduct this step is available in the regional planning body, it can be done prior to selecting an investigator (Step 3), and used to provide a more detailed tender brief. It is essentially a rapid ‘desktop assessment’ of existing information in order to determine:

- available information that can be used in the study;
- gaps in available information that can be filled by survey;
- an indication of the magnitude of survey work required, including an indicative number of survey sites and key species that may be targeted by particular methods;
- any limitations on survey work due to physiographic features of the landscape which may require changes to the timetable, budget or objectives of the study

2.1.7 Stages of a preliminary assessment

The Preliminary Assessment can be broken into five consecutive stages:

1. **Define the region**. This will include identifying its natural, political and management boundaries and land tenures (Section 5.1.1);

2. **Assemble information about the region**. Much of the information required for the study may have already been collected by key stakeholders for other purposes. Concentrate initially both on information that will assist in assessing what survey work will be required (such as recent fauna and flora surveys and a comprehensive species list) and information which assists assessment of the logistics of survey work (such as topographic maps, vegetation maps and aerial photographs). Chapter 4 and **Appendix D** discuss sources of data.

3. **Review and critically evaluate existing information**. Determine what types of information exist and do not exist. Assess the value of existing information for meeting the objectives of the current study, based on its accuracy, currency, and the methods by which it was collected (Section 4.2). This evaluation will indicate what information gaps exist, and therefore what new information should be collected through survey.

4. **Preliminarily stratify the study area**. From the mapped information available, determine the physical and biotic factors which will be used to divide the region up into areas for sampling. Identify any areas that may be of particular interest because they are rare, unusual or may provide specialised habitat;

5. **Scope the field survey**. On the basis of the preliminary stratification and existing information, estimate the field survey effort required. Ensure the sampling program complements and supplements existing information rather than duplicates it. Identify any potential constraints to the field survey, such as restricted access. Identify any aspects of the region that might introduce unusual occupational safety risks, such as waterways prone to flash flood and areas that are impassable after rain .

2.1.8 Outputs of a preliminary assessment

The outputs of a preliminary assessment should be:

- a description of the region based on existing information, including any information about the types and condition of the vegetation and habitats;
- a list of existing data types and their reliability, and information gaps in existing data;

- a list of flora and fauna species (including threatened species, endangered populations and endangered ecological communities) that have been found in the study area, or found in similar habitat elsewhere;
- an idea of the information available to stratify the study area;
- a ‘desktop’ identification of areas which may prove difficult to survey or of most interest to survey;
- a more accurate estimate of the timeframes and costs of further work.

CHAPTER 4

STEP 5: ESTABLISH DATA MANAGEMENT SYSTEMS

- principles for the systematic management of data

The level of field survey required for a regional study will be influenced by the suitability of existing data for the objectives of the study. Suitability will be influenced by its reliability, currency, and the methods by which it was gathered. Different types of data need to be treated in different ways: some data which will not be suited to one objective may be used for another.

Factors to consider in the management of data are:

1. **Maximise use of existing information.** Ensure an exhaustive search of databases, and published and unpublished literature, is conducted prior to investigation (Section 4.1).
2. **Data evaluation.** The methods by which the data was gathered (systematically or non-systematically; as presence-only, presence/absence or abundance data) will influence the purposes to which the data can be put. Evaluate the reliability of the source, the accuracy of the location information, and identify gaps to shape future studies (Section 4.2).
3. **Data collection during field surveys.** Ensure that systematic survey methods are followed and proformas are used consistently in order to maximise the value of the data collected (Section 4.3).
4. **Data collation.** Data entry into databases and spatial data packages maximises the ease of data manipulation. Sharing of data with centralised data users (particularly natural resource agencies) increases the value of the data (Section 4.4).

CHAPTER 5
CHAPTER 6

STEP 6: DESIGN AND CONDUCT FIELD SURVEYS

- define the technical objectives of survey
- determine the final stratification and sampling design
- determine data analysis methods
- determine the survey methods and intensity

The primary purpose of field investigations is to systematically survey the region or those parts that were identified as information gaps in the preliminary assessment (Step 4).

Factors to consider when designing and conducting field investigations are:

1. **Survey objectives** - defining the technical objectives of the survey in order to meet higher objectives and aims of the study (***Chapter 5***);
2. **Stratification and sampling design –** recognise sources of variation and develop a robust stratification processes (***Chapter 5***);
3. **Data Analysis –** identifying how data will be analysed in order to marry the study aims with the sampling design and survey methods (***Chapter 5***);
4. **Survey Methods –** determine field methods that will be used for gathering new data about flora and fauna and their habitats (***Chapter 6***).

Chapter 7

STEP 7: INTERPRET AND REPORT

- interpret data with regard to the aims and objectives of the study
- report the work with the varying information needs of different stakeholders in mind

Interpretations of data will influence bioregional planning decisions which are made on the basis of the study. The quality with which the study is reported will influence its usefulness in both the long and short term. A well-reported study is likely to have a greater impact on bioregional planning decisions, and influence the direction of future studies.

2.1.9 Interpret data

By this stage of the process there should be data that shows the pattern, extent and types of flora and fauna and their habitats for the region. Also of importance is information (often as overlay maps) showing features such as topography, geology, and land use, and perhaps various aspects of significance to conservation (Greening Australia 1995).

The results of the study should always be interpreted with respect to the aims and objectives of the study and the plans and policies they are being applied to. From this, the outcomes of study can be developed into specific provisions of plans and policies (Section 7.3).

The interpretation of the results of any regional-scale biodiversity survey and assessment should consider:

- identifying areas of outstandingly high biological diversity and areas of outstandingly high threatened species diversity or abundance;
- evaluating and ranking biodiversity conservation value;
- region-wide or localised occurrences of biodiversity threats;
- developing strategic land management options;
- ensuring the principles of ESD are considered;
- its input into plans and policies.

2.1.10 Report the study

Factors of particular importance in reporting are:

- pitching the material appropriately to different audiences, something which may require the use of different formats (for example, a detailed technical report and a separate summary of findings written for non-scientists);
- providing sufficient detail of methods and design such that the work could be replicated;
- providing raw data as well as interpreted data;
- making the material available electronically and in paper form;
- clear and concise language.

STEP 8: APPRAISE, DISTRIBUTE AND REVIEW

- the value of appraisal and review by different stakeholders

Prior to the release of the report to key stakeholders, an internal review by the regional planning body will ensure the document has reached an acceptable standard.

2.1.11 Appraise

The goal of appraising the study is to ensure that the investigator has met the aims and objectives of the study, considered all relevant statutory and technical issues, has made reasonable conclusions given the limitations of the study, and done so adequately and objectively. **Appendix E** provides a checklist for evaluating regional-scale biodiversity surveys and assessment reports. An review of the study by an independent body may also be valuable in improving the quality of the report.

2.1.12 Distribute

Once the report has been evaluated and revised to a standard suitable for further circulation or publication, it should be distributed to key stakeholders identified in Step 1. Regional-scale biodiversity studies should be provided to NPWS, DUAP, DLWC and the Local Governments whose areas include or bound the study area.

Key stakeholders may be made aware of the study through:

- public exhibition of the document at regional offices of agencies, Local Government offices and local libraries;
- presentation of the study by the investigator at a stakeholder meeting;
- display on a web-site or distribution through e-mail;
- local media;
- sending a copy of the report, a summary of the report, or a letter stating where copies may be viewed or obtained.

2.1.13 Review

Comment on the report from stakeholders:

- enables stakeholders to become aware of its findings and recommendations;
- ensures all relevant issues are covered, both statutory and technical;
- identifies any weaknesses in the study;
- adds relevant information;
- strengthens support;
- determines if their needs identified in Step 1 are addressed.

To ensure adequate feedback from the review process, it is good practice to supply easy feedback mechanisms such as a toll-free number, e-mail address and/or postage-free envelopes with a feedback form attached. Responses should be fed back into the study and the outcomes refined with that advice. These outcomes can then be applied to relevant plans and policies (Step 9).

Where the report may be of interest outside of the organisation that produced it (including sections of the community, government, non-government organisations or other bodies engaged in similar work), the report should be given an ISBN (International Standard Book Number). This assists libraries to catalogue the report, and interested people to locate it more easily. Further information about ISBNs can be found at: www.isbn.spk-berlin.de/index.html.

STEP 9: APPLY OUTCOMES TO BIOREGIONAL PLANNING

- the outcomes of the biodiversity study should be applied to plans, policies and other actions that promote and implement biodiversity conservation objectives;
- incentive programs are available to assist in achieving these results.

By this step, the biodiversity study is completed and its potential outcomes have been defined. The regional planning body can then develop an integrated view of the study's implications, incorporating environment, social, economic, cultural, and political considerations. This is likely to be in the form of plans, policies, and other regional actions.

Plans and policies provide the framework and context for development and management actions and enable strategic approaches to biodiversity conservation (Fallding *et al.* 2001). Where biodiversity outcomes do not promote the amendment or creation of a plan or policy, regional actions may only be needed. These may include changes to management techniques such as prohibiting the use of herbicides or burning where threatened plants have been located.

2.1.14 Biodiversity outcomes

From the recommendations provided in the report, the regional planning body can identify which of these recommendations, if any can be implemented. Implementation may depend on resources available, the perceived importance of the recommendation, and how easily they can be implemented. Recommendations that can be implemented would then be identified as biodiversity outcomes.

Examples of biodiversity outcomes are (Fallding *et al.* 2001):

- identifying all land zoned for urban or other development purposes with high biodiversity, and revise applicable planning controls;
- designating conservation zones and prepare appropriate management plans for these areas;
- retaining or restoring habitat corridors;
- prescribing biodiversity management practices for certain activities (e.g. forestry or agriculture;
- restricting the density of subdivision or development;
- train staff about important biodiversity values and issues;
- support biodiversity conservation initiatives by community groups.

2.1.15 Types of Plans & Policies

The biodiversity outcomes of the study may be implemented through appropriate planning instruments such as:

- Regional Environmental Plans
- Local Environmental Plans/Studies
- Regional Vegetation Management Plans
- Bush Fire Risk Management Plans under the Rural Fires Act
- Catchment management planning under the Total Catchment Management Act or the Healthy Rivers policy initiatives
- Plans of Management

Section 7.3 further discusses each of these plans and policies and provides examples of biodiversity outcomes relevant to each.

3 THE INVESTIGATOR

3.1 SELECTING AN INVESTIGATOR THROUGH TENDER

Selecting an appropriate investigator can ensure the quality and success of the study. Using a tender process with a detailed project brief which asks for specific information can be a valuable tool in finding an appropriate investigator.

3.1.1 Preparing a tender brief

The tender brief should describe the study's aims, some background to the study, and any objectives, limitations and timeframes already determined. It should also describe the area in which the study will be conducted, and supply enough detail for investigators to accurately cost the work. The tender brief should also identify the types of information required in the investigator's response in order for the planning body to assess its merits. Consider that tendering may be a two-step process if conducting a pilot or preliminary study followed by a full assessment.

The tender brief should include the following information:

1. **Conditions of Tender**, which describes the rules about the tender. This should include:
   - a general description of services and goods required;
   - details of when, where and how the bid should be submitted;
   - information on completing the bid and what a complete bid should consist of;
   - a description of the tender process detailing how the bid will be evaluated, the expected time taken to evaluate responses and the nominated contact officer.

1. **Project Brief**, which is generally regarded as stating specific conditions of the contract, and describes in some detail the nature and scope of the study, including:
   - the title of the study;
   - the reason for the study and its aims;
   - physical details of the study area including its size, location and introductory information about vegetation types and extent of cover;
   - any objectives and outputs already determined;

- any technical requirements for the study (for example, the work will involve much field survey to gather new data; the work should be done in the ArcView GIS package);
- any specific tasks, methods, information sources or processes already determined;
- any known limitations on the study (Step 4);
- a list of any available resources.

1. **Project Management** arrangements, including whether a project manager or steering committee will coordinate and manage the project. Any information about how much contact is required with the project manager or steering committee over the life of the project (e.g. number of meetings and progress reports) should be specified.

2. **General Conditions of Contract** that may be generic to the regional planning authority. These may include the conditions under which the contract can be terminated, and the ownership of copyright. The investigator is required to comply with these conditions or suggest alternatives if they do not agree. This portion of the tender brief may consist of a copy of the contract which the successful tenderer will be expected to sign.

3. **Project timetable** should include:
   - when the contract is expected to commence;
   - if field work is be undertaken during certain periods (e.g. during flowering period or when farmers are not harvesting so that they can provide access to properties);
   - a request for the investigator to predict when certain milestones are likely to be achieved (e.g. commencement of field work and production of draft report);
   - when the project must be completed by.

1. **Response requirements** which details the specific information which the tenderer should include in their bid. This information will be used by the regional planning body to determine if the tenderer is capable of conducting the work. It should include:
   - the name, ABN, and contact details of the company or individual making the bid;
   - the names, qualifications and experience of individuals who will principally be responsible for conducting the work, including any work which will be sub-contracted;
   - a demonstration that the tenderer can meet each aim and objective specified in the project brief through qualifications, experience, technical understanding and theoretical understanding of the work involved;
   - any additional information about how the tenderer proposes to conduct the work in order to fulfil the aims of the project, including proposed technical objectives, methods, processes, or use of information sources;
   - any additional qualifications or experience the tenderer may have in specific techniques mentioned in the project brief;
   - any examples of similar work the tenderer has previously conducted and contacts details for clients who will act as referees;
   - a statement of the level of liability insurance held by the company or individual;

- a statement either that the tenderer agrees to the other conditions contained in the tender brief (including those set out in the project brief, general conditions of contract and project timetable) or what parts the tenderer proposes to vary.

1. **Cost of the project**. The investigator should be requested to provide a breakdown of the cost of each project task nominated, and a total fee.

The example provided in Section 11.1 of Fallding *et al* (2001) may also be considered when preparing a tender brief.

3.1.2 Determining the successful tenderer

The regional planning body should develop criteria for assessing tender bids at the same time that it develops the tender brief, in order to ensure that the brief asks for information relevant to the assessment of bids. Some criteria that may be used to assess tender bids include:

- whether the individuals who will principally be responsible for conducting the work are qualified for, and experienced in, such work (Section 3.2);
- whether the bid demonstrates that the tenderer can meet each aim and objective specified in the project brief;
- the quality of any additional information about how the tenderer proposes to conduct the work, particularly any proposed technical objectives;
- whether the tenderer has any additional qualifications or experience in specific techniques mentioned in the project brief;
- the quality of any examples of similar work the tenderer has previously conducted;
- whether the tenderer has a suitable level of liability insurance (Section 3.4);
- whether any conditions contained in the tender brief which the tenderer proposes to vary are acceptable to by the regional planning body, particularly any variations to the project timetable;
- the cost of the proposed work.

3.2 QUALIFICATIONS AND EXPERIENCE

Investigators undertaking survey for the purposes described in these guidelines must be suitably experienced and trained. Suitable experience and qualifications include, but are not limited to:

- demonstrable experience in flora and/or fauna survey methods, field equipment, and identification of flora and/or fauna specific to the region. Investigators must be able to identify threatened species and their habitats potentially occurring in the region, and be familiar with similar species with which they may be confused;
- an understanding of the ecology of species found in the study region;
- experience in survey design, stratification and stratified sampling methods;
- experience in data analysis and its interpretation for conservation planning purposes;
- experience in the use of specific non-field based techniques or tool which might be required for the study (eg GIS programs)

- experience in similar scale investigations and investigations in the same study region or similar regions;
- relevant tertiary qualifications are preferable but not essential if the above criteria are met.

Investigators should be prepared to provide referees and examples of reports completed for previous work of a similar nature. Ideally, investigators should have local knowledge of, or experience in, the region in question. *Curricula vitae* for all investigators involved in the study (including sub-contractors) should be included in the tender bid.

3.3 AUTHORITIES TO CONDUCT FIELD WORK

3.3.1 NPWS Scientific Licence

A Scientific Licence is required from the National Parks & Wildlife Service to undertake most forms of ecological field work. Scientific Licenses for fauna work are issued under Section 120 of the NPW Act and under Clause 20 of the *National Parks & Wildlife (Land Management) Regulations, 1995*. Scientific Licences for threatened flora work are issued under section 91 of the TSC Act. Section 171 of the NPW Act allows the Director General to authorise any person to harm or pick flora and fauna within or outside of protected areas in NSW. This direction may be provided with limits to numbers or species.

NPWS Scientific Licenses are required in order to:

- undertake scientific investigations in National Parks;
- conduct research on protected fauna and threatened flora;
- collect specimens of protected and threatened flora and fauna anywhere within NSW;
- conduct research on, or the collection of, any animal (including invertebrates), plants, fungus, geological, hydrological, or other specimen or sample from areas managed by the NPWS.

Two classes of licences, ‘A’ and ‘B’, are applicable for investigators conducting biodiversity surveys. An ‘A’ Class license allows the investigator to conduct surveys independently while the holder of a ‘B’ Class license must be supported and supervised by an ‘A’ Class licensee. An ‘A’ class licensee is also responsible for submission of reports to the Service documenting any results obtained by themselves and the ‘B’ Class licensee under their supervision.

If the survey involves capturing and banding birds or bats with Australian Bird and Bat Banding Scheme bands, a ‘C’ Class or ‘D’ class NPWS research licence is also required.

An assistant working in the field only in the presence of a licence holder is not required to hold a separate licence. An assistant working without such supervision is required to hold their own licence.

Licence application form may be obtained from the NPWS web site (www.npws.nsw.gov.au) and enquires may be directed to the Wildlife Licensing Unit of the NPWS via e-mail at wildlife.licensing@npws.nsw.gov.au.

3.3.2 Special Purpose Permit for work in state forests

A Special Purposes Permit is required to undertake biological surveys of any kind within lands controlled by State Forests of NSW, including state forests, flora reserves and timber reserves. Special Purpose Permits are issued under Section 32 of the *Forestry Act 1916* and Clauses 110-115 of the *Forestry Regulations 1983*.

The Permit application form can be obtained by contacting the state-wide office of State Forests of NSW (121-131 Oratava Avenue, West Pennant Hills, NSW 2125 or by phone on 02 9872 0111).

The standard conditions of a Special Purpose Permit usually include providing notice to the relevant State Forests regional manager prior to commencing work, and the provision of a report of findings within 12 months of the permit issue. Permit holders are also required to notify State Forests regional managers within 48 hours of any sightings of organisms listed on Schedules 1 and 2 of the TSC Act.

3.3.3 Animal Research Authority

Investigators must be aware of the requirements relating to animal care and ethics when conducting fauna surveys. The *NSW Animal Research Act 1985* (AR Act) and the *NSW Animal Research Regulations 1985* regulate activities involving handling and capture of animals, and are administered by NSW Agriculture.

The AR Act requires that every person undertaking animal research must be the holder of an Animal Research Authority (ARA) under Section 25. Under the Act, animal research includes the use of animals in field surveys, and an animal is defined as a vertebrate (excluding humans) including mammals, birds, reptiles, amphibians or fish (NSW Agriculture 2000).

Animal Research Authorities are issued for specific projects by Animal Ethics Committees run by agencies, universities or research institutions. Fauna consultants are usually issued ARAs through the Director-General of NSW Agriculture's Animal Ethics Committee. Holders of ARAs must conform to any conditions set by the Animal Ethics Committee and the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes* (NHMRC 1997).

The Animal Welfare Unit of NSW Agriculture has issued a series of guidelines that should be referred to prior to conducting biodiversity surveys. These include guidelines for wildlife surveys, the use of pitfall traps, the collection of voucher specimens, and the use of feral animals. The guidelines are regularly updated and can be obtained from the Animal Welfare Unit of NSW Agriculture, or from www.agric.nsw.gov.au.

3.4 LIABILITY AND INDEMNITY

Investigators should be appropriately insured before undertaking a study. The details of relevant insurance policies need to be attached to their proposal and should include:

- type of insurance;
- amount of cover;
- name of the legal entity that is insured.

3.5 CODES OF CONDUCT

Investigators should make themselves aware of any written codes of conduct relevant to the work they will be undertaking. Currently there are no widely adopted written codes of conduct for NSW ecological consultants.

4 DATA

4.1 USE OF EXISTING INFORMATION

- many types and sources of existing information should be considered;
- electronic databases provide an easily accessed source of existing information;
- there may be constraints on the availability of existing information.

4.1.1 Types and sources

Types of information relevant to the aims of a regional-scale biodiversity survey and assessment study may include, but not be limited to:

- electronic databases and internet sources (Section 4.1.2);
- aerial photographs and satellite images;
- topographic maps, vegetation maps, geological maps and soil maps (including those for contamination, salinity, hazards);
- previous fauna and flora surveys or field studies at any scale in published and unpublished literature;
- historic records of fauna, flora and vegetation communities in the area;
- lists of threatened species, populations or ecological communities, or species of regional significance from the region;
- literature about the ecology of the species, communities and habitats found or likely to be found in the area (species profiles, scientific papers);
- Environmental Planning Instruments relevant to the region (e.g. SEPPs, REPs, LEPs and associated zone information and regulations);
- guidelines relevant to the study;
- planning documents specific to the study being undertaken.

The largest sources of information are likely to be the libraries and databases of government natural resource agencies (particularly NPWS, DLWC, DUAP, the Australian Museum and Royal Botanic Gardens), and local governments, landcare groups and libraries of the study region. Appendix D provides a list of key sources and the types of information that they are likely to provide.

4.1.2 Databases

Biodiversity data found in databases is generally of two types: 'systematic data' which has been gathered by using a standard set of methods and standard sampling intensity; and 'point locality data' which has been gathered by non-systematic means. These data types are often not interchangeable in terms of the uses to which they can be put (see Section 4.2.1), and care should be taken to distinguish between the two types when gathering existing data.

There are several large databases of biodiversity data accessible in NSW. A useful starting point is the Community Access to Natural Resource Information (CANRI) website at www.canri.nsw.gov.au, which gives access from a single point to a range of natural resource information from government agencies. CANRI is useful assembling information for a preliminary assessment of information (Chapter 2, Step 4) but it may be necessary to contact agencies individually to get information of the detail required for a full bioregional assessment.

The biodiversity data held in databases are particularly valuable for predictive modelling purposes, to assist in the design of biodiversity surveys, and as an indication of past flora and fauna distribution in the region. Where a substantial body of systematic data exists (such as NPWS's Biodiversity Survey System database) it may be possible to combine that data directly with new systematic survey data if the same survey methods and sampling intensity are used.

Details of the administrative procedures and databases are outlined in **Appendix F**.

4.1.3 Data availability

Access to existing data for a study may be made difficult by time constraints or confidentiality. Requests for data to other organisations or individuals should be made with reasonable timeframes. Some charge a small fee for data supply.

Any flora and fauna report that is submitted to Local or State Government with a development application is a public document and therefore available for review. Most other reports submitted to Local and State Government Departments are exhibited under the auspices of the EP&A Act. However, if a report's findings have adverse commercial or legal implications, a report may be withheld, and an application under the *Freedom of Information Act, 1989* may need to be lodged. The availability of unpublished data will depend upon individual contract agreements between parties involved.

4.2 EVALUATION OF EXISTING INFORMATION

- existing information needs to be evaluated for how it may help to address the aims and objectives of the current study;
- identifying information gaps provides direction for survey objectives;
- evaluate whether the data is sufficiently recent to provide a reliable indication of the current status.

4.2.1 Evaluating existing information for the needs of the current study

Existing information should be critically assessed in terms of what it may contribute to the study. Historic information may, for example, be used to derive a species list of what may possibly be present in the area now; or when compared with recent survey data, historic information may provide a subjective indication of species that may have disappeared from the area. Recent systematic data may be added directly to new survey data if the same survey methods and sampling intensity are used; or it may be used in modelling species distributions or as measures of biodiversity abundance because it has been systematically gathered.

Existing information should also be critically assessed in terms of its of reliability. Records may be wrong, duplicated, or species names may have changed. Examples of factors to consider when determining the reliability of information and its contribution to the current study include, but are not limited to, the following:

- **Date of record**. Older records are not likely to be as reliable as recent records in indicating that the species is present in the area. Cut off dates for data regarded as "current" may be arbitrarily chosen, based on some biological event, or nominated by NPWS if that agency has a legislated responsibility in directing the study.
- **Survey design**. Whether the data was gathered systematically (by using a standard set of methods and standard sampling intensity) or non-systematically will affect the uses to which the data can be put: 'systematic data' can be used in analyses requiring presence/absence or abundance data; 'point locality data' which has been gathered by non-systematic means can be used only in analyses requiring presence-only data.
- **Survey methods and effort.** In order to use existing survey data as evidence that a species is not present, the methods used must have been appropriate for detecting that species, and the effort sufficient to give a reasonable probability of detecting a species if it was present.
- **Accuracy of taxonomy.** Where taxonomic changes have resulted in splitting a species into more than one species with overlapping distributions, records which can't be verified with a voucher specimen may be of very little use in new studies.
- **Accuracy of location of record.** Some older records have insufficiently specific location information for the purpose of some technical objectives.
- **Accuracy of identification.** Some observers will have a greater specialist knowledge of species identification than will others. Some species are easily confused with others.

Some sources of compiled data (such as the NPWS Wildlife Atlas) already have reliability estimated given to each record (Table 4.1).

Table 4.1 Reliability codes for records in the NPWS Wildlife Atlas

Code	Definition
1	Specimen with Public Museum
2	Specimen with other collection
3	Voucher specimen used in identification
4	Specialist reliability
5	Standard reliability
6	Suspect sighting

Reliability codes should also be assigned to any new records collected during the current biodiversity survey to assist future users of the data in their evaluations. A coding system similar to that used by NPWS (Table 4.1) is recommended. Information about the habitat in which the record was made may also support the reliability of the record, particularly if it is out of the known range of the species.

4.2.2 Evaluating data gaps

The objectives of field survey (eg vegetation, flora, mammal, bird, etc) will depend on the aims and objectives of the study in general, and how far existing information goes in meeting those general study objectives.

Gaps in the existing information about a region may form the basis for setting objectives for new survey work. Information gaps may take many forms, including:

- **spatial gaps**. For example, part of the region has much less existing information than does the rest.
- **taxonomic gaps**. For example, surveys have concentrated on birds, mammals and vegetation, but not reptiles or frogs.
- **methodological gaps**. For example, bat surveys have used harp traps but not bat call detection methods.
- **ecological gaps**. For example, surveys have concentrated on forests but not grasslands and heathlands.
- **topographic gaps**. For example, surveys have concentrated on flat areas and ridge tops, but not steep slopes or gullies.
- **tenure gaps**. For example, surveys have concentrated on national parks and state forests but not privately owned land.

In most regions, a combination of these factors will apply. Be aware that there may be logistical reasons for some gaps. For example, it may be much more difficult to access steep slopes and gullies during surveys than it is to access flat areas and ridge tops; survey of private lands found in a study region may require the permission of dozens of land holders, rather than the permission of one or two.

4.2.3 Up-to-date information

Changes to legislation and regulations that may affect regional scale biodiversity work can be followed through www.austlii.edu.au, and are published in the monthly Government Gazette. In particular, investigators should be awareness of the frequent changes to the Schedules of the TSC and EPBC Acts that list protected areas, threatened species, threatened populations and endangered ecological communities. Entities subject to Preliminary Determinations under the TSC Act should also be included.

TSC Act listings can be obtained on-line at www.npws.nsw.gov.au/notes/exhbtsc/htm. EPBC Act listings can be obtained on-line at www.environment.gov.au/epbc/db/index.html.

4.3 DATA COLLECTION DURING FIELD SURVEYS

- pointers to essential data, data that adds value to the survey, and choosing the right data fields for the technical objectives of the survey;
- general points about precision in data collection;
- using proformas assists consistency and quality in data collection;
- using correct taxonomy and nomenclature assists data quality.

4.3.1 Data requirements in survey

The fields of data that will be collected during survey should be determined before the survey begins, and will depend both on the objectives of the survey and the end use of the technical outputs. However, irrespective of what type of survey will be conducted, some data is essential for every new record of a species:

- location information:
  - AMG zone, easting (6 digits) and northing (7 digits)
  - site number (as allocated for the survey)
- date (day-month-year format);
- observer's name;
- observation type (trapped, sighted, killed by cat, heard call, etc);
- species identification:
  - species code (4 digit nationally-agreed codes available from NPWS)
  - species name (nationally-agreed names available from NPWS and Royal Botanic Gardens);
- type of survey (systematic effort and method or opportunistic).

The value of collecting other data fields will depend on the specific type of survey method and group of target species. For example, weather conditions (cloud cover, rain, wind speed) are generally regarded as influencing the success of survey for bats, reptiles, frogs and spotlighting for arboreal mammals, but not to survey for small ground-dwelling mammals or plants. Some optional data fields provide information, which is useful in developing a model of the habitat preferences of a species, its reproductive behaviour or diet.

Vegetation maps may be based on many different types of data (for example, overstorey only or overstorey and understorey; levels of detail in floristic). The types of data used and the scale at which the mapping is done will depend on a variety of factors (Table 4.2). These include the purposes to which the information will be put, resources available for new field survey work, existing information about vegetation in the area, and the desirability of consistency with maps made for other regions.

Table 4.2 Examples of data that may be required to fulfil some technical objectives

Objective	**Suggested Data**
Gather data required to make a map of vegetation communities that will be used in modelling the distribution of ground-dwelling mammals	Plant species making up both the understorey and overstorey; cover-abundance and structure measures for understorey and overstorey; disturbance history; soil type; topographic measurements; location and species of ground-dwelling mammals from trapping survey.
Gather data required to model the distribution threatened plants	Structure measures for understorey and overstorey; disturbance history; soil type; topographic measurements; location and species of threatened plants from survey.
Gather data required to make a map of vegetation communities that will be used in modelling the distribution of arboreal mammals	Plant species making up the overstorey; cover-abundance and structure measures for overstorey; abundance and size measures of tree hollows and stag trees; abundance, size and breeding condition of any specialised plant food resources; location, number and species of arboreal mammals from survey.

A comprehensive regional biodiversity study will have objectives that will typically include the outputs similar to those in the Reporting Checklist (Appendix E).

4.3.2 Precision during data collection

Data collected during field investigations should be recorded accurately, legibly, consistently and at the time of observation.

Accurate location information is essential for survey work. Geographic positioning systems (GPS) assist in providing accurate location information. Note that Australian Geodectic Datum (AGD) has changed to the Geocentric Datum of Australia (GDA). Land and Property Information NSW is currently updating topographic maps from the existing AGD66 system to the new GDA2000 system, but the transition may take up to ten years. In the interim, grid references across NSW may be between 200-220 metres out, which may cause confusion when using GPS units or fixed points in the field. GPS units working on World Geodetic System 84 are synonymous with GDA. To avoid data reporting errors, it is essential that GPS and/or topographic map users be aware of which system is in use, and report in a consistent datum ie. either AGD or GDA.

Information about samples (water, sediment, voucher specimens etc) must recorded at the time of collection. At a minimum, details should include date, time, person collecting the sample, location, habitat and test required. These details should be kept with the sample and also recorded in a central log.

4.3.3 Use of proformas

Use of standard proformas:

- allows information to be collected and reported in a consistent format;
- prompts investigators to record all information;
- alerts assessors to omissions in data.

Example proformas used by NPWS for regional-scale biodiversity surveys are provided in **Appendix G**. The series contains individual proformas for a range of survey types.

A survey log recording summary information for the entire field survey program should be maintained, and include for each survey site: the dates of sampling, precise location, site number, stratification category, and the exact types of surveys (methods and functional groups targeted) conducted on each day the site was sampled. Information such as the number of data sheets held for each site assists in checking that all data has been entered into databases.

4.3.4 Taxonomy and nomenclature

The Scientific name of species must be specified by both the Genus and Specific name. Scientific names of species must appear in italics and should be cited along with the common name if one exists. However, the common name should not be used on its own except for birds, where there is national agreement on a standard list of common names.

At the time of writing this Guideline, the most up-to-date lists of scientific names were:

- ***CSIRO List of Australian Vertebrates*** (CSIRO 1998) for mammals, birds, amphibians, and reptiles. Copies of the publication can be ordered on-line at www.publish.csiro.au;
- **Plantnet** produced by the Royal Botanic Gardens for all vascular plants in NSW. This database can be accessed on-line at www.plantnet.rbgsyd.gov.au.

4.4 DATA COLLATION

- data entry into databases, and the collation of existing information with new information;
- the value of reporting raw data and making it accessible to reviewers and to other studies

4.4.1 Data entry

Field data should be entered into an electronic database in its raw format and subsequently subject to any modifications required for its analysis and interpretation, rather than entered as pre-manipulated or pre-classified information. This ensures that, amongst other benefits, the raw data is always available as a reference point against which each stage of manipulation can be checked.

Data should then be checked and validated against the original field data sheets by someone other than the person who entered the data. At this stage duplications, taxonomic inconsistencies and errors should be edited, and the sampling log and checklist of proformas consulted to ensure all data has been transferred.

While entering new survey data and collating it with other sources of information , care should be taken to distinguish between:

- presence-only, presence-absence, and abundance data;
- data gathered from new field surveys and already-existing data from previous field studies;
- data gathered by different methods but for survey of the same taxonomic group (eg bat data from harp trapping and from call recording);
- data gathered through systematic methods and effort, and data gathered opportunistically or through targeted survey.

A reliable data management system for storing, retrieving, manipulating and outputting information is required to accurately record and report large scale biodiversity surveys. For example, a database may be designed to store flora and fauna sighting data, records from specific sites and systematic surveys, and the range of survey methods used to survey the fauna at different sites. Manipulations to reflect relationships between species, sites, remnants, biotic and abiotic characteristics, as well as the range of survey methods used to survey the fauna at different sites should be possible in such a database. Use of Geographic Information Systems (GIS) is becoming common practise for biodiversity studies, due to the ease of manoeuvrability, manipulation and presentation of information.

Ideally, a copy of new raw survey data should be held in a format which is compatible with the databases of agencies and local governments which might be interested in the data.

4.4.2 Reporting data

Data should be reported in its raw form, as well as in any manipulated, analysed or summarised form required for its interpretation. Making raw data available delivers three benefits:

- the integrity of the study is enhanced by the study’s transparency;
- the soundness of the study’s findings can be better evaluated by reference to the source material for those findings;
- the data becomes available to the widest possible range of other studies.

New raw survey data generated by the study’s surveys (whether used in analysis or not) should be made available as an appendix to paper copies of the report, and by being lodged in electronic format with one or more centralised databases such as those held by NPWS, DLWC, State Forests or local governments. Ideally both media would be used, but appendices may be impractical for large data sets. A requirement of Scientific Licenses from NPWS and Special Purpose Permits from State Forests is that the locality of all native species, including threatened species, be supplied to those agencies (preferably as an Excel Spreadsheet, see Section 7.2.3) for incorporation in those agency’s databases.

Existing data which has been taken from a centralised database should not be supplied back to that database without prior consultation with the database’s manager, to avoid duplicating records.

The source of all data (raw or otherwise, new or existing) used in the study should be noted in the study’s report, and the report should clearly indicate which data comes from which sources. The report should also note the protocols that were used to select data for use in the study, particularly data from large centralised databases (such as those held by governments).

Where data comes from easily available sources (such government databases), it is not necessary to include copies of the data in appendices if protocols for data selection are well described. However, data which comes from hard-to-access sources should be included in an appendix. Any data use agreement which prevents the supply of that data in an appendix should be noted.

Data also should be summarised within the report using maps, tables and graphs wherever possible. Reporting standards are discussed further in Chapter 7.

5 SURVEY DESIGN

5.1 DEFINING SURVEY REQUIREMENTS

5.1.1 The region and the survey area

These guidelines are intended for use at a variety of regional scales, hence the region is simply the area where the biodiversity study will be undertaken. For example, the region could be a catchment, one or more local government areas, a planning instrument zone or an IBRA region (*Interim Biogeographic Regionalisation for Australia* - Thackway & Cresswell 1995). The aims of the study will broadly define the region.

The area to be surveyed may not be the same as the study region. A subset of the study region may be targeted for survey in order to make the best use of available resources in fulfilling study aims, or because survey data already exists for other parts of the region. For example, if the aim is simply to document the species-level diversity of native fauna in a region, then resources may be focused on the least disturbed habitats of each vegetation type, while ignoring the most degraded areas which are likely to provide habitat for fewer native animals. An example of this is the Urban Bushland Biodiversity Survey (NPWS 1997d). However, if the aim is to identify native biodiversity values (including ecosystem diversity) and the impact of threatening process on those values, then it is appropriate to also survey disturbed habitat in the region.

If a region includes an area which is already recently well-surveyed, it may not be necessary to put more survey effort into that area. New survey effort can be put into areas for which little survey data is available, using a survey design which will allow the new data set to be compared with the existing set.

The potential influence of surrounding areas on the region's biodiversity should also be taken into account. For example, adjacent vegetation in a National Park or State Forest may provide habitat which is continuous with that of the study region, or vegetation in the study region may be acting as an important habitat corridor between areas outside the study region. In some cases it may be necessary to collect existing or new survey information about areas adjacent to the study region in order to develop an understanding of the relative values of areas within the study region. Some general information about areas outside the study region should be gathered during survey design, particularly information about land use and vegetation type.

5.1.2 Setting survey objectives which will meet the aims of the study

Before designing the survey, the aims, objectives, outputs and limitations for the study will have been identified (Chapter 2 – Step 2 and Section 4.3.1). The more clearly defined they are, the more tailored the survey can be to fulfilling them using the available resources. A set of survey objectives can be formulated, and field survey methods can be chosen to meet them (Table 5.1).

Table 5.1 Examples of survey objectives designed to fulfil some study objectives

Study Objective	Survey Objective
Identify which vegetation communities (based on an existing map) provide habitat for a range of ground-dwelling mammals	Systematically survey the ground dwelling fauna which may (on the basis of species lists) be in the study region using a range of survey methods (Elliott traps, cage traps, dry pitfall traps); systematically sample the cover, abundance and structure of the understorey, disturbance types and intensity, and any microhabitat features which may influence the distribution of small mammal species; use the existing vegetation map as the basis for stratification of sampling.
Identify vegetation communities of potentially high conservation value from an existing vegetation map, using the criteria of regional and statewide rarity.	Systematically survey floristic and structural characteristics of vegetation, abiotic characteristics and disturbance levels, stratifying on the basis of the existing vegetation map, to assess and confirm the condition, extent and classification of those communities.
Identify areas of potentially high habitat value for arboreal mammals	Systematically survey for features that are known to influence the distribution of arboreal mammals, including cover-abundance and structure measures for overstorey; abundance and size measures of tree hollows and stag trees; abundance, size and breeding condition of any specialised plant food resources; Systematically survey for arboreal mammals using spotlighting, call playback, and scat and sign searches.

The investigator will generally take the role of developing specific technical objectives and survey objectives from the study's general aim. Hypotheses related to the presence or absence of certain species or ecological communities in various areas of the region may be generated, and a sampling program designed to test them.

5.2 DESIGNING A SURVEY

5.2.1 Types of field sampling design

Meeting the aims of most regional-scale biodiversity surveys will generally require the application of standardised survey at sites selected by principles of stratified random sampling, and targeted sampling for those species which are not well surveyed by randomised sampling (Table 5.2).

Table 5.2 Some types of field survey, their values and limitations

Type	Description	Values	Limitations
Standardised survey	Same set of field techniques applied with same effort at each survey location; samples evenly across sites.	Generally gathers presence-absence data which can be subject to more discriminating statistical analysis. Provides a more objective view of the variation in biodiversity across a regional-scale study area.	May poorly sample locally rare species.
Non-standardised survey	Variable set of field techniques and/or applied with different effort at each survey location; does not sample evenly across sites.	Generally gathers presence-only data. Useful for gathering a species list rapidly.	Limited statistical analysis possible. Objective comparisons of variation in biodiversity across a regional-scale study area is often not possible.
Randomised survey site selection	Survey sites chosen without bias of perceptions of habitat availability or observer's interests.	Generally provides a more objective view of the variation in biodiversity across a regional-scale study area.	Does not well sample species with highly specific habitat requirements such as frogs and many threatened species.
Targeted survey site selection	Survey sites chosen because they offer "good habitat", thereby increasing chances of locating species of interest.	Samples species with highly specific habitat requirements such as frogs and many threatened species.	Alone, does not provide an objective view of the variation in biodiversity across a regional-scale study area.
Incidental or opportunistic data collection	Records of fauna and flora detected while doing other things, including survey for other groups.	Data can be useful addition to species lists, particularly for species which are rare or which have poorly understood habitat requirements.	No statistical analysis possible; can't provide view of the variation in biodiversity across a regional-scale study area.

Standardised sampling requires the application of the same set of field techniques at the same level of effort at every survey site, and increases the types and reliability of conclusions that can be drawn from the data (Table 5.3). There are several components of survey effort, which can be standardised:

- length of time (number of minutes of search, number of days traps are set);
- number of traps or observers;
- area (searched or in which traps are laid) or length of transect.

Table 5.3 Simple examples of the value of standardised sampling effort and methods in survey

	From field survey:	Using standardised sampling	Using non-standardised sampling
survey effort	Survey in Environmental Unit A recorded twice the number of bird species than found in Environmental Unit B.	Sites in both units sampled for the same length of time. *Validly conclude that Environmental Unit A has twice the bird diversity of Environmental Unit B.*	Sites in Unit A sampled for quadruple the length of time as sites in Unit B, thus increasing the chance of finding birds. *Difficult to draw reliable conclusions about differences in bird diversity.*
survey method	Survey in Environmental Unit A recorded twice the number of bat species than in Environmental Unit B.	Sites in both units sampled using the same set of methods. *Validly conclude that Environmental Unit A has twice the bat diversity of Environmental Unit B.*	Sites in Unit A sampled using call recording, trip lines and harp traps. Sites in Unit B sampled using only harp traps, which rarely detect some high-flying species. *Difficult to draw reliable conclusions about differences in bat diversity.*

5.2.2 Stratification of the study area

Stratified sampling is usually required in regional biodiversity studies. In general, the large areas of regional biodiversity studies will encompass more than one 'ecologically meaningful' environmental unit. Environmental units which are composed of different combinations of environmental variables (eg soil, topography, vegetation) will influence the presence or abundance of species, and the type and quality of habitat for those species.

The purpose of stratification is to sample the full range of environmental variation present in the study region, and hence hopefully sample all vegetation types and habitats for species. Stratification is usually based on some combination of physical attributes, vegetation structure or community type, location or disturbance, depending on what mapped information about these features is available, the aims of the study, and the resources available to do the work.

Maps of the region at appropriate scales are important tools in designing a field survey. Existing maps of environmental characteristics (typically topography, vegetation, and geology or soil) are often overlain to produce environmental units for stratified random sampling. Aerial photographs may provide useful detail of landscape features.

i Physical Attributes

Physical attributes can include:

- latitude and longitude (particularly if the study region is large);
- altitude;
- soil or geology (if soil maps not available);
- slope and aspect;
- rainfall.

Where terrain is has high topographic variability, gully areas, ridge tops and mid-slope areas may provide significantly different habitat from one another, as will areas with different aspects.

ii Vegetation

Vegetation maps are very useful in stratification, based on the assumption that differences in vegetation communities also reflect differences in the distribution of species of plants and animals. Vegetation structure and floristic composition is assumed to be an important element of habitat for plant and animal species.

In the absence of a vegetation map, aerial photographs can be used to select representative combinations of colour, tone, texture, canopy spacing and pattern that reflect some features of vegetation. Sites may be further stratified using knowledge of the area, which may be gained from literature, topographic maps, soil maps, and local knowledge. A field visit to the study area prior to survey may be advantageous to check preliminary site selection and identify vegetation types not identified by areal photography.

iii Disturbance

Disturbance due to fire, logging or weeds may strongly influence the distribution of fauna and flora in the region, and should be used to stratify the study area if sufficient information is available. If disturbed and undisturbed areas occur within an environmental unit (such as the same vegetation type), both should be sampled. Do not assume that surveying disturbed areas will detect only a subset of species that would be found in surveys of undisturbed areas. Some species specialise in making use of undisturbed areas, where particular resources may be more abundant or competition with other species less intense. Similarly, degraded habitats within the region should be included in the survey unless clear reasons are given for excluding them as these habitats may contain regionally significant, rarely seen or threatened species.

.a.1.1 Where significantly large areas of several successional stages occur in the same stratum, successional stage should be viewed as another stratification variable in the survey design, and sampled separately with replicates. Where a continuum of succession appears to be present, stages (or classes of success) may be arbitrarily allocated across the continuum (for example, 0-2 years since fire, 3-7 years since fire, 8+ years since fire). Where successional stage cannot be made a stratification variable (perhaps because only a small area of some successional stages are present), it is probably preferable to place sites to include all successional stages within that strata. This will encapsulate at least some of the diversity which may be the result of succession.

5.2.3 Season

It will be necessary to repeat the survey in different seasons to obtain a more complete list of species present in the area. Some species of both plants and animals can only be detected in certain seasons or even years (eg. many ground orchids, migratory birds, frogs and microchiropteran bats). If sampling in appropriate seasons is not possible, then very little can be validly concluded about the presence or absence of these species in the study area, and this limitation on the study should be noted in the report.

5.2.4 Replicates and random variation

Sources of variation that have not been characterised are sometimes described as random or unexplained variation. Species may be patchily distributed in seemingly homogeneous habitat due to small scale factors that have not been identified. Other species may have large home ranges and move in and out of areas at various time scales, for example in response to trees flowering. Random or unexplained variation is minimised by the use of replicates.

Locations for replicate survey sites are randomly chosen within each strata. The more replicates, the more powerful any statistical comparisons will be. However, as replicates increase the more expensive the project will be. There are statistical methods available for calculating the most efficient allocation of resources in sampling design, based on undertaking a pilot study to estimate variance (Krebs 1989).

Increasing the time spent surveying each replicate will reduce random variability by taking into account some of the short-term temporal variability associated with species moving in and out of the replicate plot. Increasing the size of each replicate plot may also decrease variability in data..

5.2.5 Statistical Analysis

If statistical tests are to be undertaken, sufficient replicates must be sampled to allow tests to be powerful enough to detect differences among factors of particular interest. Ideally, the survey should be orthogonally designed with an equal number of replicates for each factor wherever possible. Detailed explanations of sampling design and statistical tests, including different types of analysis of variance, are given in many texts on sampling design and statistical analysis. Consultation with a biometrician may assist decisions about the best allocation of sampling effort among the different factors. Conducting a pilot study may provide information useful for designing the full survey, and Cochran (1977) gives suggestions on the size of pilot studies.

5.2.6 Some examples of sampling designs

Table 5.4 shows a simple orthogonal sampling design for the example noted in section 5.2.2. This design gives a total of 48 replicates to be sampled - 24 in summer and 24 in winter.

Table 5.4 Orthogonal Sampling Design

Factor	No of Levels
Areas (3 forested areas)	3
Habitats (woodland/open forest)	2
Seasons (Summer Winter)	2
Replicates (Number of randomly chosen sites in each stratification unit)	4

An alternative nested design for a more general survey where specific areas were not of interest is shown in Table 5.5. This design would lead to 120 sites being sampled.

Table 5.5 Nested Design

Factor	No. of Levels
Habitats (5 habitat types)	5
Areas(Habitats) (3 randomly selected areas of each habitat)	3
Seasons (summer/winter)	2
Replicates (Number of randomly chosen sites in each stratification unit)	4

This basic sampling design could be expanded to include small-scale spatial variation (ie. sites within sites) and short-term temporal variability (eg. weeks within seasons) or additional environmental factors. These factors can be combined if, on analysis, they are not found to be significant.

For statistical purposes, the design should be balanced (eg the same number of areas sampled for each habitat type and the same number of replicates). Unbalanced designs will result in weaker statistical tests for comparisons among factors (ie. areas or habitats). However, depending on the relative size of the habitat types in the region, it may be necessary to have an unbalanced design by having the number of replicate sites proportional to the area of habitat (Sanders *et al* 1988; Keith & Sanders 1990; Cohn 1995).

If a region contains large areas of relatively homogenous habitat such as grassland or pasture, as well as area of more heterogenous habitat, such as woodland, it may be necessary to stratify the complex habitat further to allow more samples to be taken. In some cases, only a tiny patch of a habitat type (eg. rainforest) may occur in the region and it may be very useful to describe that patch, although it may be excluded from statistical analysis.

It is important to clearly explain the rationale for the survey design, any limitations imposed, and why any deviations from a balanced design were undertaken.

Survey effort and sample sizes are discussed further in chapter 6.

6 SURVEY METHODS

6.1 BASIS OF THE SUGGESTED METHODS

The methods discussed here assume that survey for regional-scale biodiversity studies will be based upon the use of a standardised set of methods and efforts (Chapter 5). Using a standardised survey enables the results of samples to be validly compared and grouped with one another. The conclusions drawn from those survey results about how parts of the study region differ from one another will not be biased by the survey effort or technique applied to gathering those results.

The value of regional biodiversity surveys is enhanced when comparable survey methods and effort are used across surveys. Data gathered from different surveys can then be validly compared and combined to produce an understand of biodiversity patterns and trends in a wider regional context, and over time. Adequate reporting of survey methods is integral to allowing repetition of those methods in subsequent surveys.

The survey protocols suggested in these guidelines are based on those that have been used in broad-scale biodiversity studies for a range of purposes. They include:

- The Comprehensive Regional Assessments of forested ecosystems on the east coast of NSW (conducted by NPWS and RACAC in 1995-1998);
- *Environmental Impact Statements in State Forests* (York *et al.* 1991);
- *Assessment of clearing applications under the Native Vegetation Conservation Act 1997* (DLWC 1999);
- Bioregional studies conducted in the Cobar Peneplain (eg Masters & Foster 2000) and the Brigalow Belt South (NPWS 2000b).

Examples of field survey proformas for the methods suggested in this chapter are found in **Appendix G**.

6.2 FACTORS INFLUENCING CHOICE OF SURVEY METHODS

The choice of field survey methods will depend on the:

- **aims of the study, including the uses planned for the final information.** The aims of the study will determine what types of data are required (presence only, presence-absence of abundance data) and for what taxonomic groups, and hence what survey methods may be required to gather those data. If in doubt, advice should be sought from literature and from environmental scientists with experience in experimental design.
- **broad biome or vegetation type in which the study is to take place.** The general methods outlined here are broadly appropriate for the most common biomes, and some considerations for survey in western NSW and rainforest (or other tall dense vegetation types) are given in Section 6.3.1 and6.3.2.
- **cost effectiveness of the method and resources available for the field work.** Labour intensive methods such as pitfall traps may be beyond the resources of the study. Investing more time and effort into alternative and cheaper techniques may provide a better 'return' than would pitfall traps.
- **field survey methods used by other studies.** Field methods may be chosen for their compatibility with other studies done in the same region or elsewhere, particularly if the data from the new work will be compared or combined with data from other studies.

In general, there is a direct relationship between the value of different data types (in terms of the strength and range of conclusions that can be validly drawn from it) and the effort required to gather it. Presence/absence data is the primary data type required to measure species level diversity, and comparisons of faunal biodiversity are primarily made on species level diversity. Abundance data is of greater value in that it also allows for comparisons to be made about the relative value of areas in conserving individual species, and sometimes also about temporal trends in their conservation status in particular areas.

Collecting presence/absence data requires the use of systematic survey methods and effort, and is relatively easy to gather for many species of flora and fauna. However, presence/absence data can be difficult or impossible to reliably gather for species whose detection is highly dependent on weather, climate, disturbance (typically fire or flood) or temporarily available food or breeding resources. Examples include many species of frogs, ground orchids, and opportunistically nomadic birds such as the Regent Honey Eater. In general, regional biodiversity studies will only gather presence-only data for such species.

The detectability of many animals may change with time, as species become trap-shy or trap-happy, or detectability may change at higher densities or with seasonal or other environmental factors. Many cryptic and rare plants are more detectable during flowering or seed set. These factors need to be taken into account by the investigator when planning the timing of survey.

Abundance data can be relatively easily gathered for many species of flora, but is more costly and time consuming to gather for fauna. The abundance of species as measured in most biodiversity surveys are estimates only, and hence should be regarded as indices of abundance rather than measures of absolute population numbers. Estimates may not be comparable between habitats (eg birds may be more difficult to survey in dense vegetation).

6.3 REGIONALLY-SPECIFIC SURVEY

6.3.1 Western NSW and other semi-arid areas

Vegetation sample sites are often larger in western NSW, in order to compensate for the generally greater structural heterogeneity of vegetation (and hence to reduce the variance of measurements taken from sites within the same stratum).

The higher maximum daily temperatures, greater aridity and generally less dense and more patchy vegetation are some factors which probably influence the observability of animals in western NSW, and therefore also the choice of survey methods. Some points to consider are:

- **Elliott trapping** for small ground-dwelling mammals often has lower success rates in western NSW compared to more easterly areas. Pitfall trapping with drift fences is often a better way to detect small ground-dwelling mammals in western NSW.
- **Bat trapping** may be less productive in sparse vegetation where there are few obvious flyways in which to set harp traps.
- **Water sources** (natural and human-made) are known to strongly influence the distribution of many species of mammals (particularly large ones) and birds.
- **The most successful time in the day to search for reptiles** will depend on the maximum and minimum temperatures of the area in that season. In eastern areas, searches in the hottest part of the day are often most successful. In the summer in western NSW where summer maximum temperatures are much higher, many reptiles are inactive in the hottest part of the day, and those that are active move too quickly for easy identification. Hence, active search for reptiles in cooler parts of the day may be more successful than those in the hottest part of the day.
- **Searches of randomly picked survey sites** may yield little or no observations of frogs, as their observability is likely to be even more strongly linked with rainfall and water bodies than is the case in less arid areas. Survey targeted to water bodies or at times of rain may be required.

6.3.2 Rainforest and other dense tall vegetation types

Walker and Hopkins (1990) suggest detailed methods which are appropriate for survey of rainforest vegetation.

Survey of animals in rainforest is often constrained by the high density of vegetation, which results in shorter distances of visibility and greater difficulty in traversing study sites. Consideration should be given to the following changes to methods:

- **Small mammal traps** are often placed at shorter distances from one another, such that one trap station can still be seen from the stations around it. Alternatively, points are marked between trap stations in order to guide field workers.
- **Bird surveys**:
  - Observing for a longer period at each site may go some way to compensating for shorter distances of visibility and the greater difficulty of traversing the site.
  - Observations may rely less heavily on visual identifications and more heavily on identifying calls than would be the case in more open vegetation.
  - Use call playback methods to target species of particular interest. Be aware that this technique will bias the overall survey results to the species being targeted, and that if used in conjunction with area search or point locality methods, the combined results should not be used as measures of species abundance.
- **Reptile and frog survey**s: search for longer periods at each site in order to compensate for the greater structural diversity of the habitat.

6.4 SITE AND HABITAT ATTRIBUTES

Information should be gathered systematically for a range of environmental variables at every survey site. Such data provides a measure of habitat for species (and hence is sometimes referred to as habitat measurement), as well as providing objective evidence that sites assumed to be replicates at the survey design stage are suitably similar to one another.

A generic proforma for collecting site and habitat attribute data is provided in Appendix F, but the data types collected should be tailored for the environments being surveyed, and for the known habitat preferences of any species of particular interest. For example, the characteristics of rocky outcrops on site might be measured in areas where species known to rely on such habitats are found. However, the aim is to objectively describe the range of environments present in the region through a common set of measurements, so the same set of attributes should be looked for and measured in the same way at every site.

Site and habitat attribute survey may be undertaken during a preliminary site survey, prior to intensive sampling of flora and fauna, when it will help to confirm that the area has been correctly allocated to the right stratification unit and is a reasonable replicate of other plots in the same unit. In practice, its more frequently undertaken at the time of survey for flora and fauna.

Some forms of disturbance are known to influence the distribution of plants and animals, and any evidence of the major forms of disturbance (eg fire, logging, grazing and weed invasion) should be gathered at every site. Some forms of disturbance particularly influence some taxa, such as rubbish dumping and bush rock removal (the former may provide additional reptile shelter while the latter may remove it). Pollution of waterways should be noted for its potential impact on frogs.

6.5 FLORA

Table 6.1 Suggested survey techniques and minimum effort for flora survey

Survey technique	Suggested minimum effort	Information recorded
Transect	If quadrat-based techniques used, transects should be used as required to supplement quadrat information. If quadrat-based techniques not used: 1x100m traverse per stratification unit <2 hectares 2x100m traverse per 2-50 hectares of stratification unit 3x100m traverse per 51-250 hectares of stratification unit 5x100m traverse per 251-500 hectares of stratification unit 10x100m traverse per 501-1000 hectares of stratification unit, plus 1 additional 100m traverse for each extra 100 hectares thereof.	Qualitative information about floristics, structure and vegetation variation, location of vegetation boundaries
Random meander	30 minutes for each quadrat sampled within the same stratification unit as the quadrat.	Location and abundance of threatened flora
Quadrat	At least 1 quadrat per stratification unit <2 hectares 2 quadrats per 2-50 hectares of stratification unit 3 quadrats per 51-250 hectares of stratification unit 5 quadrats per 251-500 hectares of stratification unit 10 quadrats per 501-1000 hectares of stratification unit, plus 1 additional quadrat for each extra 100 hectares thereof.	Quantification of floristic composition and structure.

6.5.1 Vegetation survey

A combination of transects and plot based surveys can be used to provide information on vegetation community boundaries and composition, vegetation structure and successional stage, and the possible presence of threatened species. An appropriate combination of techniques may depend in part on the size and characteristics of the region.

i Transects

Transects are valuable for obtaining qualitative information such as an overview of the vegetation communities in the area, identifying community boundaries, and assembling species lists (Forest Fauna Surveys *et al.* 1997). They are also useful for rapid quantitative survey for rare or threatened flora. However, plot-based sampling is generally a more robust means of quantifying vegetation community composition or structure.

Depending on the size of the area to be surveyed and the density of the vegetation, transects may be undertaken on foot or from a vehicle. The information recorded while undertaking transect depends primarily on the purpose of the transect, but accurate location information (including for the transect as a whole) is essential.

A variation on the transect survey for threatened plants is the random meander method, which is discussed in relation to threatened species survey in Section 6.5.2.

ii Plot-based Surveys

A plot-based (or quadrat) vegetation survey has some advantages over transects. Plot based surveys enable a quantitative examination of species distribution and abundance, are more likely to detect inconspicuous or threatened species as a smaller area is sampled in a concentrated search, and provide a basis for any subsequent monitoring required (Forest Fauna Surveys *et al.* 1997).

The vegetation plot size used widely and recommended by Walker and Hopkins (1990) and NPWS is 400 m^2, typically as 20 x 20 metres. However, where a single vegetation type is found as linear patches, the plot shape can be changed to fit within the vegetation type as long as the total area remains the same and the minimum dimension is 10m. Examples include riparian vegetation, or vegetation found on dune crests or swamp margins. State Forests EIS surveys commonly use a 20x20 m plot nested within a 50x20m plot, with the larger plot used only to collect canopy data (York *et al.* 1991).

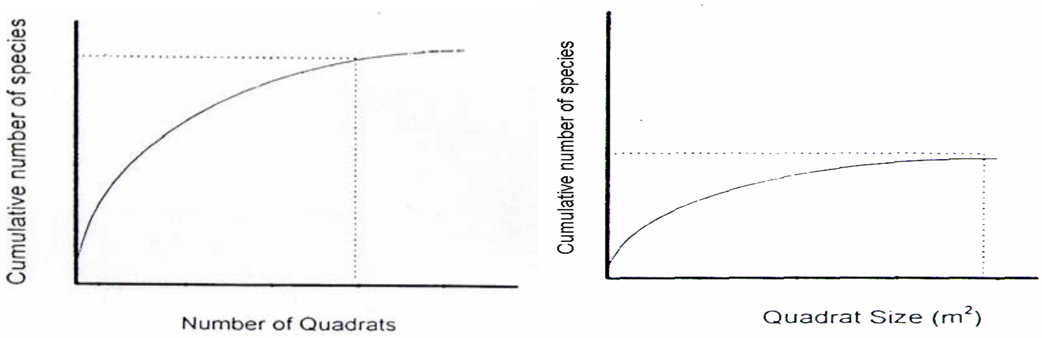
Depending on the vegetation type that is being sampled, a variation on the 400 metre squared (20 metre x 20 metre) plot may be appropriate. For a community which is relatively floristically homogeneous, a 10 metre by 10 metre plot may be used. Similarly, Cohn (1995) found that for sampling the structural and floristic characteristics of mallee vegetation in central western NSW a 30 metre by 30 metre plot was better suited. In western NSW, and other semi-arid areas, vegetation samples may often need to be larger (eg 20 x 50 m) to compensate for the generally greater heterogeneity of vegetation.

If there are doubts as to whether plot size is large enough to adequately represent the floristic composition of the vegetation, a species-area curve can be constructed. Species-area curves and number of sample plots are discussed in the section on survey effort below.

iii Survey Effort

Some simple techniques can be used to guide decisions about what level of survey is adequate for a given area. A simple species-area curve or species-plot number curve (Figure 6.1) can be constructed if there is doubt as to whether the plot size, or number of plots, is adequate to sample the floristic composition of the vegetation unit. In respect of the relationship between number of quadrats and cumulative number of species, the replication of sample plots is fundamental for statistical precision, analysis and interpretation of results in the ecological context (Krebs 1989).

Figure 6.1 Indicative species-area curves showing the relationship between the number of species observed and the number of quadrats sampled (left) and quadrat size (right).



iv Selection of sampling sites

Stratified random sampling is usually required for regional biodiversity studies because the large study areas involved will encompass much environmental variation (see Chapter 5). Sample sites will be chosen at random within pre-selected environmental units (or strata) based on environmental variables.

Sample sites should be randomly selected at the ‘desktop stage’ from maps of the strata to ensure objectivity. In practice, it may be necessary to deviate from a completely random choice and change the location of sites when out in the field. This may be because of practical considerations (eg difficulty of access), or because the actual location is not typical of that strata (perhaps due to local clearing, erosion or a recent fire). The principles, which are used to select sample sites, should be acknowledged in the study’s report.

The following criteria were used to select sample sites within each strata in the eastern CRA forest surveys (NPWS & RACAC 1995-1998), in order to reduce variation within strata:

- away from the boundaries of the environmental stratum;
- in homogeneous vegetation considered to be representative of the strata;
- away from, or free from local disturbances such as roads, mines, quarries and eroded areas;
- the axis of the plot should be aligned with the contour of hillsides or elongated vegetation communities (eg riparian areas) to avoid significant environmental gradients (eg soil moisture).

v Plot description

Each plot should be assigned a unique identifier or plot number. Large studies may benefit from using a coding system which includes a designator for the stratum in which the plot falls. This approach may be useful during analysis by reducing the need to refer back to field data sheets or maps for such information.

Information which will assist others to locate the sites if necessary should be recorded, including marking the location of the plot on a reference map. If there is any intention to monitor sites after the initial survey, sites should be marked by a numbered star picket located at a consistent position within each plot. The photo number and direction of photos should also be recorded on a map.

Information that should be recorded includes:

- date and time
- plot number or unique identifier
- name(s) of observers
- plot size (and dimensions)
- location – (AMG, 6 digit easting, 7 digit northing, map name and number)
- locality description to assist relocation, for example, distance from road, track or distinctive landmark, walking distance and direction; property name or reserve name if known.
- land tenure
- landform type
- soil type (clay, loam, sand, organic)
- geology (rock outcrops)
- slope (using clinometer)
- aspect (estimated using compass bearing)
- altitude

vi Floristic data

Ideally, surveys should characterise the vegetation as fully as possible by gathering plot-based data which includes a full list of species present, their cover and abundance, structural measurements, and additional information on any threatened species present. However, the aims of the survey will determine which field survey methods are used. For example, if there is no intention to produce a detailed map of vegetation communities, it may be sufficient to gather cover-abundance data for a few dominant species in each structural layer rather than conduct a full plot-based floristic survey. If the aim of the project is only to characterise the vegetation in as much as it provides habitat for animals, surveys targeting threatened plants may not be required.

vii Species present

All plant species present within the plot should be identified and recorded. Plants should be identified as far as possible to the species or subspecies level. If abundance data (below) will not be gathered, the identity of the dominant (one or more) species within each plot, or within each structural layer of each plot, should be noted, as a coarse vegetation community description.

Voucher specimens should be gathered for plants that cannot be identified in the field, and for species which are known to be difficult to identify or where taxonomic revision is under way or likely. Standard taxonomic keys such as *Flora of New South Wales* (Harden 1990, 1991, 1992, 1993) should be used, and unidentified specimens sent to the National Herbarium of NSW (located at the Royal Botanic Gardens in Sydney) for identification. When sending specimens for identification a duplicate specimen should be kept and subsequently correctly labelled for future reference.

Name changes and taxonomic revisions for plants can be sourced from journals such as the *Australian Journal of Botany, Telopea*, *Cunninghamia* and the web sites of the Australian National Botanic Gardens (155.187.10.12/anbg) and the Royal Botanic Gardens of NSW (www.rbgsyd.gov.au).

viii Cover-abundance

A modified Braun-Blanquet system (Table 6.2) is most commonly used for collecting cover-abundance data for each species in each separate vegetation layer.

Table 6.2 A modified Braun-Blanquet system for cover-abundance data

Rating	Cover-abundance
1	Less than 5% cover and few individuals
2	Less than 5% cover and many individuals
3	5-25% cover
4	25-50% cover
5	50-75% cover
6	75-100% cover

ix Additional information

Depending on the objectives of the flora survey additional information such as life stage may be recorded for some or all species. Life stage data may be particularly useful for specific species such as threatened species or locally or regionally significant species. Typically a life stage category is recorded if it applies to more than 10% of the individuals (DENR 1997). The life stage classes identified by the DENR (1997) are presented in Table 6.3.

Table 6.3 Life stage classes

Life Stage	Observation
Seedling	Record when any number of seedlings observed
Budding	Plants have buds formed in varying stages of development for flowering
Flowering	Plants are in flower
Immature fruit	Immature fruits not shedding seed
Mature fruit	Fruits ripe and/or shedding seed
Recently shed	Plants are in a non-reproductive phase which show signs of having shed seed or fruit within the last 12 months
Dead/dormant	Indicates that above ground material only is dead and includes plant species that may still have dormant below ground organs (eg. orchids, lilies)
Vegetative	Only refers to plants in a non-reproductive phase ie. no flowers, buds or unshed seed
regenerating	Woody perennial which is resprouting after significant loss of foliage

Source: DENR (1997)

x Structure

Growth forms (trees, shrubs, grasses etc.), height (in strata or layers) and spacing (percentage plant cover) are typically used to classify vegetation structure (McDonald *et al.* 1990). Vegetation structure is best measured in plots, but can also be systematically recorded during transects where it may provide useful information regarding structural variability within a community. Structural information is also a major factor in defining fauna habitats.

Each structural layer should be identified, along with the dominant growth form of each layer, the height range of each layer, and the relative percentage crown cover of the layer. A brief description of these factors is given below.

Structural layers and growth form

The classes of structural layers described by Walker and Hopkins (1990) are set out in Table 6.4. The most common growth forms, as described by Walker and Hopkins (1990), are described in Table 6.5. Where species may be present in more than one growth form, the most common growth form and height should be recorded. Indicating on field data sheets which species are found in the canopy layer assists in rapidly separating canopy species during analysis.

Table 6.4 Structural layer classes

Stratum	Description
Emergent	Individuals rising above the upper stratum (up to 5% of crown cover)
Upper stratum	The tallest significant (dominant) growth form present
Mid-stratum	All layers between the upper stratum and 1 metre in height. More than one mid-stratum may be identified.
Lower stratum	The ground layer including all grasses and other vegetation up to 1 metre tall. More than one lower strata may be identified.

Source: Walker and Hopkins (1990).

Table 6.5 Growth form classes

Growth form	Description
Tree	Woody plant more than 2 m tall with a single stem or branches well above the base.
Tree mallee	Woody, multi-stemmed with fewer than 5 trunks , usually 8 m high or more. Often *Eucalyptus.*
Shrub	Woody plant multi-stemmed near base or, if single stemmed less than 2 m tall.
Mallee shrub	Commonly less than 8 metres tall, usually with 5 or more trunks.
Heath shrub	Shrub usually less than 2 metres tall, commonly with small (less than 3 centimetres) leaves.
Chenopod shrub	Xeromorphic single or multi-stemmed halophyte exhibiting drought and salt tolerance.
Tussock grass	Forms discrete but open tussocks (clumps or tufts).
Hummock grass	Coarse xeromorphic with a mound like form, often dead in the middle.
Sod grass	Grass of short to medium height forming dense tussocks in close contact at the base.
Sedge	Herbaceous, erect plant, usually with tufted habit. Often Cyperaceae and Restionaceae.
Rush	Herbaceous, erect plant, in the families Juncaceae, Typhaceae, Restionaceae and the genus *Lomandra.*
Forb	Herbaceous or slightly woody plant; not a grass.
Fern	Characterised by large usually branched fronds. Herbaceous to arborescent, terrestrial to aquatic.
Moss	Small plant with slender stems and no true vascular tissue.
Vine	Climbing, twining, winding or sprawling plant usually with a woody stem.

Source: Walker and Hopkins (1990)

Height

The upper and lower heights of each stratum should be measured in metres. If a stratum is relatively uniform in height then a single average height can be given. Accurate measures of tree height can be taken using a clinometer.

Cover

Several different estimation methods for percentage plant cover have been described. The ones most commonly used in regional scale biodiversity survey appear to be defined in Walker and Hopkins (1990) as:

- crown cover, which is an estimate of the percentage of the area of the plot covered by the vertical projection of the periphery of all plant crowns (treating crowns as opaque) in that stratum, usually measured to the nearest 5 or 10 per cent;
- projective foliage cover, which is the percentage of the sample site occupied by the vertical projection of foliage, and does not assume opaqueness (ie spaces within the canopy of individual plants do not count towards the figure). Where branches are included with foliage in the cover estimate, this measure is sometimes simply referred to as foliage cover.

Crown cover is independent of seasonal changes in leaf orientation and foliage density (eg deciduousness) and is usually easier to estimate in the field. However, projective foliage cover may more accurately reflect variations in foliage density among species and is the only simple measure for herbaceous species that do not form crowns. (York *et a.l* 1991). Crown cover of canopy trees can also be estimated from aerial photographs. In some studies, crown coverage is estimated only for woody plants, and projected foliage cover is estimated for ground layers.

Walker and Hopkins (1990) provide a chart to guide estimations of foliage cover of individual tree canopy types. However, cover should be estimated for the entire plot (taking into account the gaps between individual tree canopies), so cover values should not be read directly off this chart. Estimates using both measures is usually made to the nearest five or ten percent.

6.5.2 Threatened flora

Threatened species, populations and ecological communities may be identified during transect or plot surveys, or by opportunistic observations while walking or driving between sampling sites. Depending on the aims of the study, systematic targeted surveys may be conducted for threatened species considered likely to occur in the region.

Targeted surveys should generally involve a standardised effort (a standard distance or area searched for a standard length of time). They may be made only in areas of preferred habitat which may limit the usefulness of the data for modelling purposes, or be distributed according to principles of stratified random sampling.

Rather than undertaking transect or plot based surveys to target threatened species, an area may be searched by the random meander technique. This technique can allow for greater coverage than a plot based survey and is less time consuming. The random meander technique involves traversing areas of suitable habitat in no set pattern, but roughly back and forth, whilst searching for a particular threatened plants. Again, a standard effort should be used.

Many threatened species are best surveyed when they are flowering or fruiting, and hence more observable. Some cryptic orchids are only visible above-ground at some times of the year.

A voucher specimen should be collected and lodged with the National Herbarium of NSW unless the species is already known to be locally abundant. Information which should be recorded when a threatened species is located can be found in the proforma in Appendix G..

6.5.3 Voucher collection

A voucher specimen should be collected and sent to the National Herbarium of NSW for confirmation of identification where:

- there is any uncertainty regarding its identification
- the species is commonly confused with another
- this is a new record of the species in the larger area
- this is a significant range extension of the species

For regional studies at least one voucher specimen for each species should be collected and a reference set lodged with the National Herbarium of NSW. Only licensed investigators should take voucher specimens.

When collecting plants the specimen chosen should include flowers and fruits and a piece of stem with typical healthy leaves. Non-flowering plants should include reproductive features, rhizome and stipe where possible. If variation is apparent then material that reflects this variation should be collected. Notes should be taken regarding the precise locality, collector's name, date, and botanical information such as habit, habitat, size of plant, colour of flowers and fruit, and type and colour of bark.

Voucher specimens should be pressed in the field where possible, but may be kept temporarily in a paper bag and pressed later. Orchids that cannot be identified in the field should be preserved in orchid vials in 80% ethanol and kept away from light and heat.

Instructions for preserving plant voucher specimens can be found in many places, including Harden (1990) and the web site of the Australian National Botanic Gardens (155.187.10.12/anbg/).

6.6 FAUNA

6.6.1 Plot-based systematic survey

Sampling fauna is made more complex by the mobility of animals, and their diverse modes of behaviour. The 2ha fauna survey site commonly used in regional biodiversity surveys are a compromise, as different sized plots may be more appropriate for sampling different species. Species with very large home ranges (such as large forest owls) will not be adequately sampled by restricting detection to a 2ha plot.

Plots should be randomly selected within the stratification unit, but ideally will be no less than 1km apart to reduce the chances of sampling the same animals. Plots of 100x200m are standard, but may be modified in shape to fit within the boundaries of the stratification unit.

The following sections list general methods that are commonly used to survey a broad range of species. Additional methods, including those useful for targeted survey for threatened species are given in NPWS Threatened Species Profiles.

Methods should be used consistently, and with the same level of effort at each sample point. Deviation from the study's standard set of methods at any sample point should be noted on field data sheets. Climatic variables such as rainfall, temperature, wind speed and cloud cover which are known to significantly influence the success of survey for some species should be recorded for some survey methods, as per the example field data proformas in Appendix F.

6.6.2 Limitations

Regional-scale biodiversity surveys generally survey a broad range of fauna species. The effectiveness of a survey in detecting a certain species may be affected by:

- the species' behaviour;
- the position of the breeding cycle (Morin & Conant 1994);
- the methods used to survey;
- the experience of the observer (Kavanagh & Recher 1983; Catterall *et al.* 1996);
- weather (rainfall, temperature, wind, cloud cover) (O'Connor & Hicks 1980);
- season;
- the type of vegetation (Morin & Conant, 1994);
- time of day.

In general, the survey effort applied should be the same at each sample site. However, species may be harder to detect in environments which are highly complex or dense, warranting some compensatory increase in sampling effort. However, the adjustment should be made consistently for all sample sites in that stratification unit, and not for some sample sites only.

The effects of season are relatively well known for many species. Some species are only present in an area in certain seasons (e.g. many species of threatened migratory or opportunistic birds). Others may be always present but can only be detected in certain seasons (e.g. during rain or the breeding season for certain frogs) or are less active in cool weather (e.g. microchiropteran bats, reptiles and frogs).

Limitations are discussed in the following sections for the various functional fauna groups. Limitations of surveys should always be detailed in the survey report and taken into account when drawing conclusions from the study.

6.6.3 Invertebrates

Invertebrates occupy a wide range of habitats and exhibit enormous spatial and temporal variability. Their value in regional planning and biodiversity assessment has recently been highlighted by forest surveys showing the inadequacy of environmental surrogates in predicting distributions of ground-dwelling invertebrates (Ferrier & Watson 1997). This indicates that biodiversity conservation strategies relying on assumptions that invertebrate assemblages exhibit strong associations with vegetation types or vertebrate assemblages may not be justifiable.

Sampling the invertebrate fauna comprehensively introduces substantial logistic constraints. Surveys often involve the use of several techniques to encompass the great diversity of invertebrate life habits, and samples often need to be processed by experts at substantial cost (Oliver & Beattie 1993, 1996). The use of a range of techniques will give an estimate of the species diversity but is unlikely to provide an exhaustive inventory unless temporal and spatial variation in invertebrate distribution and abundance can be accounted for. A further problem is that the sample units are not easily defined and are difficult to replicate with a range of quantitative techniques, introducing substantial systematic biases.

The choice of appropriate techniques for survey must clearly be driven by the aims of the survey. However, if these involve identifying areas of high conservation value for invertebrates or areas that have been significantly affected by anthropogenic disturbance, it is likely that a range of invertebrate taxa must be surveyed and processed to a relatively fine level of taxonomic resolution.

Ausden,(1996) and Southwood & Henderson (2000) describe and evaluate a number of commonly used methods for surveying invertebrates in a range of habitats, noting the benefits and shortcomings in each case. A common theme running through discussions of shortcomings reflects the difficulty in quantitatively comparing samples, as well as the limited range of taxa sampled using any one method. Invertebrate sampling is also particularly prone to the influence of weather, season, and (seemingly) random variation. A brief description of some the more popular of the range of techniques available for collecting invertebrates as listed below, adapted from Ausden (1996) and Southwood & Henderson (2000). No sampling efforts are recommended.

i Terrestrial insects

Direct observation and counting (transect walks)

Adapting this technique that is commonly used for vertebrates is of limited worth, owing to the size of insects and the difficulty of identifying most of them from quick visual inspections. It is useful when a particular species that is large and conspicuous has been targeted and the observer is trained to identify them under field conditions. It is not particularly useful for overall surveys of the insect fauna, but may support these through observations of species of importance. It is commonly used and most effective for butterflies, ants and active orthopterans (grasshoppers and locusts).

ii Insects from plants

Misting/chemical knockdown

The sample unit is often the entire tree, which is “fogged” with an insecticide. Invertebrates drop off the foliage onto sheets below and are collected. Some insects are attached to the plant by mechanisms that may not allow them to be separated simply by chemical knockdown (e.g. aphids), or may remain under bark.

Direct suction

This technique involves vacuuming insects off leaves and plants, but the results can be strongly influenced by user technique.

Beating

The tree or branch is hit sharply a predetermined number of times and the insects collected on beating tray, a cloth covered frame of known area. Some insects are attached to the plant by mechanisms that may not allow them to be separated by mechanical means (e.g. aphids).

Sweep nets

Sweep nets are swept through vegetation such as long grasses and small shrubs for a predetermined number of times.

iii Insects from air

Suction traps

Suction traps feature an electric fan that drives air through a fine gauze cone that filters out insects which are collected in a jar. They can also be fitted to take multiple samples at predetermined times, so that fauna can be sampled throughout the day. They are effective for small aerial invertebrates but captures may be affected by wind velocity.

Malaise traps

A malaise trap is an open fronted tent of cotton net where the "roof" slopes towards an innermost corner where there is an aperture leading to a trap (usually filled with ethanol). The trap is placed across flight paths.

Water traps (pan traps)

These traps simply consist of bowls (usually plastic containers of standardised dimensions) filled with water, a small amount of detergent and preservative, and laid out in grid patterns. The bottoms of the traps can be painted different colours to attract different taxa, and three traps in white, green and yellow are often laid out at each station. These traps produce a highly selective catch, and also attract ground-dwelling invertebrates under appropriate conditions.

Light traps

Light traps are effective for targeting nocturnally active moths and beetles.

iv Ground and litter-dwelling invertebrates

Tullgren funnels (and associated extraction techniques)

This technique utilises a light bulb as a heat source to drive insects out of samples of soil or leaf litter into a vial placed below the funnel. Immobile insects (such as pupae) may not sampled unless direct sorting of the soil or leaf litter is also done.

Pitfall traps

Pitfall traps are one of the more quantitative sampling techniques. Traps, (vials with glycol, ethanol, anti-freeze or formalin) can be laid out in grid patterns. The results may be influenced by the size of the trap, the type of preservative (some species may be attracted) and by the length of time the trap has been in place.

v Aquatic invertebrates

Dip Nets

Dip nets can be used in a similar manner to sweep nets in terrestrial systems.

Surber samplers

This technique enables the invertebrates in a known volume of water to be sampled, provided current speed is also estimated.

Ekman-Burge grab

This technique collects a known amount of benthos (mud or sand). The technique obviously does not work on rocky or hard substrates.

6.6.4 Amphibians

Table 6.6 Suggested survey methods and effort for amphibians (conducted mid-September – February)

Method	Suggested minimum effort	Areas
Area search (plot based)	Per 2 ha site: 1 x 1 person hour search of a 0.5ha subplot of site	2 ha survey site used for sampling other fauna
Nocturnal habitat search	30 minute search on 2 separate nights	Targeted to breeding sites and likely habitat
Nocturnal call playback	1 playback session on 2 separate nights per location, preferably sampling at different times on each night	Targeted to breeding sites
Watercourse search	1 x 2 person hours search per 200m of watercourse edge (preferably at night but by day if night search would be hazardous)	Targeted to linear waterbodies (eg creeks, gullies, drainage lines)

In many biomes, species diversity of frogs will generally not be well sampled solely by survey in 2 ha sites recommended here as the basic unit of fauna survey, simply because frog distribution is so strongly dependent on moist microclimate which is highly spatially and temporally variable in its distribution. Additional sites for targeted frog survey should be chosen in areas likely to provide good quality frog habitat. These targeted survey sites should be selected within the same stratification units used for the rest of the study, but with the added condition that the sites are located along drainage lines, creeks, soaks, gullies or other areas likely to provide moist microclimate.

Most frogs are nocturnal and most easily detected by their calls. Surveys will have the greatest chance of detecting most species if undertaken at night, in wet weather and in the warmer months when a large number of species are breeding. The conditions that trigger some species of frogs, including some threatened species, are not well understood. Nocturnal reptiles, particularly geckoes, may also be encountered during these searches.

In habitats that contain watercourses, nocturnal searches using spotlight should be undertaken. The standard search effort, which has been used in many bioregional surveys, is one person-hour of effort per 200m of river, stream or gully. Call recording may be useful as a means of validating identifications, and Heyer (1994) describes equipment suitable for recording frog calls.

Frog detection during non-breeding periods is more difficult, and may require more vigorous and destructive searching techniques. In desert regions, searching for aestivating frogs may be the only practical technique and should be conducted by appropriately experienced specialist herpetologists.

Frogs may also be encountered opportunistically while spotlighting for mammals, or undertaking diurnal surveys for reptiles, or while driving along roads during rain.

A number of reference texts are available for identifying NSW frogs (Barker *et al.* 1995; Robinson, 1994; Cogger, 2000) and calls can be identified using reference tapes (Grigg and Barker, 1973). It may be necessary to have expert identifications of some calls.

6.6.5 Reptiles

A range of sampling techniques are necessary for reptiles as no one technique will capture all species, and some techniques may be of limited value in some habitats.

Diurnal active searches are a useful technique in most habitats, and the standard effort that has been used in many regional studies has been one 60-minute search of a 0.5ha area, located within each 2ha site. Searches should be undertaken during warm and dry weather, avoiding overcast days, and generally undertaken before mid-morning when reptiles have not reached their optimal body temperature. Basking individuals often can be identified by sight alone but cryptic species will require destructive searching of fallen logs, litter, decorticating and fallen bark and rock outcrops (NPWS 1997b). Detection of burrowing species requires looking and raking substrate under rocks. Rubbish and building materials such as corrugated iron may also provide reptile shelter.

Table 6.7 Suggested survey methods and effort for reptiles (conducted November – March)

Method	Suggested minimum effort	Areas
Area search (plot based)	Per 2 ha site: 1 x 1 person hour search of a 0.5ha subplot of site	2 ha survey site used for sampling other fauna
Pitfall traps with drift fences	Per 2 ha site: 24 trap nights, preferably 6 traps over 4 consecutive nights (will also trap some ground-dwelling mammals and frogs)	2 ha survey site used for sampling other fauna and targeted to likely habitat
Habitat search	30 minute search on 2 separate days	Targeted to likely habitat
Spotlighting on foot	30 minute search on 2 separate nights	Targeted to likely habitat

Nocturnal spotlighting on the 2ha survey site of tree trunks and other habitat should be used to detect geckoes and nocturnal snakes. Targeted survey of particular microhabitats (eg rocky outcrops) may be undertaken

Pitfall trapping with drift fences is also an effective technique during the warmer months when reptiles are active. They should be used where possible (where the substrate and the survey's budget do not prevent their use), and can also be used to sample frogs and small mammal species which are hard to trap by other means. Deep pits (>1.1m) capture many species (eg geckoes, legless lizards, dragons and snakes) which appear to escape from shallow pits (Woinarski *et al.* 2000). Traps should be open both day and night, and checked at dawn, dusk, and at least once during the day to reduce heat stress to captured animals.

Studies with reptile survey confined solely to the cold months of the year will not adequately sample the reptile fauna, as many species will be hibernating. Collection in colder months involves active and intense searching for hibernating species by experienced herpetologists, and fewer species will be recorded.

Kennet (1992) describes specialised trapping techniques involving drum nets that are required for freshwater turtles.

6.6.6 Birds

Table 6.8 Suggested survey methods and effort for birds

Method	Suggested minimum effort	Areas
Area search (plot based) OR Point locality search	Per 2 ha site: 20 minutes on two separate days, one at first light, one at dusk. Ten minute observations made at each of five points on a 500m transect (points 100 m apart with observations recorded at 0-5 m 5-10 m, 10-20m, 20-30m, 30-50 m and >50m distances from the point) on two separate days	2 ha survey site used for sampling other fauna and to target likely habitat
Wetland census	For each identified wetland, one 60-minute census at dawn or dusk	Targeted survey of waterbird breeding sites
Waterbody census	For each identified waterbody, one 20-minute census at dawn or dusk	Targeted survey of waterbodies other than waterbird breeding sites (see Wetland census)
Nocturnal call playback	Per 2 ha site: one call playback series on two separate nights from centre of site; each playback series to be preceded by 10 minutes of listening and 10 minutes of spotlighting; each playback series to be followed by 10 minutes of spotlighting.	2 ha survey site used for sampling other fauna if forest or woodland; and targeted to likely habitat of nocturnal birds, particularly owls.
Daytime search for roosts, nesting hollows and owl pellets	Per 2 ha site: 30 minute search. Targeted to habitat: as transect of set distance	Only in areas likely to provide roosts and hollows for predatory birds.

i Diurnal Birds

Many methods have been used for surveying birds, and summaries can be found in Bibby *et al.* (1992) and Gibbons *et al.* (1996). The most common methods for broad-scale biodiversity surveys are:

- area search methods, where observers walk around an area of predetermined size for a predetermined length of time. A 2 ha 20 minute search was used in the NSW CRA surveys (NPWS 1997c)

- point count methods, where observations are made from a series of predetermined points for predetermined lengths of time. By recording the bird's distance from the point, density estimates can also be made. Ten minute observations were made at each of five points on a 500m transect (points 100 m apart with observations recorded at 0-5 m 5-10 m, 10-20m, 20-30m, 30-50 m and >50m distances from the point) in the State Forests EIS surveys (York *et al.* 1991).

Each method has its advantages and disadvantages. Evidence from a study of the two methods (Catterall *et al.* 1996) indicates that the point count method is more appropriate for studies where multiple bird observers are used and the immediate aim is to make comparisons. For example, a study designed to assess the effect of some habitat change on the species composition, diversity or density. For an aim such as this, control of observer bias (differences in the results due to using different observers) becomes highly important, and Catterall *et al.* (1996) found that it could be reduced by using the point count method. However, in studies where the aim is a species inventory (to record as large a list of species as possible and do so as quickly as possible) the area search method is recommended, as this method is slightly more likely to detect small cryptic birds.

Diurnal birds are usually surveyed using an observational method such the point count methods or the active timed area search (Recher 1989, Ralph *et al.*1993). Birds can be observed by both sight and vocalisations. Birds are best surveyed early in the morning as overall activity decreases with time after dawn. Wet, windy and extremely hot weather should be avoided as bird activity is decreased under these conditions (Bibby *et al.* 1993).

An experienced observer is likely to record many more species than an inexperienced one (Catterall, *et al.* 1996) and all observers should be appropriately trained. There are many field guides to visual bird identification, such as Slater *et al*., 1989; Kingsford, 1991; Simpson and Day, 1996; Pizzey and Knight, 1997; Debus, 1998) and song-based identification (Lindsey, 1987).

The time spent searching is an important factor in the number of species that will be detected. Many species forage over large area each day and it may take several visits to record their presence. Loyn (1986) showed that 3 x 20 minute censuses of a 2ha block revealed only 53% of the species present while 3 x 60minute searches revealed 90.4. %. Birds are also more difficult to census in dense vegetation and may require longer sampling times in such areas to achieve the same level of detection as in more open areas.

Many birds are seasonal migrants (eg regent honeyeater and many species of shorebirds) and this should be taken into account in the timing of the survey or listed as a constraint of the study.

ii Nocturnal Birds

Several studies have found owls are most likely to be detected by call playback techniques combined with spotlighting (Debus, 1995; Kavanagh and Stanton, 1998). Kavanagh and

Peake (1993) found that call playback more than doubled detection rate for all species. This technique involves listening for vocalisations, broadcasting calls using a 10W amplifier, and spotlighting. Owls in approximately a 1km radius may hear a 10W amplifier. Calls should not be broadcast at too-loud a volume as return calls may be too far away to be heard by surveyors.

Owls call most frequently in the early evening and before dawn and surveys should be undertaken at these times (Kavanagh and Peake 1993). Wet and windy weather should be avoided as owls are most vocal on calm dry nights (Debus, 1995)

As with diurnal birds, the time spent surveying is very important. Debus (1995) found that several sampling sessions were required to have even a 50% probability of detecting owl species that were in fact present on a site (Table 6.9). With only one sampling session, the probability of finding a species that was in fact present dropped to 20-26%.

Table 6.9 Number of sampling sessions required to find an owl species (that was in fact present on site) with a given probability (Debus 1995)

Owl Species	**50% probability**	**90% probability**
Powerful Owl	3	7
Masked Owl	4	9
Sooty Owl	3	8

It should be noted that some individual owls never reply to broadcasting (Galeotti and Pavan 1993).

Other nocturnal birds should be surveyed by spotlighting, generally using a 12v 100w spotlight. This can be combined with spotlighting for mammals.

It is important to avoid undertaking activities that may directly affect sensitive species or species sensitive at a particular survey time such as nesting owls.

6.6.7 Non-flying Mammals

Many studies comparing different sampling techniques for mammals have concluded that all methods are biased towards certain animal groups (eg Stanton and Anderson 1998; Lindenmayer *et al.*1998). Hence, the wider the variety of methods used, the more likely is a regional biodiversity survey to sample the full range of species present in the region. Ideally, a survey should include all or most of the techniques in Table 6.10, although techniques that are known to be not particularly effective or feasible in some environments should be omitted.

Some techniques can be used to gather data both systematically and opportunistically. These include the collection of predator scats and owl pellets for hair and bone analysis (Triggs 1996), the observation of general signs (tracks, scats and scratches), and nocturnal vocalisations.

In areas where the density of small ground-dwelling mammals is particularly high, a higher density of Elliott traps (or other types of traps that usually capture only one individual) will be required in order to improve confidence that trapping is also detecting those species in lower densities. At least some traps should be available (unsprung and still baited) to capture animals each morning. Some small mammal species, particularly those in arid and semi-arid zones, are best captured by dry pitfall traps, which can also be used for reptile survey.

Table 6.10 Suggested survey methods and effort for non-flying mammals

Method	Suggested minimum effort	Fauna sampled
Elliott trapping (small traps)	Per 2 ha site: 100 trap nights over 3-4 consecutive nights, placed at 20-40m intervals as transects, baited with peanut butter and oatmeal.	Small ground-dwellers
Wire cage trapping	Per 2 ha site: 24 trap nights over 3-4 consecutive nights, placed at 40m intervals as a transect, baited with peanut butter and oatmeal or meat.	Medium-sized ground dwellers
Pitfall traps with drift fences	Per 2 ha site: 24 trap nights over 3-4 consecutive nights.	Small ground-dwellers
Hair tubes (Suckling, 1978) or funnels	Per 2 ha site: 10 large and 10 small in pairs, or 10 funnels, over 10 consecutive nights, placed at 20m intervals as a transect Targeted to likely habitat for arboreal species: 3 tubes or funnels per tree likely to offer nesting sites over 10 consecutive nights.	Mostly small and medium-sized ground dwellers; possums, gliders and arboreal carnivorous marsupials if set in trees.
Spotlighting	Walked: 1 hour and 1 km on two separate nights Vehicle: 1 hour at 5kph maximum on two separate nights	mostly medium to large mammals including arboreal ones; also owls.
Sand plots	No effort suggested. Probably most effective when targeted to tracks through thick vegetation.	mostly medium to large terrestrial mammals, especially feral species
Call playback	Per 2 ha site: one call playback series on two separate nights from centre of site	Gliders, koala
Search for scats, signs and owl pellets	Per 2 ha site: 30 minute search. Targeted to habitat: as transect of set distance	Many
Track search	Targeted to tracks and roads with soft substrate: 1 km	mostly medium to large terrestrial mammals. especially feral species

Specialist techniques for species such as koala and platypus should be included if these species are considered likely to occur in the region. Threatened species should be targeted using information in NPWS Threatened Species Profiles.

Specialists should identify hair samples, scats and the contents of owl pellets. In particular, hair samples should be identified according to techniques described by Brunner and Coman (1974). Scat analysis often provides information about the species that made the scat and the species that form its prey.

6.6.8 Bats

Table 6.11 Suggested survey methods and effort for bats (October to March)

Method	Suggested minimum effort	Areas
Harp trapping	two traps set for two nights each per location	2 ha survey site used for sampling other fauna and targeted to likely habitat
Ultrasonic call recording	Sound activated recording for whole night starting at dusk, for two nights per location	2 ha survey site used for sampling other fauna and targeted to likely habitat
Mist netting	At least 2 hours duration starting at dusk for two nights	Targeted to likely habitat
Trip line	At least 2 hours duration starting at dusk for two nights	Targeted to dams and other waterbodies
Spotlighting and transect walking	1 hour on 2 separate nights, starting at dusk	Targeted to likely habitat for megachiropterans, especially food resources such as fruiting and flowering trees
Daytime habitat search	Examine likely habitats for bat excreta	Targeted to stags, caves, mine mouths, underside of bridges

"Ecological requirements of bats, such as foraging strategies, dietary requirements and roost preferences, are highly variable both between and within species. Requirements can also change at different times of the year, or between years. Detailed information on the ecological requirements of bats is very limited for most species and is often outdated, anecdotal, inaccurate or based on isolated observations and interpreted as representative of the species' requirements." (Parnaby 1998)

i Microchiropteran bats

Survey for microchiropteran bats in bioregional studies should include site-based systematic survey, targeted survey at specific locations identified by their potential to offer bat roosting sites, and assessment of potential bat habitat. This is especially necessary given the decline in many bat species within NSW, the lack of knowledge about their ecological requirements, and the difficulty in identifying all the species that may utilise an area.

Microchiropteran bat species can be identified by their unique ultrasonic echolocation calls (Woodside & Taylor 1985) or by trapping and physical identification (Helman & Churchill

1986). However, a combination of both ultrasonic detection and trapping is essential as neither method can detect all species (Parnaby 1992; Corben 1989). Ultrasonic methods are more likely to capture high flying species but trapping methods are needed to detect low intensity echolocators (e.g. Long-eared Bat and Golden-tipped Bat - Corben, 1989).

Bats are most active from October to March and sampling should be undertaken during this period (Lumsden & Bennet 1995). High wind, heavy rain and full moon should be avoided when undertaking bat surveys (Law *et al.* 1998). Bats also show local patchiness associated with flowering of trees and other unknown factors (Lumsden & Bennet 1995).

Microchiropteran trapping

Several species are difficult to record with electronic detectors, especially species that have low intensity calls. Direct capture methods must be used to identify these species (Richards). Churchill (1998) and Helman & Churchill (1986) provide details of methods for trapping bats. Commonly used trapping methods involve harp, mist and tripline traps over water. Many species use regular flyways, which may be located by observation or ultrasonic detection.

Harp traps (Tidemann & Woodside 1978; Tidemann & Loughland 1993) are suited both to survey of sites which are chosen by random sampling principles, and to targeted survey of likely flyways, across tracks, near water, or near roosting sites.

Since many bat species are very small with high metabolic rates, the time that they spend in traps should be minimised. Lactating females may also need to return to feed young. Harp traps should ideally be cleared and closed before dawn, to allow released bats to find roosts before light. The frequency with which harp traps should be checked during the night will depend on the rate at which bats are captured. As a general rule, traps should be checked about 2 hours after dusk. Subsequent checks at 3-4 hour intervals may be necessary where the rate of capture is particularly high. However, traps, which have captured very few bats in the 2 hours after dusk, may not require any further check until the final one before dawn. Care should be taken to ensure that bats do not become dehydrated or cold before release. Harp traps should be checked regularly to avoid predation by larger species.
Extensive bat trapping studies in NSW and Victoria indicate that a minority of species (typically 4 or 5 species or perhaps a quarter of species in the area) account for the vast majority (70 to 90%) of total individuals captured (Parnaby 1986; Mills *et al.* 1994). Parnaby (1986) suggests that the greater the number of trap sites per night the greater the likelihood of capturing more species.

In general, bat activity levels are much higher over water than over forest, and water bodies should be targeted where they occur. Trip lines can be used to catch bats where water is too deep to access mist nets (Churchill 1998). Investigators must watch the water surface and retrieve those bats unable to exit the water of their own accord.

Mist nets can be used in addition to harp traps and may trap different species of bats in the same locality (Churchill, 1998). Mist nets must be monitored continuously once set.

Ultrasonic call detection

Ultrasonic call detection records most calls in the first two hours after dusk when bats are most active. However, several species experience additional activity peaks in the night, and sampling throughout the night using a delay switch may increase the chance of detecting some rare species. The Anabat detector (Titley Electronics, Ballina, NSW) can be used throughout the night without attendance by an operator. The rate of species accumulation is such that 3 hours of recording immediately after dusk is required to identify 90% of species (Richards 2001).

Ultrasonic call detection is most efficient when using a detector which records calls to a laptop rather than onto cassette tape. Recordings taken from a tape recorder frequently produce ambiguous calls, requiring the investigator to nominate the range of species to which the call could be attributed.

People appropriately skilled and experienced (particularly with bats of the local area) should do identification of bat calls. Most specialists allocate each call to one of three categories (definite, probable and possible) at identification, with only definite identifications used for analysis of bat distributions in the bioregion. Probable and possible calls of threatened, rare or unusual species may be used to prompt further targeted investigation for that species. Recording reference calls from at least some species caught in harp traps may also assist in identification of call records, particularly in regard to regional variation of calls.

Assessment and targeted survey of potential bat habitat

Selection of roosts by microchiroptera fall into two broad groups; those that roost in tree hollows or fissures, and those that roost in subterranean roost sites such as caves and disused mine tunnels. A few species are known to utilise both types of roost. A review of potential subterranean roost sites is therefore required before field surveys commence. Information on the location of caves can be obtained from the Australian Karst Index (Matthews 1985) and other literature, and the location of derelict mines can be obtained from metallogenic and geological maps. In addition the study area should be inspected for bridges, and other human-made structures with the potential to support bats (Richards 2001).

Several studies indicate that subterranean roosting species change roosts to select an appropriate roost microclimate determined by factors such as changing weather conditions, seasonal changes in climate and changes in reproductive status (e.g. Hall 1982). Individuals are also likely to change roost site in response to social factors and the availability of food.

Opportunistic day searches may reveal bat droppings at daytime roosts and suitable trees, caves, culverts and disused buildings should be searched.

ii Megachiropterans (flying-foxes, fruit bats)

Spotlight searches combined with listening for audible calls should be undertaken for flying-foxes.

Mist netting is the only suitable technique for the capture of the Common Blossom Bat, and the nets should be set near flowering food resources, preferably on moonless nights (B. Laws pers.

comm.). The Eastern Tube-nosed bat has a distinctive, clearly audible call which provides an indication of its presence.

Camps of the three flying-fox species in NSW are often located near creeks or rivers (Hall and Richards 1991). Camps of the Grey-headed Flying-Fox and Black Flying-Fox are located in rainforest remnants, often in gullies, and riparian situations, mangroves, melaleuca swamps, or casuarina stands in riparian areas (Eby 1995). Camps appear to be located to enable access to food resources. However, other factors that determine camp locations include:

- protection from strong winds;
- access to updraughts;
- protection from the sun and location in relation to topographic features, such as river systems, that could be used as navigational aids (Hall and Richards 1991; Eby 1995).

A mapping project of the Grey-headed Flying-Fox camp sites has been undertaken by Eby and is available from NPWS.

6.6.9 Handling and ethics

The legal requirements relating to animal ethics are covered in Section 3.3.3 of these guidelines. Investigators should be aware of:

- their responsibilities under the Australian Code of Practice for the care and use of animals for scientific purposes (NH&MRC 1997);
- guidelines issued by the Animal Welfare Unit of NSW Agriculture (available at their web site);
- any specific requirements of the Animal Research Authority and Scientific Licence under which the work is undertaken.

Some practical considerations relating to animal welfare while undertaking surveys are given below.

i General

It is necessary to minimise noise when handling animals and minimise the time spent handling animals to reduce stress. Animals should be released as soon as possible after capture into shelter at the capture site. If animals must be kept before release they should be kept in quiet cool and well ventilated conditions. The NSW NPW Act requires that animals be released at the point of capture.

ii Pitfall Traps

Wet pitfall traps (containing a preservative) should not be used for capture of vertebrates. If used for invertebrates, the traps should be managed to minimise inadvertent capture of vertebrates. Dry pitfall traps need to be checked more than once each day because they capture a range of nocturnal and diurnal animals.

iii Frogs and Reptiles

The *Hygiene Protocol for the Control of Disease in Frogs* (NPWS 2000c) should be followed when working on frogs or conducting fieldwork in wetlands or other freshwater environments. A copy of the protocol can be found on the NPWS web-site. This Protocol aims to prevent the spread of pathogens, such as Chytrid fungus, which appear to be a cause of the decline of frogs (Berger *et al.*, 1998; 1999). This Protocol covers on-site hygiene issues including cleaning and disinfection of footwear, equipment, and vehicles and handling of frogs in the field.

Trampling or breaking of vegetation should be avoided and any habitat moved during active searching should be replaced.

Frogs should be handled as little as possible to avoid removing skin secretions and should be kept moist during identification and before release.

iv Birds

Unnecessary close range observation of feeding and breeding birds and overuse of mimicry calls should be avoided. Avoid playing distress calls while using call playback methods.

v Mammals

When trapping mammals in cold or very hot weather, insulating material, such as dry leaves, should be placed in and over metal-sided traps. Cage traps can be covered to reduce stress to captured animals.

All traps should be inspected and emptied at first light. Traps should be closed or inspected during the day in warm weather if there is evidence that animals are being caught during the day. Particular care should be taken when handling marsupials with advanced pouch young which are prone to ejecting young when under stress.

Since many bat species are very small with high metabolic rates, the time that they spend in traps must be minimised. Lactating females may also need to return to feed young. Traps may be cleared before midnight to allow captured species to continue feeding, and again before dawn, to allow bats to find roosts before light. Care should be taken to ensure that bats do not become dehydrated or cold before release. Harp traps should be checked regularly to avoid predation by larger species.

If it is necessary to retain bats during the day, they should be stored in a cool, dark, well ventilated environment. The horseshoe bats and Queensland blossom bat are susceptible to dehydration and should not be retained during the day. All bats should be released at the capture site.

Human visitation of subterranean roosts is particularly detrimental during winter when bats are torpid, as the energy consumed during arousal from torpor can jeopardise fat stores, and potentially lead to starvation. Thomas (1995) suspects that even if a few bats are initially disturbed a cascading effect takes place leading to the arousal of a significant proportion of the animals (Parnaby). This also applies equally to hollow utilising bats.

6.6.10 Voucher Specimens

A voucher specimen should be taken and lodged with a museum to record the presence of a species outside its known range, if it is believed that an undescribed species has been captured, or to confirm the identity of a species if identification is uncertain. Only licensed investigators can take voucher specimens, and the date of capture, location (AMG, eastings and northings), identification and collector must be recorded and kept with the voucher at all times.

The taking of voucher specimens is covered by the *Australian Code of Practice for the Care and Use of Animals* (NHMRC 1997).

All specimens must be humanely euthanased as per the conditions of the Animal Research Authority issued for the survey, and an identification tag must be attached to the specimen.

In NSW, voucher specimens must be sent to:

> Collection Manager (birds/mammals/herpetology/insects – as relevant to the material)
> Australian Museum
> 6 College Street
> Sydney NSW 2000.

Investigators should check with the Australian Museum about their requirements for fixation and data collection prior to survey.

6.6.11 Health and Safety

All persons involved in field surveys should follow a health and safety procedure for field work which covers issues such as personal safety, emergency procedures and emergency contact. Fieldworkers should be trained in emergency procedures, including CPR, and should carry appropriate First Aid Kits. All field workers should have up-to-date tetanus vaccinations. When handling certain groups of animals, the following additional precautions need to be taken.

i Invertebrates

Insect bites may produce a severe allergic reaction in some people leading, in extreme cases, to anaphylactic shock. Measures should be taken to avoid insect bites and appropriate first aid kits should be carried. The venom of some ticks can seriously affect people allergic to it and care should be taken to remove and kill all ticks.

Venomous funnel web and redback spiders may be captured in pits traps in some locations in NSW. Field workers should be aware of the dangers of these species and appropriate emergency procedures should somebody be bittern.

ii Frogs

The Hygiene Protocol for the Control of Disease in Frogs (NPWS 2000c) should be followed when working on frogs or conducting fieldwork in wetlands or other freshwater environments.

iii Snakes

Experienced persons should only handle snakes. All field workers should be aware of the treatment for snakebite and carry appropriate pressure bandages in their first aid kits. Protective footwear should be worn during fieldwork.

iv Animal bites

Gloves should be worn when removing large and some medium-sized mammals from traps.

v Scats and Owl Pellets

Scats and pellets may contain eggs of parasites as well as bacteria and viruses. Eggs of hydatid tapeworms, which can form lethal cysts in humans, may be present in the scats of dingoes and dogs. All scats and pellets should be collected using disposable plastic gloves, placed in an envelope and sealed.

vi Bats

Bats may carry the potentially fatal rabies-related lyssavirus. Gloves should be worn when handling bats, and field workers handling bats should consider having the pre-exposure rabies vaccine. Disturbance of soil and guana in bat roosts and caves should be avoided due to the possible presence of spores of the fungus *Histoplasma capsulatum* that can infect the lungs of humans.

7 INTERPRETATION, REPORTING AND IMPLEMENTATION

7.1 INTERPRETATION

Results of field surveys and in combination with information gathered from literature and databases must be interpreted with respect to the aims and objectives of the study and the plans and policies to which they are being applied. Statistical analyses and manipulations to which data may be subject are not within the scope of these Guidelines.

Readers are directed to *Biodiversity Planning Guide for Local Government* (Fallding *et al.* 2001) for detailed guidance about developing and implementing regional biodiversity plans for local government areas.

Ideally, data should be made available in GIS layers that assist evaluation of the patterns, extent and types of flora, fauna and habitats for the whole of the region, and which can be overlain and analysed with other important spatial features (eg. topography, geology and land use). This not only maximises the ease of data manipulation and analysis, but often allows the results to be presented in a more compelling way in order to support recommendation drawn from them.

7.1.1 Identifying areas of outstandingly high biological diversity and threatened species diversity or abundance

Display key biodiversity features including locations of high biodiversity and threatened species and important habitat on a series of maps for the whole region. This information can then be overlayed with zoning and landuse information for bioregional planning purposes.

Objectives of biodiversity surveys are often to identify areas of outstandingly high biological diversity, threatened species diversity or abundance, and special features such as large breeding sites. Identifying these areas will assist in strategic land management planning, assessing future development applications and prioritising with respect to limited resources allocated to conservation. It is important to display these areas on a series of maps for the region..

There are no generally accepted benchmarks or objective ratings for what constitutes high, medium or low levels of biodiversity. Any such assessment must be made by comparison to existing information from similar biomes, adjacent regions, or by ranking areas within the study region.

Such biodiversity ratings are generally measured as one or more of the following:

- number of taxa (usually species);
- number of ecological communities;
- extent of differences between ecological communities (eg. an area containing rainforest, heathland and sclerophyll forest may be regarded as more diverse than one containing three different types of sclerophyll forest).

However, such ratings are extremely subjective and entirely relative to the scale at which they are measured, and the units used to measure them. For example, an area of native grassland may contain low species diversity when comparing to neighbouring vegetation types, but if grasslands and grassland species are rare within the larger bioregion, the grassland area may make a significant contribution to the biodiversity of the larger area.

Identification of areas of high species diversity will be based solely on the taxa for which information is available, and biased by the methods used in the survey. A truly comprehensive biodiversity survey would encompass groups which are difficult to survey and identify such as microbes, and is generally not technically nor financially feasible.

An area may be denoted as outstandingly high for a particular taxonomic level, for example where an unusually large number of species belonging to a single family, order or class have been found in the same location. Or, an area may be denoted as outstanding for a particular species if any unusually high abundance of the species has been found there.

Decisions about where outstandingly high biological diversity and threatened species diversity or abundance occur may involve comparing units of land with one another. Comparisons may be based directly on survey data, or on models of species or ecosystem distribution. Those units typically may be:

- arbitrarily defined during the assessment (eg. the study area may be divided into 3x3km blocks);
- pre-existing planning units (such as forest coups); or

- based on some environmental or biotic variable (such as vegetation type).

7.1.2 Determining biodiversity conservation values in the region

A common aim of regional biodiversity surveys is an assessment of the biodiversity conservation value of specific parcels of land for planning purposes. For ease of understanding, these assigned parcels of land will be called ‘biodiversity conservation units’. It is important to not only assess the value of specific parcels of land relative to others in the study area, but to consider their contribution to achieving conservation goals at a range of larger scales.

Determining the relative value of biodiversity conservation units:

- allows land to be prioritised with respect to limited resources allocated to conservation;
- may assist in determining suitable recommendations for conservation and sustainable land management;
- enables strategic land management options to be developed.

In regional-scale studies, remnant vegetation is often the basis for conservation planning (and is used as a surrogate for fauna values) because:

- diversity and integrity of vegetation is a factor in determining faunal habitat suitability and biodiversity maintenance;
- vegetation cover plays a large part in catchment protection and natural landscape qualities;
- land development generally involves clearing of native vegetation (Greening Australia 1995).

Vegetation is also used as a basis for conservation planning because it is relatively easy to characterise, and is certainly easier to describe and analyse than other values of conservation such as ecological processes and genetic diversity.

To determine biodiversity conservation units it is often necessary to establish a ranking system of relative significance and to define an arbitrary boundary based on their conservation value. This will involve:

a) overlaying and comparing all relevant information;
b) assigning boundaries;
c) ascribing conservation values.

i Overlaying and comparing information

Types of information to be overlayed and compared include:

- the pattern, extent and types of flora and fauna and their habitats obtained during the field surveys and literature review;
- physical datasets including topography, hydrology, soils and geology;
- administrative datasets including land tenure, zoning, land use and roads;
- other datasets including climate and land capability;
- air photos and satellite images;

- socio-economic information including population growth and industrial expansion.

ii Assigning boundaries

Assigning boundaries to biodiversity conservation units incorporates the locations of boundaries, defining the size of each unit, and differentiating between each unit. This will need to be determined on a case by case basis, as it will depend on the objectives of the study and the issues to be addressed.

Of particular importance is assigning boundaries to areas that are similar in ecological structure and function and where planning and site management can be most effective. However, this can be difficult particularly as traditional planning scales have defined boundaries that are often not related to the ecology of an area. For example, traditional planning scales are usually based on administrative areas and social-economic factors (such as property boundaries and local government areas) compared with ecological landscapes such as vegetation corridor that may extend across a number of properties following a ridgeline (Fallding *et al.* 2001).

One approach is to define boundaries using typical landscape characteristics identified in the study and overlaying the zoning of each parcel of land. Examples of typical landscapes are displayed in Tables 7.1. The zoning of the land gives an indication of the land use and the amount of conservation effort that is or can be applied to each parcel. Table 7.2 provides criteria to determine the conservation effort applied to various zonings and who takes responsibility for that zoning.

Table 7.1 Typical landscape and vegetation categories

Category	Features
Core areas of indigenous vegetation	Large areas of original indigenous vegetation that are essentially undisturbed, and provide continuous areas of habitat capable of sustaining certain key parts of the ecosystem.
Small vegetation fragments	Small, often isolated remnants of original vegetation.
Vegetation corridors	These may be continuous stretches of linear vegetation along waterways, drainage lines, roads and reserves, stock routes, rail lines, etc.
Areas of habitat for threatened species	Areas capable of supporting threatened species are usually susceptible to damage, and require special care to protect them.
Scenic areas and escarpments	Vegetation along scenic routes, valleys, lookouts, ridge tops and coastlines.
Wetlands	Lakes, swamps, ponds and areas that are regularly flooded.

Source: Greening Australia (1995)

Table 7.2 Criteria to determine the conservation effort of zoned land

Conservation Effort	Zoning	Criteria
High	National Parks, Nature Reserves, Environmental Protection (bushland), Bushland Reserves and State Recreation Areas	These lands are dedicated to the care, preservation and conservation of flora and fauna and their habitats. The Director-General and a Board of Management are appointed to maintain the care, control and management of all National Parks, State Recreation Areas and Nature Reserves. Councils manage lands zoned Environmental Protection and Bushland Reserve. Councils manage lands zoned Environmental Protection and Bushland Reserve.
Medium	Council Reserves, Council Recreational Areas, and Open Space	These lands are used for the purpose of public recreation and are not committed to the preservation and conservation of flora and fauna and their habitats. Council provides the management, care and control of these areas.
Low	Rural, Residential, Industrial and Commercial	These lands are committed for development, where consent is usually required. Preservation and conservation of flora and fauna and their habitats is limited, although they include development restrictions through implementing tree preservation and consideration of environmental legislation such as the TSC Act before approval is given.

iii Ascribing conservation values

In ascribing values to biodiversity conservation units, a useful guide is the NPWS's (1997b) *Conservation Value Assessment Guidelines (Site Specific)*, particularly the ecological value section. Under these guidelines, ecological values can be assessed using five characteristics:

1. **Rarity**. Presence of rare or threatened species, populations, communities and their habitats, and the nature of the rarity.
2. **Naturalness**. The extent of human interference using native vegetation disturbance as a measure.
3. **Diversity**. Variety or richness of ecosystems, habitat, communities, and species present.
4. **Representativeness**. The extent to which the selected areas sample the known biological/biophysical diversity (Thackway & Cresswell 1995).
5. **Viability**. Ability to sustain the ecological process and the practicability of managing it considering such factors as size, shape, proximity and temporal variations (eg. Green house).

Greening Australia (1995) is another useful resource as they provide an example of the *Pine Rivers Greening Plan*, which identifies conservation management areas for the entire shire. The plan defines parcels of land into four broad categories:

1. **Priority conservation areas**. Areas of integral bushland in their natural or near natural condition, which are of high conservation significance. Conservation of vegetation is the intended land use.
2. **Major conservation areas**. Areas with high conservation value but of a lower level of significance. Conservation of vegetation is a high priority, but co-dominant with other intended land uses and activities.
3. **General conservation areas**. Watercourses without natural riverine vegetation and remnant natural bushland that are not part of Priority or Major areas. Protection and enhancement is a priority, but conservation is generally a secondary land use objective.
4. **Enhancement areas**. All remaining areas consisting of cleared, developed and otherwise disturbed land with agricultural, pastoral, urban and industrial land uses. Other activities are dominant but vegetation replacement and enhancement is actively encouraged for multiple community benefits.

7.1.3 Identifying region-wide or localised occurrences of biodiversity threats

Understanding the patterns of biodiversity in a region and making worthwhile conservation recommendations can be facilitated by the identification of threatening processes. It may be necessary to define these at both a region-wide and local scale to enable all threats to be identified and to prioritise areas for the allocation of resources and future planning purposes. A particular region may support a variety of biodiversity threats which occur throughout the region, such as fox predation, land clearing and road mortalities. However, of most concern are those threats that occur to areas of high conservation value such as a habitat corridor, or an area that supports an outstandingly high biological diversity.

For example, a habitat corridor may provide important benefits to the region's biodiversity through fauna movement and exchange of genetic information. Expansion of urban development may threaten those benefits by causing greater edge effects, loss of connectivity for many species, and increased weed invasion. Local threats to this corridor should be addressed in order to avoid flow of impacts at a wider scale, such as the bodies of vegetation which are connected by that corridor.

i Key Threatening Processes

Key threatening processes are specified in Schedule 3 of the TSC Act and are defined as a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. A requirement of their listing on the TSC Act is that they threaten two or more threatened species, populations or ecological communities. However, many threatening processes may be threats to biodiversity in general.

The current list of key threatening processes on the TSC Act can be found at: www.npws.nsw.gov.au/notes/exhbtsc/htm.

ii Identifying threats

A range of threats to biodiversity are likely to be relevant to all regional scale assessments. Table 7.3 outlines useful tools/sources to determine the location and extent of major threats, and Table 7.4 outlines the relationship of these threats to land use activities and possible solutions (Fallding *et al*. 2001).

Table 7.3 Useful tools/sources to determine the location and extent of major threats in the region.

Threat	Useful tools/sources
Clearing of native vegetation	Historical aerial photos; vegetation community maps; landsat imagery available from Department of Land & Water Conservation (DLWC).
Bush fire management	Bush Fire Risk Management Plans for the region from NSW Rural Fire Services (NSW Bush Fire Coordinating Committee 1998 & 1999)
Stock grazing	Land tenure information; visual inspection of stock trampling; consultation with Department of Agriculture
Pollution and land contamination	Records of past land uses from Land Title Office; sediment testing; consultation with Environment Protection Authority
Alteration to hydrological systems; increase nutrients; salinity	Sediment and water sampling, flood history, consultation with DLWC
Soil erosion, sedimentation and compaction	Visual evidence of erosion, scouring, and undercutting; soil landscape information from DLWC.
Introduction of non-native plants	Weed Management Plans from Council; vegetation inventories; flora surveys; consultation with land owners/occupiers.
Introduction of non-native animals	Fauna inventories; trapping and scat surveys; consultation with land owners/occupiers.

7.1.4 Determining the level of protection required

A valuable outcome of any regional-scale biodiversity survey and assessment is to recommend the levels of protection required for assessed areas, based on the conservation options available (Table 7.5). The investigator should recommend for each area of. Recommendations for specific conservation options for areas of moderate to high biodiversity conservation value can be used by the Regional Planning Body to develop an integrated view of the study region, incorporating environment, social, economic, cultural, and political considerations.

Table 7.4 Associated activities and possible solutions to major threats

Threat	Associated Activity	Possible solutions
Clearing of native vegetation	Agriculture; Forestry; All urban	Clearing controls; financial incentives; biodiversity assessments at early stages of planning; regeneration of fragmented habitat.
Bush fire management	Agriculture; All urban	Design and siting of development; appropriate fire management and vegetation monitoring.
Stock grazing	Agriculture	Protection of remnant bushland, alternative grazing strategies.
Pollution and land contamination	Agriculture; All urban	Reduction in use of persistent artificial chemicals; improved land management practices.
Alteration to hydrological systems; increase nutrients; salinity	Agriculture; All urban	Reduced development runoff, better design, reduced fertiliser use; retain native vegetation.
Soil erosion, sedimentation and compaction	Agriculture; All urban; Extractive industry	Land capability planning; better site design.
Introduction of non-native plants	Agriculture; All urban	Education programs; regulations; use locally indigenous landscaping species; maintain resilient natural ecosystems; weed control.
Introduction of non-native animals	Agriculture; All urban	Education; regulation; predator control.

Source: Fallding *et al.* (2001)

Table 7.5 Conservation options available under Acts and agreements

Conservation option	Features
National Parks & Wildlife Act 1974	
Reservation or dedication under the NPW Act	This is for areas found to have significant conservation values at the regional level and include National Parks, State Recreation Areas and Nature Reserves. The Director-General and a Board of Management are appointed to maintain the care, control and management of these areas.
Voluntary Conservation Agreements	Applies to privately owned lands that have conservation values worth protecting (but not of the value that requires a high degree such as reservation) and where the owner is eager to protect the conservation values of the land.
Wildlife Refuge	Applies to privately owned rural lands with the owner's consent to preserve, conserve, propagate and study wildlife and to conserve, study and stimulate natural environments.

Table 7.5 Conservation options available under Acts and agreements (continued)

Conservation option	Features
Wildlife Act 1987	
Reservation under the WA Act	Areas have been assessed to have strong wilderness qualities as identified in the WA Act and the NPW Act.
Wilderness Protection Agreement	Agreements entered into by the Minister for the Environment and the relevant Minister or public body who has jurisdiction over the area. This agreement can be negotiated for lands identified as wilderness area under the WA Act and the NPW Act.
Threatened Species Conservation Act 1995	
Property Management Planning	It is a voluntary scheme that aims to help land managers farm in a sustainable manner to prevent land degradation. Under the scheme the NPWS will provide ecological advice to farmers to assist them in producing a threatened species property plan.
Total Management Planning	It is a voluntary scheme that aims at assisting farmers and their families to further develop their skills in planning for a sustainable and productive property in harmony with environmental and family needs. This conservation option is NSW's contribution to the National Property Management Planning campaign and the NPWS is involved in this under the Farming for the Future program.
Environment Planning & Assessment Act 1979	
Environmental Planning Instruments and Zoning	Refers to the use of zoning and land use controls to regulate land use. An area with conservation value may be zoned to protect these values in an environmental planning instrument (i.e. SEPP, REP and LEP). The degree of protection offered to an area by zoning varies and does not contain provisions for the owners to carry out management activities.
Crown Lands Act 1989	
Retention of Crown Land	Involves the retention of lands under Crown ownership through objections to Crown lease conversions and Aboriginal land claims. Under this, leasehold status cannot be revoked (converted to freehold) without referral to NPWS.
Forestry Act 1916	
Flora reserve	Applies to areas within state forests that are relatively undisturbed. The aims of setting aside these areas as flora reserves are to assist in understanding forest growth process, providing areas for scientific study, and to maintain reference or baseline areas (Farrier et al 1999).
International Agreements	
World Heritage Sites	The World Heritage Committee will consider inclusion of natural heritage property into the World Heritage List if it is of outstanding universal value for the purposes of the Convention. Areas recommended for inclusion should meet one or more of the criteria and fulfil certain conditions of integrity.
Ramsar Sites	These are wetlands of international importance especially as waterfowl habitat. A wetland is of international importance if it meets at least one of the criteria specified by the Convention.

Source: NPWS (1997a)

7.1.5 Applying principles of ESD

There is a growing understanding that economic development, social services and environmental protection and management are inter-dependant and interact in complex ways (Department of Local Government 1999). Regional-scale biodiversity surveys and assessments is one mechanism is for identifying and evaluating sustainability issues through:

- identifying areas of importance for biodiversity and threatened species;
- recommending suitable protection and management of these areas;
- assisting the decision-making process in strategic land management options.

Consideration of the principles of ESD needs to be given in all regional-scale biodiversity surveys and assessments. The principles of ESD are enshrined in some NSW legislation, for example the EP&A Act and the POEO Act. Appendix C further discusses the principles of ESD.

7.1.6 Developing suitable recommendations

An outcome of the survey and assessment process may be recommendations to protect, enhance and/or manage specific areas. These recommendations will need to be developed with regard to strategic land management options developed for the region in order to be implemented by the Regional Planning Body. Fallding *et al.* (2001, part 10) provides a set of sample practices and standard conditions to fulfil various management objectives for biodiversity conservation, which should be consulted.

Recommendations will need to be specific to each region and are expected to vary greatly depending on the goal of the study. Factors to consider when determining suitable recommendations for conservation of biodiversity are:

- **protecting** areas at a range of levels and a variety of means, most of which involve some change in land tenure or creation of voluntary covenants;
- **enhancing** areas that may provide important bushland corridors and buffer zones. This may be achieved through land acquisition, changing management approaches, and/or bush regeneration activities;
- **managing** areas that are recognised as supporting high biodiversity. Management activities may include weed control, bush fire, monitoring programs, and restricting livestock and humans to certain areas;
- **identifying further research needs** to identify areas where further survey work will be required at a local level to determine the significance of the area and provide a thorough assessment of the biodiversity and threatened species habitat values.

7.2 WRITING THE REPORT

7.2.1 Structure and content

In general, biodiversity survey reports should follow the format of a scientific paper or thesis, and where possible adopt a similar approach with regard to objective evaluation of results and the use of evidence and references to support its conclusions and recommendations. Minimum report requirements is provided below, but additional information may be required according to:

- the nature of the proposed project;
- the tender brief provided by the Regional Planning Authority;
- specific requirements of key stakeholders.

Information should be broken down into manageable parts (particularly chapters, sections and subsections) and have a logical flow from one to the next. The text of the report needs to be concise yet detailed enough to allow the reader to evaluate whether the investigator has summarised or interpreted the results of the survey correctly. Put raw data or detailed technical information in appendices to improve the readability. Table 7.6 outlines the structure and content of the report and identifies the purpose of each section.

Table 7.6 Structure and content of the report

Section	Purpose	Content
Summary	Facilitates understanding by the general public.	Non-technical description of the study and its findings. It should be restricted to less than two pages
Glossary	Assists reader's understanding	Explanation of technical terms used throughout the report.
Introduction	Sets the scene of the study	- the author of the study and who it was commissioned by; - the trigger for the study; - the study's aim and objectives; - any constraints or limitations on the study; - how the report is structured.
Legislative Requirements	Outlines the legislative requirements and regulations pertaining to the study	- all applicable environmental planning instruments; - the provisions of all applicable legislation; - all approvals and licences.

Table 7.6 Structure and content of the report (continued)

ection	urpose	ontent
lethods	etails the desktop and field ırvey methods employed. he technical information ıould be sufficiently detailed enable the field survey to e replicated. The choice of eld methods and extent of ırvey should be justified, ıd any constraints noted.	onsultation with key stakeholders; ıta sources, and an explanation of how data was handled; ratification methods and information about the spatial distribution ıd size of strata; ıe precise location and layout of survey sites (presented as grid eferences and maps); ımpling dates; ırvey techniques utilised and the intensity of sampling in each rata; pe and number of traps, their layout, baits, and the number of ırvey nights for each technique; ıta analysis methods, including any criteria used to categorise areas f high biodiversity.
esults	isplays the findings of the udy	ımmaries of the data, including which species were found in which tes, strata vegetation or habitat types, and by which methods they ere located; ıaps of survey method locations; ıy general or unusual observations; maps of environmental eatures, vegetation types, habitat types; esults of any modelling or statistical analysis of data; ıaps of any areas of high biodiversity or other areas of special gnificance; ıw data (copies of original data sheets are acceptable) should be ıcluded in an appendix.
iscussion	iscusses the results	ıterpretation of the results of the study; mitations and further issues that may need to be addressed; ting of all relevant references.
ecommendation	rovides possible outcomes f the study	ecommendations for further work; ow the findings of the study can be implemented; se references from other sources to provide additional support.
eferences	ites publications used in the eport	ists all documents cited within the report with author, year of ublication, title of publications, journal volume and pages and/or ame of publisher.
ppendices	ollates detailed information the back of the report and lows the main body of the eport to be concise.	ıw field survey data (copies of original data sheets area acceptable); ıalifications of the investigator; ertification of the report by the investigator; sue number and the names of issuing bodies of any licences, ermits or authorities under which the field work was carried out.

7.2.2 Format

When deciding on the reporting format, give consideration to (SMEC & Australian Industry Group 2000):

- key stakeholder requirements;
- various reporting formats available such as an Internet, stand-alone hard copy, CD-ROM, and e-mail;
- available resources;
- summary report versions for wider distribution and keeping printing costs down.

7.2.3 Forwarding information to centralised databases.

i NPWS Wildlife Atlas

One of the requirements of an 'A' Class License from NPWS (Section 3.3.1) is to supply the localities of all native species recorded, including all threatened species. An Excel spreadsheet for supplying data to the Wildlife Atlas in now available at the NPWS website: www.npws.nsw.gov.au.

The spreadsheet should include:

- locality (easting and northing and Australian Map Grids (AMGs));
- species name (Scientific for flora and fauna and common names for fauna);
- sightings per species (the number of records for each species in the search area);
- date of record;
- observer name;
- abundance.

ii Other databases

Investigators may be required to send information to other environmental databases including Australian Museum, Royal Botanic Gardens, and Birds Australia. This will involve accurate recording of data in the required format for each agency. Contact each agency directly to obtain the appropriate forms and data sheets.

7.2.4 Additional reporting requirements

Additional reporting requirements will depend on the:

- contract brief for the project which may have specific requirements relating to the planning uses to which the work will be applied;
- key stakeholders needs such as natural resource agencies which require survey data in specific formats and with some essential information fields;
- legislative requirements, including addressing criteria outlined in Acts and Regulations;

- reporting requirements for Scientific Licence, Animal Research Authorities (Section 3.3) any other permits under which the work was done.

A reporting checklist is provided in Appendix D that outlines specific reporting matters for inclusion in biodiversity reporting, their role and importance. This checklist provides the investigator with the requirements he or she needs to address in the report and in turn assists the Reviewing Authority when appraising the report.

7.3 IMPLEMENTATION

This section provides guidance on implementing biodiversity outcomes into specific plans and policies

From the recommendations provided in the report (Section 7.1.6), the Regional Planning Body would identify a number of biodiversity outcomes that may be implemented through appropriate planning instruments. These include:

- Regional Environmental Plans;
- Local Environmental Plans/Studies;
- Regional Vegetation Management Plans;
- Bush Fire Risk Management Plans under the *Rural Fires Act*;
- Catchment management planning under the *Total Catchment Management Act* or the Healthy Rivers policy initiatives;
- Plans of Management.

These planning instruments are described below along with examples of biodiversity outcomes relevant to each instrument and where further information can be obtained.

7.3.1 REPs and LEPs

Regional Environmental Plans (REPs) and Local Environmental Plans (LEPs) are both environmental planning instruments which are made under the EP&A Act. LEPs are primarily the domain of local government and can deal with the whole of a local government area or simply one small block. REPs are put in place by State Government and can take precedence of LEPs. They are only made where the Minister of Urban Affairs & Planning reaches the opinion that they are concerned with matters of significance for environmental planning for a region or part of a region.

The outcomes of a regional biodiversity assessment may lead to recommendations that can be implemented through an LEP or REP. Some of the matters that may be relevant include:

- establishment of ‘environment protection’ type zones, where development is prohibited or severely limited;
- restrictions on the amount of development that may occur in an area, by virtue of minimum subdivision areas or limitations on the amount and type of development that may be carried out;

- provision of vegetation corridors or requirements to reinstate nominated corridors;
- specific considerations that need to be addressed with a development application, that may relate to a particular species or group of species that are significant to a particular area.

The Biodiversity Planning Guide for Local Government (Fallding *et al.* 2001) is a valuable guide for incorporating biodiversity outcomes into both LEPs and REPs. A sample LEP is provided in Part 10 of Fallding et al. (2001), which gives an overview of the structure and organisation of an LEP and includes explanatory notes for including biodiversity planning provisions into relevant sections.

7.3.2 Regional Vegetation Management Plans

Regional Vegetation Management Plans (RVMPs) are comprehensive plans of management for a region's native vegetation. The *Native Vegetation Conservation Act 1997* (NVC Act) provides for communities to prepare RVMPs which require approval by the Minister for Land & Water Conservation. The overall aim of the plan is to develop native vegetation management that is practical, appropriate to the region and supported by the community (DLWC 1998).

Examples of management approaches in RVMP's, relevant to biodiversity include (DLWC 1998):

- assessing the amount of clearing of each vegetation community and its conservation status;
- developing regional conservation targets;
- developing a comprehensive conservation strategy to protect and enhance the full range o vegetation communities in each of the regions catchments.

DLWC (1998) has produced *The Draft Native Vegetation Handbook 1: Support Package for Regional Vegetation Committees*, which provides a useful guide to the process of preparing a RVMP. This document will assist in the implementation of the findings of the biodiversity study into RVMPs.

7.3.3 Council Management Plans

Under the Local Government Act, local government must prepare and adopt an overall Council Management Plan (CMP) which is the central management tool. From this, local government determines strategic direction and policy implementation in the short to medium term (Fallding *et al.* 2001).

The CMP process provides an opportunity for integrating biodiversity considerations within local government administrative frameworks (Fallding *et al.* 2001). CMPs are reviewed annually which provides scope for appraising achievements and identifying future actions to be undertaken and establishing targets. Biodiversity actions should be listed in the CMP along with the funding necessary to carry out these actions and allocation of responsibilities appropriately (Fallding *et al.* 2001).

Fallding *et al.* 2001 is a valuable guide for incorporating biodiversity outcomes into CMPs, particularly the sample strategies for set out in Section 10.1.

7.3.4 Management plans for natural areas

Plans of Management (POM) are developed for a range of government bodies including NPWS, Local Government, and State Forests to fulfil management obligations under specific legislation and policies. POMs applicable to biodiversity surveys include:

- State Forests POM for State Forests;
- NPWS POM for National Parks and other protected areas;
- Bushland POM for bushland managed by Local Governments.

Examples of each type of POM are provided below.

Section 10.5 of Fallding *et al.* (2001) also provides examples of biodiversity provisions that could be adapted for use in management plans for natural areas. Although this example is specific to local government, it is a useful guide for POMs outlined above.

i State Forest POM

State Forests for the Upper North East region of NSW has developed an Ecological Sustainable Forest Management Plan which contains a series of smaller management plans specific to different activities. One of the management plans is specific to the conservation management of informal reserves and areas managed by special prescriptions. Many of these areas have been identified from the creation of a comprehensive, adequate and representative (CAR) reserve system across the region. The primary function of the CAR reserve system is to ensure the conservation and protection of biodiversity and heritage values.

This POM identifies a number of strategies for management of informal reserves and areas managed by prescription. These are to manage and protect identified conservation values wile allowing other management and production activities. The main strategies are:

- permitting and excluding certain activities;
- amending boundaries of areas;
- feral animal and noxious weed management;
- protection of rare non-commercial types, high conservation value old growth forest and rainforest;
- monitoring, reporting and review.

ii Bushland POM example

Ku-ring-gai Municipal Council developed a Bushland POM as they have a substantial land management role in protecting and conserving the bushland within their open space system. The POM provides:

- an overview of Ku-ring-gai’s natural resources, cultural heritage and social values contained in open space bushland;
- highlights the basis for which bushland should be managed;
- identifies the issues which degrade open space bushland;

- accommodates the legislative requirements and the local needs of the community.

Detailed in the POM are the issues that need to be considered, the individual policies that clearly articulate the management objectives, and programs to be implemented that deal with these issues. Examples of these issues, policies and programs and how they are related are outlined in Table 7.7.

Table 7.7 Examples of environmental Issues and how they are addressed in policies and programs

Issue	Policy	Program
Weeds	Weed Management Policy	Bushland Rehabilitation Program Bushland Noxious Weed Program
Volunteers	Bushcare Volunteer Policy	Bushcare Volunteer Program
Education	Bushland Education Policy	Bushland Education Program
Vegetation linkages	Urban Tree Management Policy	Tree Preservation Order Program Tree Planting Program Street Tree Maintenance Program
Development	Development Control Plan & Council Policies	Development Control Program
Inappropriate use	Council Ordinances	Regulatory Surveillance & Enforcement Program

Source: Ku-ring-gai Council (1996)

7.3.5 Total Catchment Management

Total Catchment Management (TCM) is about coordinating community and government efforts within a catchment to ensure productive land, clean water, and a diversity of vegetation and wildlife. DLWC is the NSW Government agency with the lead role in TCM as well as a number of other community partnerships. The Department has recently established 18 Catchment Management Boards across NSW under the *Catchment Management Act 1989* and the *Catchment Management Regulation 1999*.

Each Board is required to produce a Catchment Management Plan (CMP) which will be submitted for consideration by the Minister in consultation with other Ministers involved in natural resource management. The aims of CMPs are to (DLWC 2000):

- provide focus and direction to individual and community initiatives;
- help coordinate government investment;
- contribute to the implementation of legislation such as the *Native Vegetation Conservation Act 1997* and the *Water Management Act 2000*.

7.3.6 Bush Fire Risk Management Plans

Under the NSW *Rural Fires Act 1997*, each Bush Fire Management Committee must prepare a Bush Fire Risk Management Plan. The overall aim of these plans is to achieve environmental outcomes through appropriate planning processes prior to a fire event rather than when an emergency arises. A policy on the preparation of Bush Fire Risk Management Plans is available from the NSW Rural Fire Services along with guidelines for the preparation of these plans.

One of the requirements in the plan is to develop a set of objectives, which cover the protection of environmental/ecological assets from the adverse effects of bush fires. These are defined to include both natural and cultural assets. As outlined in the guidelines, the plan should describe the environmental/ecological assets within the Committee's area and develop an understanding of the natural and cultural environment of the area. This information would then be used in the bush fire risk analysis process and to assist in developing appropriate risk management strategies. Examples of issues and possible management strategies, relevant to biodiversity are outlined in Table 7.8.

Table 7.8 Examples of environmental issues and how they are addressed by programs

Issue	Program
Bushland areas which have been burnt with a frequency or intensity that has resulted in biodiversity loss	More intensive management of ignitions and hazards in adjacent areas (appropriate to spotting potential of vegetation).
Protect fire sensitive environmental assets e.g. rainforest, fire sensitive critical habitats or threatened species sites.	More intensive management of ignitions and hazards in adjacent areas (where appropriate).
Areas with significant pest or weed invasion problems after fire.	Implement post and/or pre-fire weed/pest control programs.

Source: NSW Bush Fire Coordinating Committee (1998)

8 GLOSSARY

The Glossary defines terms, which are used in this document. The definitions are taken from the TSC Act, NVC Act and the EP&A Act unless otherwise indicated.

AEC	Animal Ethics Committees control animal research. Their role is to advise, monitor, discipline and control animal research and approve animal supply for research. They must also ensure that all research conducted in their institution or by the independent researchers they supervise, complies with the NSW *Animal Research Act 1985* and the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes*.
AMG	Australian Map Grid co-ordinates.
ARA	Australian Research Authority is a requirement for every person undertaking animal research under the NSW *Animal Research Act 1985*. The authorities are issued by either an accredited research establishment or by the Director-General of NSW Agriculture.
Biodiversity	The biological diversity of life is commonly regarded as being made up of the following 3 components: • genetic diversity – the variety of genes (or units of heredity) in any population; • Species diversity – the variety of species; • ecosystem diversity – the variety of communities or ecosystems.
Biogeographic Region	A complex land area composed of a cluster of interacting ecosystems that are repeated in similar form throughout (Thackway & Cresswell 1995).
Clearing	Clearing means any one of the following (DLWC 1999b): • cutting down, felling, thinning, logging or removing vegetation; • killing, destroying, poisoning, ringbarking, uprooting or burning vegetation; • severing, topping or lopping branches, limbs, stems or trunks of vegetation; • substantially damaging or injuring vegetation in other ways.
Conservation	Means the protection, maintenance, management, sustainable use, restoration and enhancement of the natural environment (NPWS 1997b)
Critical Habitat	Habitat declared to be critical habitat under Part 3 of the TSC Act.
DBH	Diameter of a tree at breast height
Ecological Community	An assemblage of species occupying a particular area.
Endangered Ecological Community	An ecological community specified in Part 3 of Schedule 1 of the TSC Act.
Endangered Population	A population specified in Part 2 of Schedule 1 of the TSC Act.
Endangered Species	A species specified in Part 1 of Schedule 1 of the TSC Act.
Environmental weed	Any plant that is not native to the local area that has invaded the native vegetation (DLWC 1999b)
Habitat	An area or areas occupied, or periodically or occasionally occupied by a species, population or ecological community and includes any biotic or abiotic

	components.

Hollow-bearing Tree	A tree where the base, trunk or limbs contain hollows, holes and cavities that have formed as a result of decay, injury or other damage. Such hollows may not be visible from the ground, but may be apparent from the presence of deformities such as burls, protuberances or broken limbs, or where it is apparent the head of the tree has been lost or broken off (NPWS 1999b).
Isolated trees	Isolated trees are individual or scatter small clumps of trees (1-5) that occur in a highly modified landscape (e.g. in a wheat paddock), where there are no understorey plants and the groundcover is typically comprised of non-native species. As an indication, these trees or clumps are generally spaced in excess of 100 metres apart or greater (DLWC 1999b).
Key Threatening Process	A threatening process specified in Schedule 3 of the TSC Act. Threatening process is defined as a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities.
Local population	The population that occurs within the study area, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary can be demonstrated (NPWS 1996).
Native Vegetation	Any of the following types of indigenous vegetation: trees, understorey plants, groundcover and plants occurring in a wetland (DLWC 1999b)
Nest	Includes but is not limited to, a structure built by birds, or a tree-hollow, or a site on the ground or in a cave used by birds for the purposes of the incubation and/or rearing of young. A nest also includes a site where the actual nest can not be seen or found, however there is clear evidence of breeding nearby and it is considered likely that a nest occurs nearby (ie. within 50 metres) (NPWS 1999b)
Pick	A native plant (including a threatened species, population or ecological community) means to gather, pluck, cut, pull up, destroy, poison, take, dig up, remove or injure the plant or any part of the plant (NPW Act 1974)
Population	A group of organisms, all of the same species, occupying a particular area.
Protected Areas	Any reserve that fits the IUCN criteria with its function being conservation. In NSW, this includes areas gazetted as National Parks, Nature Reserves and State Recreational Areas under the *National Parks & Wildlife Act 1974*, and those areas designated as Flora Reserves under the *Forestry Act 1916* (NPWS 1996).
Protected species	Those species defined as protected under the NPW Act. It includes all native plants and animals.
Record	Where the record pertains to fauna, includes an observation of a liver or dead individual of a species, or any parts of an individual, or a sign that indicates the species' presence. Where the record pertains to flora, includes any part of a plant including, but not limited to, roots, stems, branches, leaves, fruits, seeds and flowers (NPWS 1999b).
Recovery plan	A plan prepared an approved under Part 4 of the TSC Act
Rocky outcrop	An area where rocks or exposed boulders cover more than 70% of any 0.1 hectare area (30 metres by 30 metres); and/or areas with skeletal soils (areas with shallow soils where rocks are exposed), supporting heath or scrub (sometimes with occasional emergent trees) (NPWS 1999b).

Roost	Where the roost relates to a microchiropteran bat tree roost, it includes a tree, stag or rocky crevice where there is clear evidence that a microchiropteran bat has roosted, such as an accumulation of bat excreta or where a microchiropteran bat has been seen flying into or out. Where the roost relates to threatened owls, roost includes a site where an owl has been observed roosting (ie. Sheltering or resting during the day); and/or a site where there is clear evidence that an owl has roosted such as where there are owl pellets, remains of prey or owl ecreta (NPWS 1999b).
Sap Feed Tree	A tree with recent V-notch incisions or other incisions made by a Yellow-bellied Glider or Squirrel Glider. Recent incisions are less than two years old and not closed (NPWS 1999b)
Scientific Committee	Scientific Committee constituted under Part 8.
Scientific License	A Scientific License is required under the *National Parks & Wildlife Act 1974* to undertake scientific investigations, fauna and flora surveys or collection of wildlife for other purposes. These are issued by NPWS.
Special Purpose Permit	A permit required by Investigators to undertake biological surveys of any kind within lands controlled by State Forests of NSW, including State forests, flora reserves and timber reserves. Special Purpose Permits are issued under Section 32 of the *Forestry Act 1916* and Clauses 110-115 of the *Forestry Regulations 1983*.
Species	Of animal or plant includes any defined sub-species and taxon below a sub-species and any recognisable variant of a sub-species or taxon.
Species Impact Statement	A statement referred to in Division 2 of Part 5 of the TSC Act and includes an environmental impact statement, prepared under the EP&A Act, that contains a species impact statement.
Species presumed extinct	A species specified in Part 1 or 4 of Schedule 1 or in Schedule 2 of the TSC Act.
Stag	A standing dead and dry tree greater than 30 centimetres DBH, and greater than three metres in height (NPWS 1999b)
Threat Abatement Plan	Plan prepared and approved under Part 5 of the TSC Act.
Threatened Species	A species specified in Schedule 1 Part 1 (endangered species), Part 4 (presumed extinct) and Schedule 2 (vulnerable species) of the TSC Act.
Threatening Process	A process that threatens, or may have the capability to threaten, the survival or evolutionally development of the species, population or ecological community.
Viable local population	A population that has the capacity to live, develop and reproduce under normal conditions, unless the contrary can be conclusively demonstrated through analysis of records and references (NPWS 1996).
Vulnerable species	A species specified in Schedule 2 of the TSC Act.

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