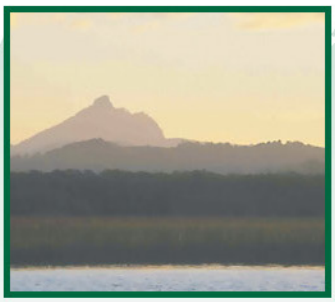

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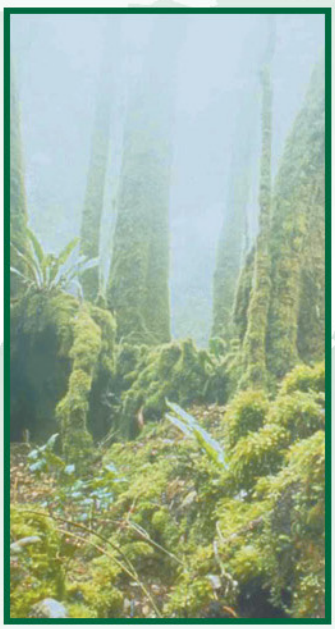

Central Eastern Rainforest Reserves of Australia: A Monitoring Strategy

Edited by Guy Chester
and Sally Bushnell

Rainforest CRC

Cooperative Research Centre for Tropical Rainforest Ecology and Management

CENTRAL EASTERN RAINFOREST RESERVES OF AUSTRALIA: A MONITORING STRATEGY

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INTRODUCTION

CERRA WORLD HERITAGE AREA

The World Heritage Central Eastern Rainforest Reserves of Australia (CERRA) represent the major remaining areas of rainforest in southeast Queensland and northeast New South Wales. They comprise National Parks, Nature Reserves and other Crown Reserves (CERRA, 2000). The property protects almost 50 individual reserves ranging in area from 11 hectares to some 103,000 hectares. These reserves extend in a discontinuous arc from Barrington Tops near Newcastle in New South Wales, to Mistake Mountains west of Brisbane in Queensland, and cover a total area of 366,514 hectares (307,284 hectares in New South Wales and 59,230 hectares in Queensland) (Hunter, 2003).

CERRA was inscribed on the World Heritage List, first in 1986 and with extensions in 1994, as a site with outstanding universal significance in terms of its natural heritage. It satisfied three of the four possible criteria for the listing of a natural property, representing outstanding examples of the major stages of Earth's evolutionary history, ongoing geological and biological processes and biological diversity.

In nominating CERRA for the World Heritage listing, the Commonwealth Government on behalf of the people of Australia accepted an obligation to ensure the identification, protection, conservation, rehabilitation and presentation of the property and its transmission to future generations. In order to fulfil this obligation, some knowledge of the state of CERRA, over time, is required. Specifically, Section 2 of the World Heritage Convention's Operational Guidelines addresses reactive monitoring and periodic reporting. Paragraph 72 of the Operational Guidelines states:

> "It is the prime responsibility of the States Parties… to put in place on-site monitoring arrangements as an integral component of day-to-day conservation and management of the sites. States Parties should do so in close collaboration with the site managers or the agency with management authority. It is necessary that every year the conditions of the property be recorded by the site manager or the agency with management authority."

With the overarching aim to assess the overall application of the World Heritage Convention, as well as to assess whether the values for which properties were inscribed on the World Heritage List are maintained over time, the Commonwealth Government was 'invited' to submit a periodic report to the World Heritage Committee every six years (paragraph 73).

The Commonwealth Government submitted a periodic report in 2003. Section 1, under *CERRA* in the property summaries, states, "the most significant factors affecting management are the identification and monitoring of values and adequate management of key pressures. In particular, the ongoing commitment to coordinated monitoring and research efforts across the property and development of systems for storage and distribution of resource data and research results is of importance" (p. 32). Thus, "priorities for future action include… Develop a strategic approach to monitoring, both as a whole of property approach and in line with respective state agency management objectives" (p. 33). Australia as a whole is committed to the monitoring of its property's World Heritage Values. Key national priorities include… "The further development and implementation of clear frameworks for monitoring World Heritage values and responding to identified pressures" (p. 28).

Therefore, the development of a monitoring strategy for the CERRA World Heritage Area is of principle importance to both CERRA and Australia. With an adequately supported and strategic monitoring program, the obligations of the World Heritage Convention may be

fulfilled, including the ability to report on CERRA's World Heritage Values in the six-yearly periodic report next due in 2009. In addition, and more specifically, the extent, quality, timeliness and relevance of the information and knowledge base of CERRA will increase, leading to more informed decision making and better management of the CERRA World Heritage Area for the maintenance of integrity of its World Heritage Values.

CERRA GEOGRAPHIC EXTENT AND REGIONS

Sites within CERRA generally fall into distinct groups, based either on geographic features or disjunctions (Hunter, 2003). The following eight groups are recognised, summarised from Hunter (2003) and updated.

Main Range Group

The Main Range Group includes Main Range National Park, parts of several Forest Reserves on the Main Range (Gilbert, Goomburra, Spicers Gap, Emu Vale, Gambubal, Teviot and Killarney), and the Wilsons Peak and Acacia Plateau sections of Koreelah National Park in New South Wales.

The predominant rainforest type is cool subtropical rainforest. Small stands of warm temperate forest are also encompassed, and a significant feature of the area is the presence of 'temperate' species in the open forests at high altitudes along the summit and western slopes.

Tweed Caldera Group

The Tweed Caldera Group includes Mount Chinghee, Border Ranges, Springbrook and Mount Warning National Parks, parts of Lamington, Wollumbin, Mebbin and Nightcap National Parks, Numinbah and Limpinwood Nature Reserves, a small section of the Palen Creek correctional facility and a Rabbit Board reserve.

This group lies wholly, or in the case of Border Ranges National Park, largely on the landforms created by the erosion of Tweed Shield Volcano. The remnant landforms of this volcano and the erosion caldera that has been carved out of the former massif are arguably the central feature of CERRA. The area is regarded as one of the two major rainforest refugia in continental Australia, the other being the Wet Tropics of northern Queensland. The area also represents a primary branch in the evolution of the Australian rainforests and has a Gondwanan ancestry.

The Focal Peak Group

The Focal Peak Group includes parts of Mount Barney National Park, Tooloom, Toonumbar, Richmond Range, Mallanganee, Mount Clunie and Mount Nothofagus National Parks, Captains Creek Nature Reserve, Burnett Creek Forest Reserve, and a number of small Rabbit Board reserves.

This group includes the rugged peaks, steep slopes and caldera valley of the central complex of the Focal Shield Volcano. The area encompasses cool subtropical rainforest, cool temperate rainforest dominated by *Nothofagus moorei* and open forest.

Coastal Group

The Coastal Group comprises Iluka Nature Reserve. The reserve is only 136 hectares in extent, thus significantly smaller than the other CERRA sites. However, it is the only CERRA site that samples littoral rainforest, which is a sub-set of the Gondwanic species that make up subtropical rainforest. This rainforest is important for providing seasonal food resources for a number of species.

Gibraltar Range Group

The Gibraltar Range Group includes parts of Washpool and Gibraltar Range National Parks.

It is a block of rugged mountain country bounded by the Great Escarpment to the east and the Demon Fault to the west. Gibraltar Range National Park is a high Plateau rising to 1200 metres and extending north into Washpool National Park as a series of high ridges and plateaux dissected by steeply inclined valleys. This group is characterised by the diversity of plant communities and the mosaic distribution of wet sclerophyll forests and rainforests. Warm temperate rainforest is the most extensive rainforest type within the area.

New England Group

The New England Group includes parts of Dorrigo, New England and Cunnawarra National Parks and Mount Hyland Nature Reserve.

Dorrigo National Park, New England National Park and Cunnawarra Nature Reserve lie on the edge of the Great Escarpment, while Mount Hyland Nature Reserve rises from the northwestern side of the Dorrigo Plateau. One of the main centres of rainforest in New South Wales at the time of European settlement, the wide altitudinal range and rugged topography of the area results in the presence of rainforest types from warm subtropical to cool temperate.

Hastings-Macleay Group

The Hastings-Macleay Group includes most of Oxley Wild Rivers and Werrikimbe National Parks, part of Willi Willi National Park, and The Castles and Mount Seaview Nature Reserves.

The sites lie on the Great Escarpment. This group includes the last remaining stands of rainforest within this area. These stands include areas of subtropical, dry, warm and temperate rainforests. The area also includes some fine stands of wet sclerophyll forest, and swamp, grassland, heath and scrub communities.

Barrington Tops Group

The Barrington Tops Group comprises parts of Barrington Tops National Park.

The site incorporates a high elevation plateau with steep dissected ridges and valley systems falling from it, with an altitude range from less than 200 metres to just under 1600 metres. The rainforests of this group have been relatively little affected by clearing. The major types present are subtropical and cool temperate, with small areas of warm temperate rainforest. The sites contain unsurpassed series of gradients between sclerophyll forests and rainforests in response to factors such as altitude, aspect, soil, rainfall and fire history.

BACKGROUND TO MONITORING STRATEGY

To ultimately improve management outcomes of CERRA, the *CERRA Strategic Overview for Management* recommends several streams of monitoring:

i. The routine monitoring of indicators to allow regular reporting on the state of CERRA World Heritage Values;

ii. The monitoring of management plans to assess their effectiveness; and

iii. Monitoring to measure the success of rehabilitation programs.

The key outcomes of this Monitoring Strategy are to meet the first of the monitoring streams outlined above. Specifically, it is a strategy for monitoring the state of the key CERRA World Heritage Values. Because the primary desired outcome of management is the long-term healthy persistence of these key values, the emphasis of this Monitoring Strategy is on outcome assessment, rather than management planning, input and processes.

The Monitoring Strategy does not replace or duplicate existing monitoring programs, it will however, pull together and extend the effectiveness of existing monitoring and research. It will follow an adaptive design that allows the specifications for monitoring to be refined over time, based on experience in implementing the program, assessing its results and feedback from users.

The Monitoring Strategy will have an initial lifespan of four years, with a review occurring in 2008 during the preparation of the CERRA input for the 2009 Periodic Report. After this, the strategy will be subject to ongoing review in an iterative process.

Objectives

The objectives of the monitoring program described by the strategy are to:

- allow the trends in the state of the CERRA World Heritage Values to be monitored over time;
- assess management effectiveness in relation to the conservation or ecological integrity of these values, and the abatement of their threats; and
- promote improved management effectiveness in CERRA through adaptive management.

METHODOLOGY AND TEAM

Scope

The intention of the Monitoring Strategy is to translate the objectives for the monitoring program into rigorous quantitative and qualitative questions, which will be used to identify:

- which attributes of the World Heritage Values can and should be monitored;
- the features of those attributes to be measured, how often and where;
- how these features are to be consistently measured; and
- how these features are clearly linked to the broader objectives, so that any change in a feature can be interpreted as an indicator of change within the context of the relevant broad questions.

Overall Approach

The priorities of the program are to identify realistic indicators, current research and survey work that is relevant to monitoring, and the 'gaps' in current research work that need to be filled to ensure that all of the indicators are being adequately measured. Any existing monitoring efforts that could achieve the objectives of the Monitoring Strategy with minimal change will be identified along with any recommended changes. Special attention will also be given to the identification of indicators required to measure the actual or potential manifestations of climate change on the CERRA World Heritage Values.

The strategy will address the issue of consistent methodologies so that measurements taken in different places or by different agencies can be combined to describe the characteristics of the attribute across CERRA. Further more, it will address the estimates of variance of the features being measured and measurement error over the relevant temporal and spatial scales so that status and trend information can be understood.

In addition, the strategy will recognise the likely barriers to implementing and carrying out an effective monitoring program. It is expected that there will be some lack of funding, time and trained personnel, possibly even a lack of political interest and support. Therefore the strategy endeavours to provide incentives and mechanisms in which these barriers can be overcome.

Acknowledgments

During the development of the CERRA Monitoring Strategy, the team liaised with a number of stakeholders including the CERRA Executive Officer; CERRA Technical and Scientific Advisory Committee (TSAC); staff of the management agencies in both New South Wales and Queensland; various researchers with activities, knowledge of and interests in CERRA; and key Rainforest CRC researchers. The team reviewed the current knowledge and monitoring programs being undertaken for CERRA, as well as the current techniques and monitoring strategies being applied to other protected areas and World Heritage Areas in order to apply the best model for the CERRA situation.

The authors would like to thank Professor Nigel Stork and Associate Professor Peter Valentine for their comments and peer review of an earlier draft.

CERRA WORLD HERITAGE VALUES

WHAT ARE THE WORLD HERITAGE VALUES?

World Heritage Values are those values directly related to the criteria for which an area is included on the World Heritage List. The CERRA was inscribed on the World Heritage List for outstanding universal values:

Natural Criterion 1 – A Record of the Past

"Outstanding examples representing the major stages of the earth's evolutionary history."

The World Heritage Values of the property related to this criterion are as follows.

CERRA World Heritage Area rainforests are an outstanding example of ecosystems and taxa from which modern biota are derived. These rainforests are exceptionally rich in primitive and relict species, many of which are similar to fossils from Gondwana.

The CERRA World Heritage Area includes an outstanding range of ecosystems and taxa, which demonstrate the origins and rise to dominance of cold-adapted/dry-adapted flora.

The CERRA preserves outstanding examples of ecosystems and taxa from which modern biota are derived, including some of the oldest elements of the world's ferns from the Carboniferous period, one of the most significant centres of survival for Araucarians, an outstanding record of Angiosperms, an outstanding number of the oldest lineages of the *Corvida* (one of the two major groups of true songbirds that evolved in the Late Cretaceous), and outstanding examples of other relict vertebrate and invertebrate fauna from ancient lineages linked to the break-up of Gondwana. World Heritage Values include:

- Rainforests, which are exceptionally rich in primitive and relict species and many of which are similar to fossils from Gondwana;
- Subtropical rainforest habitat;
- Warm temperate rainforest habitat;
- Ancient ferns and tree ferns;
- Conifers (e.g. hoop pine) and cycads;
- Primitive groups within Magnoliales and Laurales (e.g. pepper bushes, sassafras, Trimenia, Wilkiea, Cryptocarya, Litsea);
- Primitive groups within Rosidae and Dillenidae (e.g. coachwood, Antarctic Beech, *Eucryphia jinksii*, turnipwood, Pittosporum, most common in warm temperate and subtropical rainforest types);
- Primitive group of Corvida (such as lyrebirds, rufous scrub-bird, bowerbirds and tree-creepers);
- Other birds dating from Gondwana (e.g. logrunner, thornbills, scrubwrens and gerygones);
- Frogs in the families Myobatrahidae and Hylidae;
- Reptiles such as chelid turtles, leaf-tailed gecko and angle-headed dragon;
- Monotremes and marsupials; and

- Invertebrate fauna with origins in Gondwana, including fresh-water crays, land snails, velvet worms, mygalomorph spiders, flightless carabid beetles, bird-wing butterfly and glow-worms.

World Heritage Values also include ecosystems and taxa which demonstrate the origins and rise to dominance of cold-adapted/dry-adapted flora, including:

- Cool temperate rainforest habitat;
- Dry rainforest habitat; and
- Plant species in the families Myrtaceae, Casuarinaceae and Proteaceae.

Natural Criterion 2 – A Window to the Future

"Outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment."

Statements of the World Heritage Values relevant to this criterion are:

CERRA World Heritage Area includes outstanding geological features associated with the Tweed Shield, including its size, age and erosional landforms.

CERRA World Heritage Area includes significant centres of endemism where ongoing evolution of flora and fauna species is taking place.

The CERRA provides outstanding examples of ongoing geological processes associated with Tertiary volcanic activity, and of biological evolution. World Heritage Values include:

- The caldera of the Tweed Shield Volcano is considered one of the best preserved erosion caldera in the world and is notable for its size, its age (20 million years), and for the presence of a prominent central mountain mass with all three stages of the erosion of shield volcanoes (the planeze, residual and skeletal stages);
- Centres of endemism where ongoing evolution is taking place;
- Flora and fauna of low dispersal capability that occur in more than one isolated pocket of the CERRA;
- Plant taxa that show evidence of relatively recent evolution, including:
  - genera in Southern Hemisphere families (e.g. Winteraceae, Monimiaceae and Lauraceae in the Magnolidae, Proteaceae, Cunoniaceae, Euphorbiaceae, Escalloniaceae, Davidsoniaceae Pittosporaceae, Myrtaceae and Sapindaceae in the Rosidae and, Elaeocarpaceae, Sterculiaceae and Ebenaceae in the Dillenidae); and
  - monotypic endemic families (e.g. Akaniaceae and Petermanniaceae);
- Animal taxa that show evidence of relatively recent evolution, including:
  - three species of frogs in the myobatrachid genus Pseudophyrne believed to have diverged in the Pliocene;
  - species of frogs in the relict genus *Philoria* (also known as *Kyarranus*) and the *Litoria pearsoniana*/ *L. phyllochroa* complex;
  - reptiles such as *Eulamprus* spp.; and
  - invertebrates such as snails, earthworms, crays, velvet worms and carabid beetles, including taxa that show overlap and intergradation of different faunal elements (e.g. ants and dung beetles).

Criterion 4 – Hotspots of Biodiversity

"Contain the most important and significant habitats where threatened species of plants and animals of outstanding universal value from the point of view of science and conservation still survive."

The World Heritage Value relevant to this criterion is:

CERRA World Heritage Area includes the principal habitats of a large number of threatened species of plants and animals. These species are of outstanding universal value from the point of view of science and conservation, including relict and primitive taxa.

The ecosystems of the CERRA contain significant and important natural habitats species of conservation significance, particularly associated with rainforest which once covered much of the continent of Australia and is now restricted to archipelagos of small areas of rainforest isolated largely by sclerophyll vegetation and cleared land. The World Heritage Values include:

- Habitats associated with:
  - subtropical rainforest;
  - wet sclerophyll forest;
  - montane heathlands;
  - rocky outcrops; and
  - ecotones between rainforest and sclerophyll communities;
- Plant taxa of conservation significance (more than 200 plant taxa, particularly in the families Proteaceae, Myrtaceae and Euphorbiaceae and including species of *Cryptocarya*, *Tasmannia* and *Endiandra*);
- Species of vertebrate fauna of conservation significance (including at least 80 taxa such as Albert's lyrebird, rufous scrub-bird, marbled frogmouth, eastern bristlebird, black-breasted button quail, *Philoria* spp., pouched frog, barred frogs, parma wallaby, yellow-bellied glider, Hastings River mouse, New Holland mouse, fawn-footed melomys and golden-tipped bat); and
- Species of invertebrate fauna of conservation significance (such as the Richmond River bird-wing butterfly and *Euastacus jagara*).

- The diversity of plant and animal species.

OTHER VALUES

(Summarised from the *CERRA Strategic Overview for Management*, pages 15-18).

Natural Heritage

The rainforests are central to the World Heritage Listing of CERRA. This is the theme that unites the reserves, however CERRA also protects large areas of other vegetation. It contains a diverse range of heaths, as well as eucalypt-dominated forest and woodland over a range of soil types and climates. These communities have a high diversity of plants and animals that add greatly the value of CERRA as a habitat for endemic or rare and threatened species. The complex dynamics between rainforest and tall open forest, which often has a rainforest understorey, belies the close evolutionary and ecological links between these communities.

Cultural Heritage

There are several important archeological sites that date Aboriginal occupation of the area to at least 9000 years. There are also a large number of sites of religious significance, many of which are associated with or include natural features in the landscape, blurring the distinction between the natural and cultural. CERRA also contains some evidence of European settlement of the region in the form of settlement ruins, mine races, tramways, tracks and cemeteries.

Recreation

Most of the reserves in CERRA are located along the Great Escarpment behind the coastal plains, forming the mountain backdrop to a rapidly growing residential and tourist population. Because of their intrinsic beauty, natural features and accessibility from the major population centres, CERRA has high recreational values. With a wide range of recreational opportunities, an estimated 2 million visitors come annually to CERRA.

Wilderness

Formal recognition through the provisions of the New South Wales Wilderness Act has been given to several wilderness areas in CERRA. Unroaded and largely free of exotic species, they are rare examples of the indigenous Australian landscape.

Economic

The regional economy surrounding CERRA was previously based on the timber, pastoral and dairying industries; it is now increasingly supported by specialist horticulture and tourism. The national parks and reserves of CERRA have considerable economic value and can contribute directly and indirectly to the employment, income and output of the regional economy.

Research and Education

The variety of ecological communities and landscapes makes CERRA ideal for research and educational visits. Information arising from the scientific research conducted to date in CERRA supported the World Heritage nomination. In fact, the current state of knowledge about the CERRA World Heritage values is directly related to the levels of research undertaken.

Scenic and Aesthetic

CERRA includes some of the most dramatic scenery in Australia, with landscapes dominated by striking vertical cliffs and precipitous waterfalls. CERRA offers outstanding vistas: from uninterrupted views of forested wilderness covered by natural vegetation to the contrasts of steep forested slopes surrounding cleared valleys. The mosaic of rainforest and eucalypt forest adds to the complexity of colour and texture in the scenery.

Bequest, Inspiration and Existence

One of the goals of World Heritage management is to transmit areas so that future generations can experience and appreciate their uniqueness. This goal explicitly recognises an area's bequest values. The wild and rugged landscapes, diverse flora and fauna, and opportunities for solitude and quiet reflection are attributes that promote inspiration, serenity and rejuvenation of the human mind and spirit.

Water Catchment

CERRA is the source of a number of river systems, this area abounds in wild and scenic rivers. CERRA also protects the catchment areas for a number of water storage facilities, assuring water quality by their large areas of undisturbed forests.

THREATS TO AND INTEGRITY OF VALUES

THREATS TO WORLD HERITAGE VALUES

Like many protected areas, CERRA faces a range of threats to its immediate and long-term integrity. These threats vary greatly in scale from incompatible land use on an adjoining property to pest species invasion through to global climate change.

All existing plans of management (draft or adopted) and management strategies for CERRA parks and reserves were reviewed to identify specific threats to their values, along with the recovery and/or action plans for threatened species known to occur in CERRA. Other documents reviewed in identifying the threats to the CERRA values included CERRA (2000) and Hunter (2003).

The existing threats to World Heritage and associative values include:

- Inappropriate fire regimes – rainforest species and vegetation are generally fire sensitive, but rainforest often abuts fire prone vegetation or is embedded in a landscape that is susceptible to fire events. Inappropriate fire regime for Eucalyptus dominated communities (in terms of frequency, intensity and seasonality of burning) may affect their constituent species. Therefore fire management must be crafted to suit both the individual rainforest patch and the ecology of the surrounding landscapes. For all or at least most of the parks and reserves of CERRA, wildfire and an inappropriate fire regime constitute major threats therefore developing an appropriate fire regime is an issue of importance in all existing management plans. The threat of wildfire is also a major issue to both fauna and flora. Wildfire has the potential to kill a local population directly, and indirectly, including through lack of fire and the consequential loss of suitable habitat, among other affects.

- Exotic species – pest plant species which are significant because of the extent of their distribution within rainforest or because of the severity of their impact include species such as madeira vine (*Anredera cordifolia*), cat's claw climber (*Macfadyena unguis-cati*), balloon vine (*Cardiospermum grandiflorum*), asparagus vines (*Asparagus* spp.), camphor laurel (*Cinnamomum camphora*), privets (*Ligustrum* spp.), bitou bush (*Chrysanthemoides monilifera*), lantana (*Lantana camara*), mistflower (*Ageratina riparia*) and crofton weed (*A. adenophora*). In the more open communities, broom (*Genista* spp.), lantana (*Lantana camara*) and blackberry (*Rubus fruticosus*) are also pests. Exotic plants are a major threat through competition with native flora. Adverse impacts include a loss of habitat or food for native fauna.

  Pest animal species of concern include feral pigs (*Sus scrofa*), foxes (*Vulpes vulpes*), feral cats (*Felis cattus*), feral goats (*Capra hircus*) and feral horses (*Equus caballus*). The impact of the feral honeybee on the reproductive ecology of rainforest plants requires further investigation. Feral animals impact on native fauna through either predation on the species (the red fox being a good example) or through competition with the species. Feral animals are also a major threat to many species of flora where grazing or browsing in particular is ongoing.

  The presence of exotic species is an issue in all management plans, however the severity of the threat varies. Some reserves have ongoing pest control problems whereas the interior of other parks and reserves still remain intact.

- Dieback of vegetation associated with *Phytophthora cinnamomi* or Christmas beetle attack or psylid action associated with increasing numbers of bell miners (known as bell miner associated dieback).

  Bell miner associated dieback has primarily been listed as a potential threat, if at all, in the management plans. However it has recently emerged that it is now a major threat in some local areas and therefore a major management issue. State forests of New South Wales have undertaken mapping of the extent of dieback, and management strategies are being researched. A *Bell Miner Associated Dieback Strategy* was produced in 2004.

- Disruption to gene flow or changes in the pattern of gene flow in plants and animals as a result of forest fragmentation and previous clearing.

  The historical threat of clearing and the ongoing related threats, including fragmentation, were major issues in most recovery or action plans for most species, both flora and fauna. In many cases these threats were the primary or even sole reason for the listing of the species as threatened. The ongoing repercussions are serious even though clearing in CERRA is unlikely to occur in the future.

- Decline in populations of native frogs as a result of fungal pathogens and possibly exacerbated by air-borne pollutants, climate change and increased ultraviolet radiation.

- Localised damage due to increased visitation at some sites.

  Visitation as a threat and a potential threat is a major theme across most of the parks and reserves in CERRA. A number of sites in CERRA are subject to ongoing high visitation levels, and other less used sites are experiencing growing numbers of visitors correlated with the growing cities nearby. Visitation is a potential threat to a select number of animals, particularly those that nest on ground level, such as the Eastern Bristle-bird, where they can be easily disrupted.

- Straying stock – cattle (*Bos taurus*) pose a problem in some parts of CERRA.

Potential threats, as described by Hunter (2003, p. 36) include:

- Clearing of vegetation (though this is unlikely within the CERRA boundaries);
- Introduction of new exotic plants and animals or spread of existing feral species;
- Introduction of new plant or animal pathogens;
- Species loss and re-assemblages due to rapid climate changes precipitated by human impacts on planetary processes;
- Increased visitation and associated infrastructure; and
- Off site activities such as clearing and erosion within upstream catchments.

INTEGRITY

As discussed above, CERRA meets three of the four criteria for listing as a natural property on the World Heritage List. In addition, CERRA must meet several conditions of integrity, as stated in the Operational Guidelines for the Implementation of the World Heritage Convention (paragraph 44b).

The conditions of integrity that are relevant to CERRA are:

- **The sites should contain all or most of the key interrelated elements in their natural relationships.**

  CERRA does contain most of the key interrelated elements (attributes) that together constitute the World Heritage Values related to this criterion. The sizes of the ecosystems in which these attributes occur are generally sufficient to ensure that they are not threatened as a whole. However there are other areas beyond the property, the addition of which would improve the integrity of the property by including a more complete expression of the attributes (Hunter, 2003, p. 35).

- **The sites shall have sufficient size and contain the necessary elements to demonstrate the key aspects of the processes that are essential for the long-term conservation of the ecosystems and the biological diversity that they contain.**

  The property contains major portions of the sites of geological value including the most significant geological features associated with the landform. The addition of some neighbouring sites to CERRA would increase the integrity of the Tweed Shield Volcano remnants, and would add an additional section of the volcanic landform of Ebor Volcano linking the two listed areas. In relation to important biomes, the property contains the major occurrences of significant rainforest types within the region, and the property conserves the most important floristic elements. With respect to ongoing evolution, the legislative protection afforded to the property ensures the continuance of natural biological processes (Hunter, 2003, p. 46).

- **The sites should contain habitats for maintaining the most diverse flora and fauna characteristic of the biographic province and ecosystems under consideration.**

  CERRA contains the largest and most significant remaining areas of subtropical rainforest, the largest remaining area of littoral rainforest in the region, the largest and most significant areas of warm temperate rainforest and nearly all areas of cool temperate rainforest of the north Hunter River. It is a stronghold for the flora and fauna associated with these rainforests and the adjoining *Eucalyptus*-dominated vegetation. It is of sufficient size to maintain viable populations of most of the significant species found within the property. While the disjunct nature of the property makes areas susceptible to impact from factors such as fire and weed invasion, it continues to meet the requirements of integrity for this criterion, but it would benefit from additions to minimise edge effects (Hunter, 2003, p. 56).

- **The sites should be covered by a management plan.**

  A number of reserves are covered by a management plan, however this totals less than half. None of the Queensland reserves are covered by a management plan or strategy. Currently, 14 draft management plans and/or strategies are being developed covering most of the chief reserves. With the approval and implementation of these draft management plans, along with those already adopted, this condition of integrity may be

met. However, those reserves remaining without a management plan or strategy must be considered and appropriate action taken.

- **The sites should have adequate long-term legislative, regulatory, institutional or traditional protection.**

  Given that the vast majority of CERRA is within National Parks, it can be concluded that the World Heritage Area has adequate long-term legislative and regulatory protection.

- **The sites should be the most important sites for the conservation of biological diversity.**

  The boundaries of the site reflect the spatial requirements of habitats, species or processes or phenomena that provide the basis for its nomination for inscription on the World Heritage List. The boundaries include sufficient areas immediately adjacent to the area of outstanding universal value in order to protect the site's heritage values from direct effects of human encroachment and impacts of resource use outside of the nominated area.

CURRENT RESEARCH AND MONITORING

RESEARCH VERSUS MONITORING

Definition of *Research*

Webster's Revised Unabridged Dictionary, 1996, 1998: "Diligent inquiry or examination in seeking facts or principles; laborious or continued search after truth."

Definition of *Monitor*

Webster's Ninth New Collegiate Dictionary 1990: "To watch, observe, or check, especially for a purpose."

"Monitoring is a management activity not a scientific research activity… Monitoring can generate much data that could be used for scientific purposes but it needs to be focused on the original management objectives" (Crome, 1995).

CERRA Application of Monitoring

Research ultimately seeks to discover new information about a poorly understood subject or situation. It seeks 'facts or principles' and is a 'search after truth'. Monitoring 'watch(es), observe(s) or check(s)' a subject or situation of interest. This implies that information is already available in which data gained from monitoring can be compared to. Through this comparison, any deviations from the pre-existing information are detected and can be quantified, paving the way for appropriate action.

In essence, it is suggested that for the CERRA Monitoring Strategy, monitoring should be considered to be a measurement of indicators (with appropriate spatial, temporal and replication/sample design parameters) such that trends of change over time can be detected. It is recognised that in some instances monitoring will be a snapshot (i.e. current population of a species in a reserve), however it is recommended that this 'research' only be applied as part of the monitoring framework where the methodology allows repetition in other locations or at future time in a quantitative way to potentially detect change.

In relating this to the World Heritage Values of an established World Heritage Area, monitoring is most appropriate as most of the values and significant information pertaining to these values have already been identified in order to be nominated for inclusion on the World Heritage List. Therefore the values, through indicators, must be 'watch(ed), observe(d)… (and) check(ed)' to ensure that they retain their integrity. The 'seeking' of values that have not been identified to date should be done so through provisions for research, and where relevant the identified value should be incorporated in the monitoring program to also ensure the maintenance of its integrity.

One important point needs to be made about this distinction of research and monitoring. It is often hard to get funded research institutions and programs to undertake routine monitoring, graduate level students (masters and doctoral) often provide a significant resource for research, but usually are not able to be applied to long term monitoring as their work needs to be new and innovative (and not just applying previous methods at existing sites!). As such it needs to be recognised that monitoring is likely to need to be uniquely resourced.

RESEARCH

This section summarises both the current research and the current monitoring situation of the CERRA World Heritage Area using the best available information at the time of writing.

A wide range of research areas have been applied throughout CERRA from biological and genetics research to fire and weed management through to cultural studies. Major themes across the property include ecology and genetics.

Particularly in Queensland, ecological studies have included a number of species, noteworthy species including Albert's lyrebird, the Eastern bristlebird and the endangered plant species *Lepidium peregrinuim*. Ecological studies in New South Wales have included *Nothofagus*, which is recognised as a World Heritage Value. However the majority of ecological research in New South Wales has been undertaken in relation to post-disturbance responses of flora and fauna such as post-fire recruitment or recovery.

Genetics research has also included *Nothofagus*, in both New South Wales and Queensland, and the Eastern bristlebird, specifically the genetic structures and composition of Nothofagus populations, and a genetic analysis of Eastern bristlebird populations. Other endangered or vulnerable species such as *Fontainea australis* and *Grevillea rhizomatosa* have also been targeted by genetics research.

There have also been a number of inventories undertaken ranging from inventories of regions through to selected orders of species such as Coleoptera. In addition, there have been extensive surveys undertaken through the North East Forests Biodiversity Survey, the Upper North East New South Wales assessment, the Interim Assessment Process of the region's forests, and the Comprehensive Regional Assessment. However despite this work, there is a recognised lack of inventory data on both flora and fauna. As an additional point, ecological data has also been identified as lacking (Hunter, 2003).

Other particularly noteworthy studies include the investigation of the distribution and life history of *Mixophyes* spp., and a biogeographic analysis of wet forest lizards and frogs within both southeast Queensland and northeast New South Wales. An example of current research includes targeting the decline of frogs involving the development of a model based on age-class structure, the end result being a life table in which a standard method can be used to predict frog populations. There is also a research plot in Border Ranges National Park, which provides a good example for studying succession free from human disturbance, however it is overdue for follow-up measurement.

MONITORING

Monitoring primarily covers a wide range of flora and fauna populations, including both rare and valued native species as well as pest species, and a range of human induced impacts, predominantly being visitation. Much of this monitoring is not ongoing, being to establish a baseline, investigate a situation or part of once-off student projects. The following discussion of current monitoring will therefore only consider activities ongoing and those that are relevant to the monitoring strategy based on information provided and research within a limited timeframe.

A significant number of monitoring activities are undertaken within the context of various plans such as, recovery plans and threat abatement plans and (fire/weed) management plans. These monitoring activities include the endangered Hastings River mouse, threatened stream frogs of southeast Queensland, and the threatened species required to be monitored as part of the targeted control of foxes carried out under the fox threat abatement plan, including the Broad-toothed rat, Albert's lyrebird, Rufous bettong, Brush-tailed rock wallaby and Bellinger River emydura. The Rufous scrub-bird is also currently subject to a relatively intensive six-year monitoring program, and the endangered Eastern bristlebird as well as its habitat are monitored at least once a year. Other species subject to relevant monitoring programs include the Spotted-tailed quoll and *Mixophyes* spp. (one of the stream frogs), which are currently monitored across CERRA.

To monitor visitation, a new program, the Visitor Data System (VDS), is being developed. The VDS has two components, monitoring visitor numbers in various reserves through traffic and pedestrian counters, and monitoring visitor satisfaction through visitor surveys. The VDS has not currently been implemented, however there are a number of traffic and pedestrian counters in operation, particularly in New South Wales. In addition to the VDS, there is monitoring of lookouts, walking tracks and other nodes of high activity, however this is uncoordinated across the CERRA region. Across the Scenic Rim National Parks in Queensland, monitoring of bush campsites has been ongoing for many years.

Current monitoring programs are lacking, and it can be noted in particular that monitoring of plant species is absent from the discussion so far. There has been monitoring of some plant species such as *Elaeocarpus* spp., *Uromyrtus australis* and *Isoglossa eranthemoides*, however this does not occur at present. It may be possible that these projects and other past activities including both flora and fauna could be picked up again and incorporated into the Monitoring Strategy.

RESEARCH AND MONITORING PROVISIONS OF SPECIES AND RESERVE MANAGEMENT PLANS

Tables 2 and 3 in Appendix One present the research and monitoring provisions of the various species and reserve management plans for the CERRA area, as well as other relevant activities obtained from other available sources.

Note, these tables have been compiled from various sources and following contact with numerous informants, some comments on an earlier draft of this report have raised questions as to some minor aspects, wherever possible these have been resolved and updated, however the tables should be treated as a guide, the authors cannot confirm complete accuracy of the information.

It is worthwhile to note that most plans of management:

- aim to encourage scientific research programs that contribute to the understanding and management of the park's or reserve's values, or to managing and reducing the impacts of threats on these (such as pest species and fire);
- note that the implementation of recovery plans will be a priority; and
- recommend improved liaison with universities to ensure that priority topics are covered.

PROPOSED MONITORING APPROACH FOR CERRA

INTRODUCTION

There is a range of approaches to monitoring used for various applications relevant to the monitoring of the state of conservation of the CERRA World Heritage Values.

In seeking guidance to the interpretation of concepts such as 'World Heritage Values' and 'integrity' as it relates to the Monitoring Strategy for CERRA, the Convention on World Heritage was consulted. The preamble to the *Convention For The Protection Of The World Cultural And Natural Heritage* states, "…the cultural heritage and the natural heritage are increasingly threatened with destruction not only by the traditional causes of decay, but also by changing social and economic conditions which aggravate the situation with even more formidable phenomena of damage or destruction, considering that deterioration or disappearance of any item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the world."

CERRA management agencies are charged with preserving the integrity of the World Heritage values of the property, as discussed earlier.

Appendix Two sets out a range of monitoring programs used in other World Heritage areas or other protected areas, and provides a summary of the approach and indicators used. The approaches evaluated include:

- Evaluating Effectiveness;
- The Enhancing Our Heritage Toolkit Book 2;
- Pressure State Response;
- The five S Framework for Site Conservation;
- Integrity Statements;
- Wet Tropics World Heritage Area examples;
- Tasmanian World Heritage Area examples;
- State of the Parks in NSW; and
- Ecologically Sustainable Forest Management.

Our development of this Monitoring Strategy considered these approaches and attempted to adopt those aspects that are relevant to CERRA and the brief for this Monitoring Strategy.

OVERALL APPROACH

Focus on Integrity

The fundamental approach of this Monitoring Strategy is a focus on the integrity of World Heritage Values, relating to the conditions of integrity in the Operational Guidelines for the Implementation of the World Heritage Convention. The Operational Guidelines do provide a framework and most importantly they move the emphasis from specific values toward the integrity of a World Heritage property that contains those values. This leads to the integrity of ecosystem processes and functions. If ecosystem integrity is high, the condition of World Heritage Values and the integrity of the property, in all probability, will be conserved in viable functioning ecosystems.

Therefore, the key is not to monitor all values, which would require a quantified definition of all the 'values' and lead to monitoring each and every value throughout its full range, in order to "allow the trends in the state of CERRA's World Heritage values to be monitored over time" (p. 7). This is unrealistic. Rather, a monitoring program has been developed to determine the ongoing integrity of ecosystem processes, in this instance meaningful results can be obtained in a somewhat efficient and cost effective manner. Some monitoring of ecosystem processes will use indicators that include some species that are World Heritage Values. Some other key values may/should be identified, which may not be indicators for specified ecological processes, but are of significant interest in themselves.

Application of Monitoring Models

The approach set out in this Monitoring Strategy does not wholly adopt any one of the models described earlier in this Strategy, rather the Strategy adopts aspects of a few and is largely consistent with most of the approaches (given the focus on integrity of values):

- The **World Heritage Convention and Operational Guidelines** have been adopted in two ways. Firstly, the framework of Protection, Conservation, Rehabilitation and Presentation has been used as a framework for consideration of indicators. Secondly the paradigm of the integrity of World Heritage Values (and the underlying conditions of integrity for each criterion) form a fundamental basis for the Monitoring Strategy.

- The **Evaluating Effectiveness** model has been applied to some extent although not with too great a focus, owing to its main focus being the effectiveness of management (not ecological integrity). However, the associated **Enhancing Our Heritage Toolkit** provides a valuable framework for the Biodiversity Health Assessment and Threats.

- The **Biodiversity Health** assessment approach goes further than the indicators of this Monitoring Strategy in terms of attempting to set up a framework for monitoring aspects of ecosystem processes such as seed dispersal, minimum dynamic area (in relation to fires disturbance). Application of these approaches would require fundamental knowledge and research of the ecology of the area that is not considered available for CERRA at this stage (certainly not in any integrated form that was identified during the development of this Monitoring Strategy).

  The approach to identifying threats as stressors has been applied loosely (the focus being on immediate threats to biodiversity in terms of threatening processes to identified world heritage values or overall ecological processes rather than any focus on social, cultural, political and demographic trends and stressors).

- The **Pressure State Response** model is considered quite relevant and has formed a major influence on the selection of indicators for this Monitoring Strategy. However it has not been applied strictly as there are mostly not indicators for pressure, state and response for any aspect. Generally indicators chosen have addressed the state (e.g. species abundance) and in some case addressed the pressure. There are few indicators relating to responses (which is considered appropriate given the fundamental focus is to "allow trends in the state of CERRA's World Heritage values to be monitored over time").

- The **Five-S** approach has not been applied in this Monitoring Strategy, as its focus does not meet the specific aims of the Monitoring Strategy.

- The NSW State of the Parks (**SoP Reporting**) reporting and the **Ecologically Sustainable Forest Management** have been adopted as major components of the Monitoring Strategy with many indicators for both also being adopted.

- Two approaches for the Wet Tropics World Heritage Area, and one for Tasmanian World Heritage Areas have been reviewed and their approaches incorporated into the Monitoring Strategy.

Integrity of Values Versus Management Effectiveness

As stated above the focus is on monitoring the integrity of World Heritage Values. Having said this, there are important aspects of management that have a focus on the protection, conservation, rehabilitation and presentation of World Heritage Values. As such this Monitoring Strategy is in no way comprehensive in identifying management effectiveness indicators, rather some overall and a few specific management indicators have been included.

SELECTION OF MONITORING INDICATORS

Indicators have been based on the objectives for the Monitoring Strategy specified on page 4 of this report. The key approach to selecting indicators has been to:

- provide evidence of the integrity of ecological processes of CERRA (i.e. we need to define the key ecosystem processes and have indicators for them);
- provide quantification of the state of specific indicators or key values (allowing trends, spatial and/or temporal to be assessed); and
- quantify abatement of threats and potentially identify new threats before they affect the integrity.

The following criteria have been applied as filters to determine the efficacy of a particular indicator, in that indicators should be:

- related to the conditions of the state of integrity of World Heritage Values, related to threats to this integrity, or to the effectiveness of management;
- capable of showing trends over time;
- predictive, to determine change before catastrophic or irreversible change has occurred;
- scientifically credible and statistically robust;
- sensitive to change, i.e. capable of providing early warning of potential threats;
- able to permit assessment of cumulative impacts; and
- cost effective to collect and interpret.

For each of the above indicators we have offered a rating (based on the best available knowledge about the indicator). The rating ranges from 0 (zero) (does not meet criteria), 1 (unsure), 2 (reasonably meets criteria), to 3 (fully meets criteria). The ratings were then averaged and expressed as an overall rating (as a percentage of total available scores). The rating is of course subjective and only provides a guide. In general, those indicators rating greater than 60 have been considered *essential*, with those over 45 considered *desirable* and those under 45 considered *worthwhile*. Many indicators that simply do not meet a majority of the above indicators were considered, then rejected and are not presented in the table at all.

As such, indicators have been assigned one of three levels of priority:

1. Essential;
2. Desirable; or
3. Worthwhile.

Essential Indicators

Those indicators for which are required to meet the objective of "allow the trends in the state of CERRA's World Heritage values to be monitored over time". As such the suite of essential indicators as a whole address both actual values (e.g. species, monitored in its own right as a value and as an indicator of functioning ecosystem processes) and some of the fundamental ecological processes such that if all are monitored, a good understanding of trends in the integrity of world heritage values can be monitored.

Recognising other objectives for the Monitoring Strategy address abatement of threats to the integrity of values and improved management effectiveness in CERRA through adaptive management, a small suite of indicators have been identified as *essential*, which address threat abatement and management.

Analysis of essential indicators has been both 'top down' and 'bottom up', of many potential indicators each was evaluated against the above criteria and rated, then the whole suit of indicators was considered to ensure a coverage of the range of aspects required to understand the integrity of World Heritage Values. On this basis essential indicators are included as they are an important component of the suite of indicators needed to understand the state of the integrity of World Heritage Values and because the individual indicator meets the filter criteria. As such it is inappropriate to rank the indicators within this essential group, leave any out and an aspect of the integrity of World Heritage Values will not be assessed and potentially the objectives not met.

Desirable Indicators

Those indicators that would add a depth of understanding to the integrity of World Heritage Values, threats or management effectiveness (but are not considered essential above) have been included as desirable.

Worthwhile Indicators

Those indicators that would provide interesting information have been included as worthwhile.

Drivers of Indicator Identification

There have been a number of drivers for indicator identification (for each to be assessed as per above):

1. Required and/or being undertaken as part of a species recovery, threat abatement or park management plan;
2. Indicators already being measured (such as the New South Wales Fox Threat Abatement Plan (Fox TAP), State of the Parks and the Ecologically Sustainable Forest Management).
3. Aspects that relate to World Heritage Values, their integrity, ecosystem process and management.

As such, where an indicator is already being measured, it has been adopted first before new indicators have been developed.

MANAGEMENT APPLICATION

Indicators that are presently being monitored or for which there is baseline data or current research have been identified as such. Whilst this has not provided a fundamental reason for inclusion (many State of the Parks indicators are not proposed, and many indicators which are not monitored in Queensland have not been included) it does provide a guide to what can be implemented immediately.

Originally, we were asked to identify indicators on the following basis:

Priority A indicators should be those that are currently part of existing programs in either State AND relevant to monitoring the state of conservation and integrity of World Heritage Values OR relevant to monitoring the management effectiveness of dealing with the threats to their integrity. These can be taken from State of the Parks in New South Wales or from adopted or draft recovery plans (recognising in the latter that there may be some refinement). These are current agency priorities and presumably fully funded. If you believe that any of these indicators need changing (in terms of temporal or spatial coverage), please recommend this.

Priority B indicators should be those that you believe are necessary or desirable to achieve the objectives of the monitoring program described by the strategy as given on page 6 of the current draft. These indicators should be ranked in terms of importance (i.e. those needed to convert our mini-moke into a Holden should be listed first - those to make it into a Rolls Royce should be right at the bottom).

To some extent we have rejected this approach – we have identified Essential Indicators which are not presently monitored but which we believe are necessary to monitor to achieve the objectives of this study. We have not just made priorities on what is currently undertaken but rather identified indicators which, when derived from first principles, appear to meet the objectives. Our gap analysis identifies the Essential Indicators, which are not currently being monitored.

Statistical Power

A vital aspect in any experimental design is to ensure that the power of the experiment provides sufficient power to avoid Type 1 and Type 2 statistical errors. A Type 1 error is a false negative for the researcher's theory, and a Type 2 error constitutes a false positive.

With monitoring over large areas such as CERRA, the experimental design has many variables that can make design of a monitoring program with the power to actually detect change somewhat challenging. Statistical power is the probability of obtaining statistical significance in results of an experiment when the predicted effects (the hypothesis) are correct.

Increasing the statistical power of experimental designs often raises concerns that the designs, although powerful, might not be scientifically defensible. Likewise, the practicality of more ambitious, complex designs can become unfeasible given the logistical constraints, which can lower power to the point where the experiment will have little chance of success. In the case of CERRA, it will be necessary to ensure that sample size (in terms if the number of control and effect sites, area of plots), repetition (how many times one site is measured), replication (how many replicates at a site), effort (in the case of effort sensitive design such as spotlight transects etc.), accuracy and calibration of measurement are taken into account and evaluated in determining the measures of indicators at commencement and during the monitoring program to review the efficacy of the measure/indicator. The key to this is to understand both within site and among site variation, combined with a rigorous (but often

qualitative assessment) of the repeatability of sampling (given a long term monitoring program).

It is important to note that the development of this Monitoring Strategy has not involved any comprehensive the review of results of monitoring and research and has certainly not involved any form of power analysis. Further it is important to state that the inclusion of an indicator as Essential in this Monitoring Strategy does not endorse the experimental design, nor statistical analysis of any existing monitoring and research related to that indicator.

Power analysis, should be performed on results such that consideration can be given to what effect size will be able to be detected with the design and therefore whether a particular design will detect change among sites or within sites over time.

Lastly, consideration should be given to control sites to detect any change attributable to predictable confounding influences (e.g. fire, drought etc.). In a long term monitoring program, even the most powerful design can be useless when sites compared over time have other confounding affects upon them. In this case it is necessary to ensure control sites can detect that a site has had a confounding influence (and thus a data set is rejected for that time period), or that sample designs are over long time periods where the trend is not confounded by such influences.

To avoid any doubt it may be necessary to collect data other than the primary measure in order to be able to consider confounding affects (such as rainfall to detect drought, review of fire history etc.).

SPATIAL APPROACH

As far as possible the spatial approach to the identification of indicators, is to cover the whole of CERRA, or for specific values the geographic spread of the range or distribution of the species/value/aspect in CERRA.

MONITORING COORDINATION

It is vital that the implementation of this Monitoring Strategy be coordinated. Whilst many of the monitoring indicators that have been identified are already monitored as part of an existing program, many are not. Further, for many indicators that are monitored, they need the spatial application extended to provide consistent coverage across all of CERRA (for instance the State of the Parks Reporting in New South Wales indicators that are ‘adopted’ by this strategy should be monitored for Queensland Parks). Additionally, many indicators need a research program to be undertaken to prove up sites, methods and application, before they are established a routine monitoring approaches.

It is suggested that a CERRA ‘World Heritage Integrity Officer’ be resourced in some way. It is anticipated that this position would not carry out actual monitoring, but rather coordinate the establishment of additional monitoring and the collation of all results on a periodic basis.

INDICATOR IDENTIFICATION AND EVALUATION

Table 1 presents the Monitoring Indicators that have been identified and evaluated for the CERRA World Heritage Area. Indicators that have rated less than *Worthwhile* have been omitted from the table.

Table 1: Proposed Monitoring Indicators for the CERRA World Heritage Area.

PROTECTION																						
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
STATUTORY PROTECTION	Legal Framework: The extent to which the legal framework (laws, regulations, guidelines) supports the conservation and protection of the CERRA WHA	Essential	3	3	3	1	1	1	1	0	3	3	63	Reserve-State-Whole-of-CERRA	6 years	Qualitative	Periodic Report	Periodic Report; ~SoP-(Quan) (NSW)	Periodic Report; ESFM;	Periodic Report; ESFM;	Periodic Report; ESFM;	Periodic Report; ESFM;	Periodic Report; ESFM;	Periodic Report; ESFM; ~SoP-(Quan)
	Percent Area of CERRA in IUCN Catergory I or II Protected Area	Essential	3	3	3	1	0	1	3	1	3	3	70	Reserve-State-Whole-of-CERRA	6 years	Quantitative		SoP- % Wilder-ness (Quan) (NSW)						SoP- % Wilder-ness (Quan)
MANAGEMENT PLANS	CERRA WHA Strategic Plan Adopted	Essential	3	3	3	1	1	1	3	0	3	3	70	Reserve and Whole-of-CERRA	6 years	Quantitative	Periodic Report	Periodic Report	Periodic Report	Periodic Report	Periodic Report	Periodic Report	Periodic Report	Periodic Report
	Indexs for Strategic Plan implementation	Desirable	2	3	3	0	0	1	1	0	2	2	47	Reserve and Whole-of-CERRA	6 years	Qualitative: Need to determine an index								
	Number of Reserves with Adopted Management Plans	Essential	3	3	3	1	0	1	1	2	3	3	67	Reserve and Whole-of-CERRA	6 years	Quantitative	Periodic Report	Periodic Report; SoP (Qual) (NSW)	Periodic Report; SoP (Qual)	Periodic Report; SoP (Qual)	Periodic Report; SoP (Qual)	Periodic Report; SoP (Qual)	Periodic Report; SoP (Qual)	Periodic Report; SoP (Qual)

P R O T E C T I O N (cont'd)

Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
MANAGEMENT PLANTS	Index for each Management Plan implementation	Desirable	1	2	3	1	0	1	1	1	2	2	47	Reserve and Whole-of-CERRA	6 years	Qualitative: Need to determine an index								
INSTITUTIONAL ARRANGEMENTS	The extent to which institutional arrangements between QLD, NSW and the Commonwealth support the conservation and protection of the CERRA WHA	Desirable	0	2	3	0	0	2	2	0	3	3	50	Each Park and Reserve	3 years	Qualitative			ESFM	ESFM	ESFM	ESFM	ESFM	ESFM
ILLEGAL ACTIVITIES	Number of incidences of illegal activities	Desirable	0	2	2	2	2	1	2	1	3	1	53	Each Park and Reserve	3 years	Quantitative		SoP (Quan) (NSW)						SoP (Quan)
	Number of different illegal activities detected	Desirable	2	2	2	2	1	1	2	1	3	3	63	Each Park and Reserve	3 years	Quantitative								
ENFORCEMENT /PATROLS		Worthwhile	0	2	2	2	0	0	1	0	2	2	37	Each Park and Reserve	3 years	Quantitative		SoP-Evaluation of effective-ness (Qual) (NSW)	SoP-Evaluation of effective-ness (Qual)	SoP-Evaluation of effective-ness (Qual)	SoP-Evaluation of effective-ness (Qual)	SoP-Evaluation of effective-ness (Qual)	SoP-Evaluation of effective-ness (Qual)	SoP-Evaluation of effective-ness (Qual)

Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
P R O T E C T I O N (cont'd)																								
MANAGEMENT RESOURCES	Funding	Essential	1	2	3	3	1	1	2	1	3	3	67	Reserve-State-Whole-of-CERRA	6 years	Quantitative		SoP- Total budget/ Revenue (Quan/ Qual) (NSW)	SoP- Revenue (Qual)	SoP- Revenue (Qual)	SoP- Revenue (Qual)	SoP- Revenue (Qual)	SoP- Revenue (Qual)	SoP- Total budget/ Revenue (Quan/ Qual)
MANAGEMENT RESOURCES	In kind	Desirable	1	1	3	3	1	1	2	1	3	3	63	Reserve-State-Whole-of-CERRA	6 years	Quantitative		SoP (Quan-Salary) (NSW)						SoP (Quan-Salary)
MANAGEMENT RESOURCES	Staff	Essential	1	1	3	3	1	1	2	1	3	3	63	Reserve-State-Whole-of-CERRA	6 years	Quantitative		SoP (Quan/ Qual) (NSW)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Quan/ Qual)
C O N S E R V A T I O N																								
OVERALL INTEGRITY	Forest Cover: Percent (area?) of forest cover as determined by satellite imagery	Essential	3	2	0	3	3	3	2	3	3	3	83	All WHA (for each reserve)	3 years	Quantitative: Satellite Imagery (LandSat)								
OVERALL INTEGRITY	Fragmentation: Hectares (or meters/length?) of linear disturbance (roads/ powerlines) through the reserves	Desirable	3	3	0	1	1	3	1	2	1	1	53	All WHA (for each reserve)	3 years	Quantitative: Satellite Imagery (Landsat)								

CONSERVATION (cont'd)																							
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
OVERALL INTEGRITY	Boundary: length of boundary with intact natural ecosystem (>250m) outside reserve boundary	Essential	3	3	1	3	1	2	2	2	3	2	73		3 years	Quantitative: Satellite Imagery (Landsat)								
	Catchment Integrity: Percent of forest cover of upstream catchments.	Essential	3	2	1	2	2	2	1	2	3	2	67	Each Park and Reserve/ Catchment Area	3 years	Quantitative: Satellite Imagery (Landsat)								
	Habitat Condition: Hectares of disturbed habitat	Desirable	3	2	1	2	0	2	2	1	2	2	57	Each Park and Reserve	3 years									
BIODIVERSITY	Number of extinct species	Essential	3	2	1	2	0	1	1	2	3	2	57	Reserve-State-Whole-of-CERRA	6 years	Quantitative								
	Threatened and Endangered Taxa: Number of species in each of the IUCN categories (Commonwealth and NSW/QLD Status)	Essential	2	3	1	3	0	2	2	2	3	3	70	Reserve-State-Whole-of-CERRA	6 years	Quantitative								

C O N S E R V A T I O N (cont'd)

Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
BIODIVERSITY	Frogs: Stream dwelling frog species diversity and abundance	Essential	3	3	1	3	3	3	2	3	2	2	83	Selected key sites	Surveyed summer, autumn and spring	Quantitative	Yes-existing monitor-ing	Yes-existing monitor-ing	Yes-existing monitor-ing	NA	Yes-existing monitor-ing	Yes-existing monitor-ing	Yes-existing monitor-ing	Yes-existing monitor-ing
	Arboreal Fauna	Essential	3	3	1	2	1	2	2	2	2	3	70	Selected key sites	3 years									
	Rufous Scrub-Bird (*Atrichornis rufescens*) changes in populations	Essential	2	2	2	3	2	3	3	3	2	3	83	Barrington Tops and Border Ranges and other key sites in NSW and QLD	3 years	Recording number of birds heard within 7.5 minute period		Yes-existing monitoring;	Yes-existing monitoring;	NA	Yes-existing monitoring;	Yes-existing monitoring;	Yes-existing monitoring;	Yes-existing monitoring;
	Albert's Lyrebird (*Menura alberti*): Fox TAP monitoring.	Essential	2	2	1	2	2	2	2	2	2	2	63	Selected key sites in NSW and QLD	As per Fox TAP			Yes - current monitor-ing under fox TAP		NA	NA	NA	NA	NA

CONSERVATION (cont'd)																						
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
BIODIVERSITY	Rufous Bettong (*Aepyprymnus rufescens*): Fox TAP monitoring.	Essential	1	1	2	1	1	1	2	1	3	3	53	Selected key sites	As per Fox TAP		Site established through Fox TAP		Site established through Fox TAP	NA				
	Brush-tailed Rock Wallaby (*Petrogale penicillata*): Fox TAP monitoring.	Worthwhile	1	0	0	1	1	1	2	1	2	2	37	Selected key sites	3 years					NA				
	Broad-toothed rat (*Mastacomys fuscus Thomas*): Fox TAP monitoring	Essential	2	2	2	2	1	1	2	1	3	3	63	Site(s) in Barrington Tops	As per Fox TAP		NA	NA	NA	NA	NA	NA	NA	Yes-current monitoring under fox TAP
	Eastern Bristlebird (northern) (*Dasyornis brachypterus monoides*)													Sites in Lamington and Border Ranges NPs	Annual		NA	Yes-current monitoring	NA	NA	NA	NA	NA	NA

C O N S E R V A T I O N (cont'd)

Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
BIODIVERSITY	Spotted-tailed Quoll (*Dasyurus maculates*): Fox TAP monitoring.	Essential	2	2	2	2	2	2	2	2	2	2	67	Selected key sites in NSW and QLD	3 years									
	Freshwater Crayfish (*Euastacus gumar*)	Desirable	2	2	1	2	2	2	2	2	1	1	57	Selected key sites	3 years					NA				
	Hastings River Mouse (*Pseudomys oralis*)26/08/2004 population monitoring	Essential	2	2	2	3	2	2	2	2	2	3	73	Selected key sites in NSW and QLD	As per Recovery Plan		Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan	Yes - monitoring under draft national recovery plan
	North Coast Leaf-tailed Gecko (*Saltuaris swaini*)	Essential	3	2	2	2	1	2	2	2	2	2	67	Selected key sites	3 years									
	Vegetation monitoring: Permanent 1 ha plots	Essential	3	3	2	3	2	3	3	3	2	2	87	Each reserve	6 years									
	Nothofagus	Essential	3	3	2	3	2	3	3	3	2	2	87											

CONSERVATION (cont'd)																							
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
BIODIVERSITY	Key Habitat Integrity: Monitor the condition of species	Desirable	2	2	1	3	2	2	2	2	2	2	67	Selected species and sites in each Reserve										
WATER QUALITY	Water quality monitoring in streams in CERRA	Desirable	1	3	0	2	2	2	2	1	3	3	63	Selected Key sites									Yes- in Oxley Wild Rivers NP	
	Monitoring elluent quality at key polution sites (e.g. Guest House sewage treatment)	Desirable	1	3	0	2	2	2	2	1	3	3	63	Selected Key sites				Yes - in Lamington NP						
	Monitoring water quality in streams flowing into CERRA	Desirable	1	3	0	2	2	2	2	1	3	3	63	Selected Key sites										
CLIMATE CHANGE	Climate monitoring	Desirable	1	3	0	2	2	2	2	1	3	3	63	Selected Key sites										
	IKONOS Vegetation "transects" on ecotones and at extremes of bioclimatic variables	Essential	3	3	2	2	2	2	2	0	3	3	73	Selected Key sites										

CONSERVATION (cont'd)																						
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
CLIMATE CHANGE	Vegetation: network of 20m x 20m plots at extremes of bicloimatic variables	Essential	3	3	2	2	2	2	2	0	3	3	73	Selected Key sites										
FIRE	Hectares of unplanned fire	Essential	3	3	2	2	2	2	2	0	3	3	73	All reserves and surrounding land where relevant	Annual	Quantitative	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite
	Hectares of fire in fire sensitive forest	Essential	3	3	2	2	2	2	2	0	3	3	73	All reserves and surrounding land where relevant	Annual	Quantitative	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite
	Proportion of fires that start on-park and escape the park boundary and the number of hectares burnt off-park	Desirable	1	1	2	2	0	2	2	0	3	3	53	All reserves and surrounding land where relevant	Annual	Quantitative	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite; SoP (Quan) (NSW)	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite	Yes - fire monitor-ing/ mapping via satelite; SoP (Quan)

CONSERVATION (cont'd)																						
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
FIRE	Proportion of fires that start off-park and escape on to park and the number of hectares burnt on-park	Worthwhile	3	3	0	2	2	2	2	0	3	3	67	All reserves and surrounding land where relevant	Annual	Quantitative	Yes - fire monitoring/ mapping via satelite	Yes - fire monitoring/ mapping via satelite; SoP (Quan)	Yes - fire monitoring/ mapping via satelite	Yes - fire monitoring/ mapping via satelite	Yes - fire monitoring/ mapping via satelite	Yes - fire monitoring/ mapping via satelite	Yes - fire monitoring/ mapping via satelite	Yes - fire monitoring/ mapping via satelite; SoP (Quan)
	Fire management plan per reserve	Desirable	2	3	3	2	1	1	2	1	3	3	70	Each reserve	3 years	Quantitative		SoP - % (Quan)						SoP - % (Quan)
	Index of fire management plan implementation	Worthwhile	2	3	3	2	1	1	2	1	2	2	63	Each reserve	3 years	Qualitative		SoP – Evaluation of mgt. (Qual) (NSW)	SoP – Evaluation of mgt. (Qual)	SoP – Evaluation of mgt. (Qual)	SoP – Evaluation of mgt. (Qual)	SoP – Evaluation of mgt. (Qual)	SoP – Evaluation of mgt. (Qual)	SoP – Evaluation of mgt. (Qual)
CULTURAL HERITAGE	Number of listed/recorded indigenous sites	Desirable	0	0	0	2	0	1	2	1	3	3	40	Each reserve	3 years	Quantitative		SoP (Quan) (NSW)	~ESFM	~ESFM	~ESFM	~ESFM	~ESFM	SoP (Quan); ~ESFM
	Number of non-indigenous listed/recorded sites	Desirable	0	*0*	0	2	0	1	2	1	3	3	40	Each reserve	3 years	Quantitative			~ESFM	~ESFM	~ESFM	~ESFM	~ESFM	~ESFM
	Possible indicator regarding engagement of Traditional Owner knowledge?	Worthwhile	1	1	2	1	0	2	1	0	2	1	37	Each reserve	3 years	Qualitative		SoP (Qual) (NSW)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)

REHABILITATION																						
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
REVEGATION	Revegetation: Area and percent of formally cleared and disturbed area effectively re-vegetated/regenerated	Worthwhile	2	1	3	0	0	1	1	0	1	1	33	Each reserve	3 years	Quantitative			ESFM	ESFM	ESFM	ESFM	ESFM	ESFM
	Number of re-vegetation/ rehabilitation projects/activities	Desirable	1	1	2	2	1	1	2	2	3	3	60	Each reserve	3 years	Quantitative								
WEED CONTROL	Species of weeds per reserve	Essential	2	3	2	2	2	2	2	3	2	3	77	Each reserve	3 years	Quantitative		SoP (Quan) (NSW)						SoP (Quan)
	Number of invasive species	Essential	2	3	2	2	2	2	2	3	2	3	77	Each reserve	3 years	Quantitative		SoP-Within above (NSW)						SoP-Within above
	Scale of infestation- or degree to which weeds have penetrated each Reserve	Essential	3	3	2	3	3	3	2	3	2	3	90	Each reserve	3 years	Qualitative								

REHABILITATION (cont'd)																					
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
WEED CONTROL	Weed control activities underway	Desirable	2	2	3	1	1	2	1	2	3	3	67	Each reserve	3 years	Quantitative/ Qualitative		SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual) (NSW)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)
	Number of pest management strategies	Worthwhile	0	3	3	0	0	1	1	0	2	2	40	Each reserve	3 years	Quantitative			SoP - Within above	SoP - Within above	SoP - Within above	SoP - Within above	SoP - Within above	SoP - Within above
FERAL ANIMAL CONTROL	Species of feral animals per reserve	Essential	2	3	2	2	2	2	2	3	3	3	80	Each reserve	3 years	Quantitative		SoP (Quan) (NSW						SoP (Quan)
	Number of invasive species	Essential	3	3	2	2	2	2	2	3	3	3	83	Each reserve	3 years	Quantitative		SoP - Within above (NSW)						SoP - Within above
	Scale of infestation - or degree to which feral animals have penetrated the Reserve	Worthwhile	0	3	3	1	0	1	1	0	2	2	43	Each reserve	3 years	Qualitative								

R E H A B I L I T A T I O N (cont'd)

Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
FERAL ANIMAL CONTOL	Feral animal control activities	Worthwhile	0	3	3	1	0	1	1	0	2	2	43	Each reserve	3 years	Quantitative/ Qualitative		SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual) (NSW)	SoP - % Programs - Evaluation of control/ Mgt. (Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Qual)	SoP - % Programs - Evaluation of control/ Mgt. (Quan/ Qual)
	Number of pest management strategies	Worthwhile	0	3	3	1	0	1	1	0	2	2	43	Each reserve	3 years	Quantitative		SoP - Within above (NSW)	SoP - Within above	SoP - Within above	SoP - Within above	SoP - Within above	SoP - Within above	SoP - Within above
DIEBACK	Bell Miner Associated Dieback: Hectares affected	Essential	3	3	0	3	3	3	3	3	1	2	80	Reserve and Whole-of-CERRA	2 years	Quantitative			Yes- BMAD Strategy					
	Response index?	Worthwhile	0	3	1	1	2	1	1	0	1	1	37	Reserve and Whole-of-CERRA	2 years	Qualitative								
	Phytophthora cinnamomi: Hectares affected	Essential	2	3	2	2	2	2	2	3	3	3	80	Reserve and Whole-of-CERRA	2 years	Quantitative	???	???	???	???	???	???	???	???
	Response index?	Worthwhile	0	0	3	1	1	2	1	1	1	2	40	Reserve amd Whole-of-CERRA	2 years	Qualitative								

REHABILITATION (cont'd)

Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
EROSION	Ha of active erosion within Reserve	Desirable	1	3	3	1	0	2	1	0	2	2	50	Each reserve	3 years	Quantitative		SoP (Quan) (NSW)	~ESFM	~ESFM	~ESFM	~ESFM	~ESFM	SoP (Quan); ~ESFM
	Ha or erosion control within Reserve	Desirable	1	3	3	1	0	2	1	0	2	2	50	Each reserve	3 years	Quantitative		SoP-Within above (NSW)	~ESFM-Within above	~ESFM-Within above	~ESFM-Within above	~ESFM-Within above	~ESFM-Within above	SoP-Within above; ~ESFM-Within above
THREATENED SPECIES AND THREAT MANAGEMENT	Threatened Species Recovery Plans: Percent recovery plans per number of species	Essential	2	3	3	1	1	2	2	2	3	3	73	Reserve-State-Whole-of-CERRA	6 years	Quantitative		SoP (Quan) (NSW)						SoP (Quan)
	Index of species recovery plan implementation	Worthwhile	2	2	3	1	1	0	1	0	2	1	43	Reserve-State-Whole-of-CERRA	6 years	Qualitative		~SoP (Quan)						~SoP (Quan)
	Number of Threat Abatement Plans	Essential	2	3	3	2	0	1	1	1	3	3	63	Reserve-State-Whole-of-CERRA	6 years	Quantitative								
	Index of threat abatement plan implementation	Worthwhile	2	2	3	1	1	0	1	0	2	1	43	Reserve-State-Whole-of-CERRA	6 years	Qualitative								

PRESENTATION																						
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
VISITATION	Number of visitors	Essential	1	2	1	2	1	2	3	3	2	3	67	Reserve-State-Whole-of-CERRA	Annual	Quantitative	Yes-future VDS	Yes-future VDS; SoP (Quan/ Qual) (NSW)	Yes-future VDS; SoP (Qual); ESFM	Yes-future VDS; SoP (Qual); ESFM	Yes-future VDS; SoP (Qual); ESFM	Yes-future VDS; SoP (Qual); ESFM	Yes-future VDS; SoP (Qual); ESFM	Yes-future VDS; SoP (Quan/ Qual); ESFM
	Number of sites visited	Essential	1	2	1	2	1	2	3	3	2	3	67	Reserve-State-Whole-of-CERRA	Annual	Quantitative		SoP (Quan) (NSW)						SoP (Quan)
	Number of tourist facilities	Worthwhile	0	2	1	1	1	2	0	0	3	3	43	Reserve-State-Whole-of-CERRA	6 years	Quantitative		SoP (Quan) (NSW						SoP (Quan)
	Condition of tourist facilities	Worthwhile	1	0	1	1	0	2	2	1	2	2	40	Reserve-State-Whole-of-CERRA	6 years	Qualitative			SoP-Evalua-tion of mainten-ance and adequacy (Qual)	SoP-Evalua-tion of mainten-ance and adequacy (Qual)	SoP-Evalua-tion of mainten-ance and adequacy (Qual)	SoP-Evalua-tion of mainten-ance and adequacy (Qual)	SoP-Evalua-tion of mainten-ance and adequacy (Qual)	SoP-Evalua-tion of mainten-ance and adequacy (Qual)
	Visitor satisfaction	Desirable	0	2	2	1	1	2	2	2	2	3	57	Reserve-State-Whole-of-CERRA	Annual	Qualitative	Yes-future VDS	Yes-future VDS	Yes-future VDS	Yes-future VDS	Yes-future VDS	Yes-future VDS	Yes-future VDS	Yes-future VDS

PRESENTATION (cont'd)																					
Indicator	Description	Priority	Integrity	Threats	Management	Trends	Predictive	Credible	Change	Cumulative impacts	Cost effective	Feasibility	Rating (%)	Spatial Application	Temporal Application	Method	Main Range Group	Tweed Caldera Group	Focal Peak Group	Coastal Group	Gibraltar Range Group	New England Group	Hastings-Macleay Group	Barrington Tops Group
COMMUNITY AWARENESS/ ATTITUDES	An improving awareness of and attitude towards the environment in the CERRA area	Desirable	0	1	1	2	1	2	2	2	3	3	57	Reserve-State-Whole-of-CERRA	6 years	Qualitative-surveys within park and data from outside sources								
	Membership of natural history, conservation, tree-planting groups etc.	Worthwhile	0	0	0	1	0	1	1	0	3	3	30	Reserve-State-Whole-of-CERRA	6 years	Quantitative								
	Area of land outside of CERRA zoned for conservation purposes ie VCAs	Desirable	2	2	1	2	0	2	2	2	3	3	63	Reserve-State-Whole-of-CERRA	6 years	Quantitative								
ENGAGEMENT OF THE COMMUNITY IN PARK AND RESERVE MANAGEMENT	Proportion of key on-park management and planning activities that have involved formal consultation with representatives of key community groups	Worthwhile	0	0	3	0	0	1	1	0	2	2	30	Reserve-State-Whole-of-CERRA	6 years	Quantitative/ Qualitative		SoP (Quan/ Qual) (NSW)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Qual)	SoP (Quan/ Qual)

PROPOSED MONITORING INDICATORS

SUMMARY OF ESSENTIAL INDICATORS

Protection	
Statutory Protection	Legal Framework Percent Area of CERRA in IUCN Category 1 or 2 Protected Areas
Management Plans	CERRA WHA Strategic Plan Adopted Number of Reserves with Adopted Management Plans
Management Resources	Funding Staff
Conservation	
Overall Integrity	Forest Cover: Percent (area) of forest cover by satellite imagery. Boundary: Length of boundary with intact natural ecosystem (>250m) outside reserve boundary Catchment Integrity: Percent of forest cover of upstream catchments
Biodiversity	Number of extinct species Threatened and Endangered Taxa: Number of species in each of the IUCN Categories (Commonwealth and New South Wales / Queensland Status) Frogs: Stream dwelling frog species diversity and abundance Arboreal Fauna Rufous Scrub-Bird changes in populations Albert's Lyrebird: Fox TAP monitoring Rufous Bettong: Fox TAP monitoring Broad-toothed rat: Fox TAP monitoring Spotted-tailed Quoll: Fox TAP monitoring Hastings River Mouse population monitoring North Coast Leaf-tailed Gecko Vegetation monitoring: Permanent 1 ha plots Nothofagus
Climate Change	IKONOS Vegetation "transects" on ecotones and at extremes of bioclimatic variables. Vegetation: network of 20m x 20m plots at extremes of bioclimatic variables
Fire	Hectares of unplanned fire Hectares of canopy fire in adjacent fire sensitive forest
Rehabilitation	
Weed Control	Species of weeds per reserve Number of invasive species Scale of infestation, or degree to which weeds have penetrated each Reserve
Feral Animal Control	Species of feral animals per reserve Number of invasive species
Dieback	Bell Miner associated dieback: hectares affected Phytophthora associated dieback: hectares affected
Threatened Species and Threat Management	Threatened Species Recovery Plans: Percent recovery plans per number of species Number of threat abatement plans
Presentation	
Visitation	Number of visitors Number of sites visited

DETAIL FOR PRIORITY INDICATORS

The following section sets out the detail of most of the indicators identified as *Essential*. Note that some indicators have been described in a group owing to their interrelated nature.

STATUTORY PROTECTION

Background

The legal framework reflects the language, concepts and intent of conservation, and it can embrace broadly recognised international principles of conservation (NPWS, 2000). This framework includes the *National Parks and Wildlife Act 1974*, the *Environment Protection and Biodiversity Conservation Act 1999*, the New South Wales *Threatened Species Conservation Act 1995* and the Queensland *Nature Conservation Act 1992*. Ecologically sustainable development is one example of an international conservation principle that Australia has adopted and incorporated into the legal framework.

IUCN has defined a series of six protected area management categories. Based on primary management objectives, Category 1 is the highest protection that a protected area can be afforded. Within Category 1, the 'strict nature reserve' (Category 1a) is managed mainly for science and the 'wilderness area' (Category 1b) is mainly managed for wilderness protection (UNEP, 2004). Thus protected areas within Category 1 are most likely to remain in a natural and pristine state.

Category 2 areas are National Parks – protected areas managed mainly for ecosystem protection and recreation. This includes natural areas of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Details

The extent to which the legal framework supports the conservation and protection of the CERRA World Heritage Area can reflect the extent to which Australia, and the relevant States are committed to protecting the area. In addition, and importantly, protection through legal means, including increasing areas afforded protection under Category 1 or 2, reflects the degree to which the integrity of World Heritage Values can be maintained. It is therefore important to evaluate statutory protection over time to ensure that the legal means to conserve and protect CERRA are maintained and enhanced over time.

Current Status

Reporting against the legal framework protecting the CERRA World Heritage Area is required in the six-yearly Periodic Report. It specifically requires a description and evaluation, including examples, of legislation protecting and managing the property. Forest Agreements require the same reporting in the Ecologically Sustainable Forest Management reports for the Upper and Lower North East Regions.

"The proportion of land within the parks system which is declared wilderness with limited access and infrastructure" (NPWS, 2004, pp. 25), reflecting the IUCN Category 1 criteria, is a quantitative indicator required by the State of the Parks report.

Overall Approach

The laws, regulations and guidelines pertaining to the conservation and protection of the CERRA World Heritage Area should be evaluated at regular intervals to monitor any changes. The overarching aim should be to ensure that the legal framework reflects the conservation and protection requirements of CERRA over time.

The proportion of CERRA within the IUCN Category 1 Protected Area should be similarly evaluated at regular intervals to monitor changes in the status of protection afforded to the area. The overarching aim should be to ensure that outstanding areas retaining natural character and influence are conserved and protected over time.

Spatial Approach

The evaluation of statutory protection should be undertaken within three tiers: at the reserve level, state level and at the whole-of-CERRA level.

Temporal Approach

The evaluation of statutory protection should be undertaken every six years to coincide with the Periodic Report.

MANAGEMENT PLANS

Background

Park management plans contain information on the natural environment, Aboriginal heritage, history and recreational opportunities in the park. The plan provides a framework on how the planning area will be managed in the years ahead. It states the desired outcomes, guidelines and actions to protect the values and to address the issues affecting the planning area. These relate to the conservation of natural and cultural heritage and the management of visitor use, other authorised activities and park management operations (NPWS, 2001).

A management plan is a statutory document, required for each national park and nature reserve, under the *National Parks and Wildlife Act 1974*. Once the Minister for the Environment has adopted a plan, no operations may be undertaken within the planning area except in accordance with the plan (NPWS, 2001). In Queensland the *Nature Conservation Act 1992* provides for statutory management plans for protected areas.

Details

Management plans control operations within the park, thus affording the park legal protection specific to that park. In addition, they identify management priorities, which are directed at conserving and protecting that park and addressing issues specific to that park. Thus management plans help ensure the World Heritage Values of each park are protected and managed accordingly. CERRA includes almost 50 individual reserves spanning over a large geographical area. Conservation values and issues thus varies between reserves, therefore a number of management plans are required. Furthermore, Australia's international responsibilities under the World Heritage Convention require a plan that encompasses all CERRA reserves. This is to ensure that appropriate consideration is given to the World Heritage Values of CERRA by managers when developing management prescriptions for the CERRA reserves, and that they are developed and implemented in a consistent and coordinated way (CERRA, 2000).

Current Status

The six-yearly Periodic Report requires the strategic planning mechanisms for CERRA be described. This includes strategic planning at the CERRA and reserve level. It requires details of legislation under which plans have been prepared, their duration and review period, and whether it is legally binding or advisory.

Currently CERRA as a whole is being managed in accordance with a Strategic Overview for Management (2000), which is not a statutory document, and is due for review in 2007. Reserve plans of management and reserve management strategies are in various stages. However, at the reserve level, a significant number of plans are yet to be implemented.

Overall Approach

The planning mechanisms pertaining to the management of CERRA should be evaluated at regular intervals (Key: ✓ Essential; • Desirable):

- ✓ Management of CERRA as a whole should be evaluated through investigation into the continuation of a whole of CERRA management plan or equivalent over time.
- • An index of implementation of the given plan, currently being the *Strategic Overview for Management* (2000).
- ✓ Management of CERRA at the reserve level should be evaluated through investigation into the number of reserves covered by a management plan or equivalent.

- An index of implementation of the given plan.

Spatial Approach

The evaluation of management plans should be undertaken within two tiers – at the reserve level, and at the whole-of-CERRA level.

Temporal Approach

The evaluation of management plans should be undertaken every six years to coincide with the Periodic Report.

MANAGEMENT RESOURCES

Background

Management resources are vital for management of protected areas. Without funding, in kind support and staff provided from outside sources, there are few avenues in which resources for management can be obtained. Management resources are directly related to the quality of management and thus the degree of conservation and protection afforded to the protected area.

Details

Evaluating of the flow of resources to a protected area provides a mechanism to ensure that the protected area is receiving adequate resources in order to meet management objectives. Additionally it can provide a base to evaluate the efficiency of management by comparing these management inputs with management outputs.

Current Status

The New South Wales State of the Parks report requires a number of indicators relating to management resources to be measured. These include quantitative and qualitative indicators.

Quantitative indicators:

- Total salary ($) of staff on park.
- Total budget for the protection of heritage in New South Wales being: cost ($) per hectare for the management of reserves; proportion of planned management expenditure diverted to respond to large-scale unpredicted events; amount ($) of revenue generated from Business Activities; and expenditure on capital works ($).
- Maintenance of adequate staffing levels, being: numbers of staff by employment category and proportion of annual staff retention; and number of field-based staff per hectare of land managed.
- Maintenance of adequate skill levels of staff, being: number of staff who have participated in training programs and proportion of budget spent on skills development of staff.

Qualitative indicators:

- Staff;
- Budget; and
- Revenue.

Overall Approach

The evaluation of management resources, including funding, in-kind and personnel, should be undertaken in accordance with New South Wales State of the Parks.

Spatial Approach

The evaluation of management resources should be undertaken within three tiers – at the reserve level, State level, and at the whole-of-CERRA level.

Temporal Approach

The evaluation of management resources should be undertaken every six years to coincide with the Periodic Report.

Note

State of the Parks is still being refined. Queensland does not participate in State of the Parks, however its RAPID assessment may be able to be modified to be a useful basis.

STATUS OF BIODIVERSITY CONSERVATION

Background

The biological diversity of the CERRA World Heritage Area was one of three reasons why it was inscribed on the World Heritage List. A wide range of plant and animal lineages and communities with ancient origins in Gondwana survive in its collection of reserves, many of which are restricted largely or entirely to CERRA (CERRA, 2000). Therefore there is an obligation to ensure that this biological diversity is maintained.

Details

Monitoring the number of extinct species, and other species listed by the IUCN Red List, the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999, the New South Wales *Threatened Species Conservation Act 1995* and the Queensland *Nature Conservation Act 1992*, and changes in status over time, can give an indication of the integrity of biological diversity. Any increase in the number of extinct species indicates that biodiversity is not being maintained. Similarly, any increase in the number of endangered or threatened species indicates deteriorating integrity. Conversely, an increasing number of species being de-listed indicates an enhancement of integrity.

Monitoring the percent of recovery plans per number of listed species and the number of threat abatement plans, similarly can indicate the integrity of biological diversity. The greater the percent of recovery plans per number of species that have been implemented and the greater the number of threat abatement plans that have been implemented, the greater the likelihood of listed species becoming more abundant and being de-listed. Without an implemented recovery plan or actions to reduce threats that are affecting threatened and endangered species, the status of these species is likely to continue a decline, deteriorating the integrity of biodiversity.

Current Status

The Ecologically Sustainable Forest Management Report requires reporting on “the status (threatened, rare, vulnerable, endangered or extinct) of forest dwelling species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment”, and “the status of endangered populations and ecosystems as determined by legislation or scientific assessment”.

The New South Wales State of the Parks Report requires reporting on the “proportion of threatened species/endangered populations/endangered ecological communities for which Recovery Plans have been endorsed”, and the “proportion of endorsed recovery plans for which recovery actions have been implemented”.

CERRA has a list of threatened, endangered and extinct species, and for a number of these there are recovery plans at various stages of implementation. However there is a significant number of species without recovery plans. Threat abatement plans have been and are being developed. An example of an implemented plan is the Fox Threat Abatement Plan.

Overall Approach

The status of species should be monitored over time by investigating (Key: ✓ Essential; • Desirable):

✓ The number of extinct species.

- ✓ The number of species listed as endangered or threatened by the *Environment Protection and Biodiversity Conservation Act 1999*, the *Threatened Species Conservation Act 1995* and the *Nature Conservation Act 1992*.
- ✓ The number of threat abatement plans.
- An index of threat abatement plan implementation.
- ✓ The percent of recovery plans per number of species.
- An index of recovery plan implementation.

Spatial Approach

The evaluation of species status, recovery plans and threat abatements plans should be undertaken within three tiers: at the reserve level, at the state level and at the whole-of-CERRA level.

Temporal Approach

The evaluation should be undertaken every six years to coincide with the Periodic Report.

VEGETATION MONITORING

Background

CERRA encompasses a number of rare and threatened plant species, and species of conservation significance such as Nothofagus, and a variety of different forest types. Additionally, CERRA represents the major remaining areas of rainforest in southeast Queensland and northeast New South Wales (CERRA, 2000). Therefore ensuring its protection and conservation is a major priority. Climate change is potential threat with catastrophic consequences, it is thus important monitor vegetation in order to understand the looming impacts of climate change, as well as to ensure that overall forest and habitat integrity is maintained.

Details

The forests of CERRA are of immeasurable value, being its identity and critical habitat to the many key species of CERRA. Therefore permanent plots should be established throughout CERRA to enable ongoing long term monitoring of forests and habitats, and select species assemblages and species where relevant, in order to ensure conservation and protection of the CERRA World Heritage Values.

Current Status

New South Wales National Parks and Wildlife Service, in creating a 'biological information database' for the northeast region, undertook extensive flora and fauna surveys. The aims of the study were to record or estimate as reliably as possible, the distribution of flora and fauna throughout all forests of north-east New South Wales at sufficient spatial resolution for the purposes of regional conservation assessment and planning (Brown *et al*. 2000). This work has now finished, however it provides a good base to develop similar but more comprehensive methodologies for the purposes of this monitoring strategy.

More recently, as part of a PhD project, a number of permanent plots have been established within CERRA. The goal of this study is to identify environmental attributes that are driving the spatial distribution of rainforest species assemblages within the region. The survey sites chosen were those that captured the highest degree of environmental variation available based on the environmental attributes chosen (Laidlaw, *pers. comm*.). Methodologies from this study can also be applied across CERRA for the purposes of this Monitoring Strategy.

Chris Nadolny established a permanent plot in Dorrigo National Park, which was revisited in 2002.

Roger Kitching has developed two one-hectare plots in Lamington National Park and has funding proposals to include additional sites in the Dorrigo and Barrington areas (*pers. comm*). The two existing sites include subtropical and warm temperate forest types. The detailed floristics and abundance of all vascular plants could allow long term monitoring of vegetation condition change.

Overall Approach

The flora surveys undertaken by New South Wales National Parks and Wildlife Service to develop the 'biological information database' were primarily in non-rainforest vegetation due to a lack of existing data, it was felt that there was sufficient rainforest data at the time. Therefore site selection and methodologies will differ between non-rainforest sites and rainforest sites, the latter will use methodologies adapted from Laidlaw's study.

For non-rainforest sites, site selection for areas not included in the study should be facilitated through use of GIS-based techniques to optimise sampling of major environmental and

geographical gradients within CERRA. Maximum information return per unit of survey effort should be achieved by stratifying survey sites in relation to combinations of vegetation types and bioclimatic environmental variables, this can maximise the reliability and utility of derived distributional models (see Brown *et al*. 2000, pp. 83). The survey sites chosen should be 20 square metre permanently marked plots to generate comprehensive species lists and cover abundance estimates for vascular plants.

Note, there is no systematic approach to the forest types of CERRA (either structural or floristic), nor has any approach been used across the whole area. As such the application of forest types in the above model may be somewhat hampered until such classification and mapping is undertaken.

For rainforest sites, site selection should use ArcView GIS to identify potential survey sites that capture the highest degree of environmental variation available. Survey sites should be progressively chosen across CERRA until a predetermined level of environmental variation between successive plots is reached.

The survey plots chosen should also be 20 square metre permanently marked plots. All trees 5 centimetres or greater in *dbh* should be identified and measured for diameter and height. All other vascular plants within the plots should be identified and given a cover-abundance rating.

The two one-hectare plots in the Lamington area, and at least two additional one-hectare plots in the Dorrigo and Barrington areas, should be monitored in detail at least every six years.

Spatial Approach

Ideally, at least one 20 square metre permanent plot should be established in each reserve, which in total cover the range of bioclimatic variables and vegetation types in CERRA.

Temporal Approach

Monitoring should be undertaken at least every six years, such that results are ready for the periodic reporting.

FOREST COVER

Background

Fundamental to maintaining the integrity of the World Heritage Values of CERRA is ensuring forest cover is maintained. Satellite imagery offers the ability to obtain cost effective data on forest cover for both within and surrounding the many CERRA reserves.

One important aspect of the ability to monitor forest cover for CERRA is that it provides the ability to view historical data and consider where threatening processes may be exacerbating change within CERRA. For example, the ability to obtain data on vegetation cover change within CERRA reserves since the 1970s provides a unique window of any changes to forest cover (and potentially the integrity of World Heritage Values of CERRA).

Further, the ability to monitor forest cover in adjoining areas provides important indicators of two potential threats to the integrity of the CERRA World Heritage Values, edge effects along the boundaries and upstream catchment integrity.

Finally, the ability to monitor change on forest cover may provide early warning indicator of the effects of climate change.

Details

The use of Satellite Imagery to monitor vegetation cover change is described by Phinn *et al.* (2001) and Johansen *et al.* (unpublished). Vegetation cover change can be mapped using spectral vegetation index image mosaics for a region (e.g. CERRA) using a variety of remotely sensed data. Amongst the various data sources that provide land cover, land cover change, vegetation type, vegetation variables and biomass, the techniques considered most appropriate are:

- Landsat with 185 square kilometres scenes, 30 square metre pixels, and all seven spectral bands a normalised or enhanced vegetation index can be obtained. *Landsat 5* was recently replaced by *Landsat 7*, however datasets go back a number of years and it would be possible to develop a historical analysis for example using 2003, 1997 and 1991 data to detect changes. Landsat now has a limited life and will cease at some point in the next few years. Landsat is reasonably cost effective, and whilst data does need to be purchased it is readily available and has a very useful historical archive.

- *SPOT 5* has similar bands to *Landsat*, yet includes a mid Infra Red band, which allows identification of rocky outcrops (and hence removal of these from vegetation analysis). Scenes are 60 square kilometres and pixels 20 square metres, which allow a significant increase in the scale of analysis over *Landsat*. *SPOT* images are relatively expensive, yet they do offer many advantages over *Landsat*. It is understood that the New South Wales government already purchases *SPOT* images for the whole state (how often and the exact coverage is unknown).

- *MODIS* covers the CERRA area daily and one scene would cover all of CERRA. Pixel size is 250 square metres, which makes the scale somewhat less desirable than *Landsat* or *SPOT*, however it is free and vegetation cover is automatically produced. The Rainforest CRC is currently evaluating the use of *MODIS* for monitoring vegetation cover.

- *IKONOS* and *Quickbird* are both fine resolution and provide good multispectral coverages. The scenes are much smaller (15 sqaure kilometres for *IKONOS*, and 14 square kilometres for *Quickbird*) and hence more need to be purchased and a mosaic is needed for large areas (increasing processing time). Pixel size is much better, however, with 4 metres for *IKONOS* and 2 metres for *Quickbird* in the multispectral bands.

The techniques suggested in this indicator have been used and/or are being developed in the Wet Tropics World Heritage Area. Johansen *et al.* mapped vegetation cover change using spectral vegetation image mosaics of the wet tropics bioregion derived from *Landsat 5 TM* and *Landsat 7 ETM+* images collected in 1988 and 1999. Image sets were geometrically, radiometrically and atmospherically corrected by others, then vegetation index transformations and classification was undertaken. The enhanced vegetation index was considered the most appropriate to map and monitor changes in vegetation (including broadscale clearing, linear clearing and regeneration post logging). The Rainforest CRC project has now moved into investigating the use of the free *MODIS* imagery.

Current Status

At present there is no systematic, whole of CERRA monitoring of forest condition or cover.

In Queensland the CERRA area is part of the regional ecosystem mapping and there is a *SLATS* project which reviews remote sensing to identify clearing and other changes in land cover. The *SLAT* data is reviewed every two years.

Overall Approach

It is suggested that a vegetation cover history for CERRA, adjoining lands and upstream catchments be derived from past *Landsat* data. This should be taken back as far as possible at, for example, six-year intervals. Further, it is suggested that *SPOT* imagery be used to monitor vegetation cover at least every six years and preferably every three years. The key measures proposed are:

- hectares of forest cover (for all of CERRA and by reserve, stratified by forest types if possible);
- vegetation type cover per reserve;
- percentage of forested boundary (contiguous forest at least 250 metres out from the CERRA boundary) along the entire boundary of CERRA; and
- percentage of forest cover for each upstream catchment for CERRA.

Spatial Approach

It is vital that this indicator be measured for all of CERRA as it is the only broadscale indicator of any aspect of the integrity of World Heritage Values. It is desirable that the data be analysed and reported per reserve and it may be desirable to stratify the analysis by other aspects (such as vegetation type).

Temporal Approach

The measurement should be undertaken at least every three years at the same time of year (suggest October/November owing to hopefully less cloud interference and summer drought and consequent forest senescence being less of a confounding effect).

Sampling and Analysis

Sampling and analysis should use the techniques as per Phinn *et al.* and Johansen *et al*.

IMPACTS OF CLIMATE CHANGE

Background

To date there is no wide scale monitoring of the potential impacts of climate change in CERRA. There is a need to identify some potential cost effective monitoring which allows early detection of climate change impacts. Whilst on the one hand there is a view that it is worthless to monitor climate change impacts as management strategies applied to CERRA can not avoid climate change, monitoring as change occurs will provide for an understanding of the changing conservation imperatives of the CERRA World Heritage Area. For example, climate change may affect a forest type such as *Nothofagus*, and monitoring may detect trends that highlight the importance of particular areas or change in combination with other threatening processes, which are within the control of management (e.g. disease, weeds, feral animals, hydrology, fire etc.).

Hughes (2003) states, "CSIRO projections for future climatic changes indicate increases in annual average temperatures of 0.4-2.0°C by 2030 (relative to 1990) and 1.0-6. 0°C by 2070. Future changes in temperature and rainfall are predicted to have significant impacts on most vegetation types that have been modelled to date…". Most significantly, Hughes states, "Changes in vegetation distributions are expected to be most rapid and extreme at ecotones. Focussing research on boundaries between vegetation types (woodland grassland, rainforest/woodland) may give us the best chance of understanding early impacts."

Note, this indicator is proposed and really needs evaluation and consideration as a research project to prove its viability prior to resourcing as a long term monitoring approach for CERRA.

Comments received on an earlier draft of this strategy, questioned the priority for implementation of climate change monitoring. As the brief requires climate change monitoring, it has been retained. We do note that climate change could be a key threatening process for some species, communities and habitats.

Details

It is proposed to use three interrelated approaches to monitoring the effects of climate change in CERRA:

1. Detailed remote sensing transects across bioclimatic gradients and covering key ecotones;
2. Monitor vegetation condition at fixed plots within these transects; and
3. Identify and monitor key fauna species.

Current Status

- No current satellite imagery analysis.
- Melinda Laidlaw is undertaking her work as part of her doctoral studies.
- Alison Basden is undertaking work in Barrington tops National Park (although this hasn't been reviewed).
- No current monitoring of fauna targetted at detecting climate change induced impacts.

Overall Approach

1. Firstly to establish a series of 'transects' established for collection and analysis of *IKONOS* satellite imagery over environmental gradients covering the extreme of bioclimatic variables and focussing on ecotones. Most importantly a focus on various *Nothofagus* edges and rainforest/wet sclerophyll ecotones is suggested.
2. Continue the work of Melinda Laidlaw (and potentially expand it) to provide vegetation assessment in plots.
3. Investigate potential fauna (aboreal mammal, bird or even insect) species, which could be used as indicator(s) of early climate change impacts.

Spatial Approach

The target areas should be ecotones at the extremes of bioclimatic variables.

Temporal Approach

A long term ongoing approach will be required.

Sampling and Analysis

Not yet determined.

RUFOUS SCRUB-BIRD

Background

The Rufous scrub-bird (*Atrichornis rufescens*) is a rare, delictual species endemic to CERRA. It is an attribute of three World Heritage natural criteria (i, ii and iv) and an indicator of rainforest community health (particularly the absence of foxes). It is currently listed as vulnerable by the New South Wales *Threatened Species Conservation Act 1995* and as Rare under the *Nature Conservation Act 1992*. The northern subspecies *Atrichornis rufescens rufescens* is listed as vulnerable and the southern subspecies *A. rufescens ferrieri* is listed as near threatened in the Action Plan for Australian Birds (Garnett and Crowley 2000). A proposal to upgrade the listing in Queensland to Endangered is under consideration and a nomination for listing under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* is in preparation.

Details

As a World Heritage Value, it is vital that current Rufous scrub-bird populations be maintained, and desirable that they are enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored and determined in order to understand the integrity of the species in itself and as an indicator of the integrity of habitat condition.

Rufous scrub-birds are confined to high altitude areas dominated by rainforest or wet sclerophyll forests, as well as ecotones comprising a mixture of these forest types. Suitable habitat for Rufous scrub-birds are areas up to one hectare in size, containing dense ground cover, moderately dense understorey and a cool and moist microclimate at ground level and abundant leaf litter (Ekert, 2003).

In rainforest, suitable Rufous scrub-bird habitat occurs where disturbance such as natural tree fall events and the presence of creek lines has opened up the canopy allowing for the growth of a dense understorey. Thus the presence or absence of Rufous scrub-birds is an indicator of rainforest condition. Stable but low numbers are an indicator of good rainforest condition (Ekert, 2003).

In sclerophyll forests and ecotones, the overstorey is naturally more open and the presence of a dense understorey of ferns, shrubs, sedges and vines may provide a continuum or more extensive area of suitable Rufous scrub-bird habitat. Thus the presence or absence of Rufous scrub-birds is an indicator of forest condition. High numbers are an indicator of good sclerophyll forest condition (Ekert, 2003).

In both forest types, Rufous scrub-birds can be subject to predation by foxes. Thus their presence is an indicator of the absence of foxes.

Current Status

In 1999, the New South Wales National Parks and Wildlife Service initiated a six-year monitoring program for the Rufous scrub-bird. The overall aim of the project is to determine whether there are changes in the abundance of the Rufous scrub-bird over the monitoring period (1999-2004) in northeast New South Wales (Ekert, 2000).

The surveys have provided the most comprehensive assessment of the Rufous scrub-bird status since the early 1980s (e.g. Ferrieri 1984, 1985). The results as of 2002 indicate a possible decline in abundance of Rufous scrub-birds at some locations. In addition, recent trends indicate that the southern subspecies (*Atrichornis rufescens ferrieri*) is more numerous than the northern subspecies (*Atrichornis rufescens rufescens*).

The formal monitoring period is now in its last year. The methodologies have been refined, and a number of sites have been surveyed annually providing valuable baseline data, and the means to monitor the Rufous scrub-bird as a world heritage value and as an indicator of forest condition. The following methodology has been adapted from this six-year monitoring program.

Overall Approach

Each site, most of which are situated on a forest road or walking track in an area of suitable Rufous scrub-bird habitat (derived from habitat models), should be surveyed over two days on two separate occasions, approximately two weeks apart. Surveys should commence no more than three hours after sunrise and conclude no less than one hour before sunset, weather permitting as heavy rain and strong winds reduce the detectability of Rufous scrub-bird calls.

Surveys should be conducted at permanent point survey sites between 400-500 metres apart. A team of trained observers listen for the call of the male Rufous scrub-bird for a specified 7.5 minute period. All calls heard and individuals seen are recorded, however only those within the specified period are recorded formally. For formal recording, a standardised format should be utilised (refer to appropriate proforma). For incidental recording, observers should be encouraged to follow the standardised recording format. In addition, a habitat assessment should be undertaken at survey sites to enable collation of site assessment against bird presence and environmental conditions.

When compared to other survey years, population trends can be determined and from this it can be discerned as to whether further action needs to be taken. This may be in order to understand and prevent a possible population decline, or to further investigate a possible change in forest condition that may be highlighted through changes in Rufous scrub-bird numbers in certain sites or noted through habitat assessments.

Spatial Approach

Out of approximately 400 potential monitoring sites, at least 100 essential sites should be monitored. These should cover the known geographic range of the species and be centred on the following locations in or close to CERRA:

- New South Wales:
  - Border Ranges National Park;
  - Gibraltar Range, Washpool and Barool National Park;
  - New England and Dunggir National Park (additional sites are needed on the escarpment section of New England National Park);
  - Werrikimbe National Park; and
  - Barrington Tops National Park.

- Queensland (these sites need to be established):
  - Lamington National Park;
  - Springbrook National Park;
  - Main Range National Park; and
  - Mount Barney National Park.

Temporal Approach

Surveys should be undertaken during the breeding season, between September and December, every three years using at least 100 standard sites.

Sampling and Analysis

For each site and overall location, the abundance and relative abundance of the Rufous scrub-bird should be determined in accordance with the technique used by Ekert (2000, 2003). Sites should be compared with previous results to detect change in Rufous scrub-bird populations. Sites of particular concern or change, such as those affected by a major event like fire, for example, should be monitored as well as compared with similar existing sites of the same habitat in the area.

ALBERT'S LYREBIRD

Background

Albert's lyrebird (*Menura alberti*) is an attribute of two World Heritage natural criteria (i and iv). It is currently listed as Vulnerable by the New South Wales *Threatened Species Conservation Act 1995* and as Rare by the *Nature Conservation Act 1992*. It is also listed as Vulnerable in the Action Plan for Australian Birds (Garnett and Crowley 2000). Albert's lyrebird has a very restricted range, from the Lower Richmond Valley, New South Wales to the Mistake Mountains and Mount Tamborine in southern Queensland, west to Cunningham's Gap (NPWS, 2004), according to Hunter (2003) it is essentially confined to the CERRA World Heritage Area. The species was more widely distributed before the clearing of floodplain and other rainforest and now some populations are isolated in both New South Wales and Queensland (NPWS, 2004).

Details

As a World Heritage Value, it is important that Albert's lyrebird populations be maintained, and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored and determined in order to understand the integrity of the species in itself and as a World Heritage Value.

Current Status

Albert's lyrebird has been identified in the New South Wales Fox Threat Abatement Plan (Fox TAP) as a species likely to be impacted on by fox predation. It is therefore currently monitored as part of the Fox TAP. This monitoring measures the response of Albert's lyrebird populations to fox control and shows whether the species is limited by fox predation. Importantly it allows for the detection of population trends.

Overall Approach

Monitoring of Albert's lyrebird populations should be undertaken as part of the Fox TAP, however monitoring should be extended to cover the species range within CERRA including both New South Wales and Queensland.

Spatial Approach

Monitoring sites centred on the following locations in or close to CERRA:

- New South Wales:
  - Mount Jerusalem (current monitoring as part of Fox TAP);
  - Border Ranges National Park east (site established but no current monitoring as part of Fox TAP);
  - Mount Warning National Park (site established but no current monitoring as part of Fox TAP);
  - Nightcap National Park (site established but no current monitoring as part of Fox TAP); and
  - Toonumbar National Park (site needs to be established).

- Queensland (note all of these sites need to be established):
  - Lamington National Park;
  - Main Range National Park; and

- Mount Barney National Park.

Temporal Approach

Monitoring should be undertaken annually as per Fox TAP monitoring.

Sampling and Analysis

For each site and overall location, the abundance and relative abundance of Albert's lyrebird should be determined in accordance with the technique used by the Fox TAP. Sites should be compared with previous results to detect change in Albert's lyrebird populations. Sites of particular concern or change, such as those affected by a major event like fire for example, should be monitored as well as compared with similar existing sites, of the same habitat, in the area.

BROAD-TOOTHED RAT

Background

The Broad-toothed rat (*Mastacomys fuscus*) is an uncommon small ground-dwelling mammal. It is listed as endangered by the New South Wales *Threatened Species Conservation Act 1995*. In New South Wales the Broad-toothed rat is known from five disjunct populations. The largest population is in Kosciuszko National Park. The Barrington Tops population, the only population occurring within the CERRA area, is of significant conservation value as it is the second largest in New South Wales. However, the Broad-toothed rat habitats are restricted, and the species is not as common as it was 10 to 15 years ago (NPWS, 2004). The Broad-toothed rat is therefore a value of CERRA, and its existence contributes and helps maintain the biodiversity values of CERRA.

Details

As a value of CERRA, it is desired that the Broad-toothed rat populations be maintained, and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored in order to estimate the status of the species population, and ultimately the condition and integrity of the biodiversity of CERRA.

Current Status

The Broad-toothed rat has been identified in the New South Wales Fox Threat Abatement Plan (Fox TAP) as a species likely to be impacted on by fox predation. It is therefore currently monitored as part of the Fox TAP. This monitoring measures the response of the Broad-toothed rat population to fox control and shows whether the species is limited by fox predation. Importantly it allows for the detection of population trends.

Overall Approach

Monitoring of the Broad-toothed rat population should be undertaken as part of the Fox TAP.

Spatial Approach

At least one site should be monitored within Barrington Tops National Park (there is one site currently monitored through the Fox TAP) to cover the known geographical range of the species in CERRA.

Temporal Approach

Monitoring should be undertaken annually as per Fox TAP monitoring.

Sampling and Analysis

For each site and overall location, the abundance and relative abundance of the Broad-toothed rat should be delivered in accordance with the technique used by the Fox TAP. Sites should be compared with previous results to detect change in Broad-toothed rat populations. Sites of particular concern or change, such as those affected by a major event like fire, for example, should be monitored as well as compared with similar existing sites of the same habitat in the area.

EASTERN BRISTLEBIRD (NORTHERN)

Background

The Eastern Bristlebird (Northern) (*Dasyornis brachypterus monoides*) is a rare, shy and cryptic species. It is an attribute of two World Heritage natural criteria (i and iv). It is listed as Endangered by the New South Wales *Threatened Species Conservation Act 1995* and by the Queensland *Nature Conservation Act 1992*. It is also listed as Endangered by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The Eastern bristlebird is restricted to coastal eastern Australia occurring in CERRA in Lamington National Park, north New England National Park, Nightcap National Park and Border Ranges National Park (NPWS, 1999). Within and around the CERRA area, it is estimated that there are just 100 birds left (Cavanaugh, *pers. comm*.), with population numbers depleted due to habitat loss and fragmentation.

Details

As a World Heritage Value, it is vital that the Eastern bristlebird populations be maintained, and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored in order to understand the integrity of the species in itself, and as a value of the CERRA World Heritage Area.

Current Status

There is a current ongoing census of the Eastern bristlebird in northern New South Wales and southeast Queensland across all of its known territories. Eastern bristlebird habitat is also monitored for integrity of habitat condition.

Overall Approach

Due to the territorial nature of the Eastern bristlebird and low numbers, each known territory may be visited. At each site, using call play-back, bird numbers should be counted and recorded. Other potential territories should also be investigated for bird occupation (Stewart/Charley, *pers. comm*.).

Spatial Approach

Sites covering Eastern bristlebird territory in and near to CERRA at the following locations:

- New South Wales:
  - Border Ranges National Park;
  - Main Range National Park.
- Queensland:
  - Lamington National Park.

Temporal Approach

Surveys should be undertaken at a consistent time every year at the same sites, and any newly occupied sites.

Sampling and Analysis

For each site and overall location, Eastern bristlebird numbers should be compared with previous results to detect any changes in population numbers. Sites of particular concern or

change, such as those affected by a major event such as fire, for example, should be monitored as well as compared with similar existing sites of the same habitat in the area.

SPOTTED-TAILED QUOLL

Background

There are two sub-species of the Spotted-tailed quoll. *Dasyurus maculatus gracilis* occurs in a small isolated population in north Queensland, while *D. m. maculatus* occurs along the remainder of the east coast from southeast Queensland to Tasmania. This sub-species previously ranged over a much larger area, it is now distributed over a restricted range in isolated areas that may be too small to support long-term viable populations (NPWS, 1999).

The Spotted-tailed quoll is listed as Endangered by Queensland's *Nature Conservation Act 1992*; Vulnerable by the New South Wales *Threatened Species Conservation Act 199*5; and Endangered by the Commonwealth. Its range encompasses the whole of CERRA and it is a World Heritage Value of CERRA (iv). Its existence contributes to and helps maintain the biodiversity values of CERRA.

Details

As a World Heritage Value of CERRA and its biodiversity, it is desired that the Spotted-tailed quoll populations be maintained and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored in order to estimate the status of the species population, and ultimately the condition and integrity of the biodiversity of CERRA.

Current Status

The Spotted-tailed quoll is being monitored within CERRA, however this is not systematic. There is monitoring as part of 1080 baiting programs, research and monitoring by reserve management in some reserves and studies undertaken by a few researchers.

As part of a PhD project, Spotted-tailed quoll abundance and population trends will be investigated in the New England Tablelands bioregion over the next few years (Meyer-Gleaves, *pers. comm*.).

Overall Approach

Surveys should be undertaken at each site via trapping. One hundred wire traps should be placed at one site for approximately ten days to allow habituation. Four trapping nights should then be undertaken, after which they are closed for three nights, and set again for another four nights. The end result should be eight trapping nights over a two-week period. Animals should be tagged (microchipped) and measurements including weight, sex, tail length and circumference and nose length taken (Boyd-Law, *pers. comm*.).

Spatial Approach

Sites covering the range of the species in and near to CERRA, centred on the following locations in or close to CERRA:

- Werrikimbe National Park (eastern and western)
- New England National Park
- The Castles Nature Reserve
- Willi Willi National Park
- Washpool National Park
- Gibraltar Range

- Border Ranges National Park
- Barrington Tops National Park
- Iluka
- Lamington National Park
- Springbrook National Park
- Main Range National Park
- Mount Barney National Park

Temporal Approach

Surveys every three years are essential, however annual surveys are desirable. Full analysis and reporting on a CERRA-wide basis should be undertaken every three years.

Sampling and Analysis

For each site and overall location, the abundance and relative abundance of the Spotted-tailed quoll should be determined. Sites should be compared with previous results to detect change in Spotted-tailed quoll populations.

STREAM FROGS - THE BARRED RIVER FROGS

Background

There has been a significant decline in the number of stream frogs around the world. The decline has been rapid and species dependent on streams in wet forests, mainly rainforests, not species away from streams, have been affected (QPWS, 2002). As a result, many species of stream frogs have been classified as Endangered or Vulnerable. Both Fleay's barred-frog (*Mixophyes fleayi*) and the Giant barred-frog (*Mixophyes iteratus*) have been listed as Endangered by the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, the Queensland *Nature Conservation Act 1992* and the New South Wales *Threatened species Conservation Act 1995*.

CERRA provides a significant proportion of critical stream frog habitat. *M. fleayi* is currently known to occur in Queensland from Lamington plateau and the northern section of Main Range, the Mount Barney area and Currumbin and Tallebudgera Creeks below Springbrook Plateau (QPWS, 2002). In New South Wales, from Yabbra and Tooloom Scrubs, Mount Warning (Breakfast Creek), Terania and Turntable Creek catchments in the Nightcap Range, and Levers Plateau, Sheep Station and Brindle Creeks in the Border Ranges (QPWS, 2002). *M. iterates* is currently known in Queensland from scattered locations in the Mary River catchments downstream to about Kenilworth, Mariachi River, Upper Stanley River, Absoluter River, Burpengary Creek and Coomera River (QPWS, 2002). In New South Wales, it has suffered major declines in the southern, central and western portions of its range. Currently one population is known between the Hunter River and Macleay catchment at Mount Seaview. A population was recently located in the southern Nambucca River catchment. North of the catchment there are currently a substantial number of populations in the Dorrigo-Coffs Harbour area, North Washpool State Forest and Bungawalbin State Forest (QPWS, 2002).

Hunter (2003) identified the decline in populations of native frogs as an existing threat to CERRA. Therefore native frogs, particularly those that are Endangered or Vulnerable, are a value of CERRA, and each and every species contributes to and helps maintain the biodiversity values of CERRA. *M. fleayi* and *M. iterates* are attributes of two World Heritage natural criteria (i and iv). In addition, stream frogs are an indicator of stream condition.

Details

As a World Heritage Value, it is important that stream frog populations be maintained and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus the number of species present, and known declines of species and population trends of *M. fleayi* and *M. iterates*, should be monitored in order to understand the integrity of species of stream frog and *M. fleayi* and *M. iterates* populations as an indicator of the integrity of stream condition.

Stream frogs are exposed to both terrestrial and aquatic environments during their life cycles and, having highly permeable skin, are highly susceptible to environmental changes. Therefore they can be indicators of environmental health (QPWS, 2002), particularly stream condition. Any increase in stream frog population numbers may be attributed to improving environmental conditions. Conversely however, any decrease in stream frog population numbers may be a result of deteriorating environmental conditions, thus poor stream condition.

Notes

Monitoring in the future should extend further than the stream environment to encompass other rare species which are susceptible to climate and could therefore be good indicators of

climate change (Harry Hines, *pers. comm*.). Frogs could also be an indicator of visitation pressure, which should be investigated (David Newell, *pers. comm*). Finally, the whistling tree frog may be a separate population in CERRA, and if that is the case it will be one of the most endangered of all frog species, warranting consideration of monitoring in its own right (Michael Mahoney, *pers. comm*).

Current Status

In Queensland, there is a current recovery plan (QPWS, 2002) applicable to six species of stream frogs including *M. fleayi* and *M. iterates*. According to the plan, intensive monitoring of a small number of populations will be undertaken over several years to provide detailed information on population dynamics and ecology. Extensive monitoring will also be undertaken to assess the status of species over a broad geographical area. In addition, remote or previously unsurveyed areas will be targeted for surveys to locate new populations and to determine trends in distribution patterns of species over a greater geographical area.

In New South Wales, there is not a current recovery plan for any of the stream frog species. Monitoring is undertaken by a few researchers, but encompasses stream frogs and *M. fleayi* and *M. iterates*. Currently, a model based on age class structure is being developed to allow prediction of frog populations using a standard method (M. Mahoney, *pers. comm*.).

Overall Approach

For monitoring of species of stream frogs, 100 metre transects along rainforest streams should be traversed at night for a minimum of 20 person-minutes (number of observers x time). Using a 30-watt spotlight, all stream frogs seen and heard calling should be counted. This survey should be undertaken in standard weather conditions at all sites (see Goldingay, *et al*. 1999).

To estimate population trends of *M. fleayi* and *M. iterates*, transects at each of the sites should be repeated and mark-recapture methods employed.

When compared to other survey years, population and species assemblage trends can be determined and from this it can be discerned as to whether further action needs to be taken. This may be in order to understand and prevent possible species and population decline, or to investigate a possible change in environmental or stream condition that may be highlighted through changes in numbers of stream frog species or *M. fleayi* and *M. iterates* populations in certain sites.

Spatial Approach

Approximately 30 sites should be surveyed in and near to CERRA at the following locations:

- New South Wales:
  - Barrington Tops National Park;
  - Werrikimbe National Park;
  - Washpool National Park;
  - Yabbra;
  - Nightcap National Park;
  - Border Ranges;
  - Limpinwood National Park;
  - Mebbin National Park;

  - Mount Warning National Park;
  - Richmond Range National Park; and
  - Tooloom National Park.

- Queensland:
  - Lamington National Park;
  - Springbrook National Park;
  - Main Range National Park;
  - Mount Barney National Park; and
  - Goomburra Forestry Reserve.

Note, all sites have or are currently targeted for surveys using the same or similar methods described.

Temporal Approach

Surveys should be undertaken annually in summer, autumn and spring.

Sampling and Analysis

For each site and overall location, numbers of stream frog species should be compared with previous results to detect any changes in abundance of each species, or decline of numbers of species.

Data obtained through mark-recapture for *M. fleayi* and *M. iterates* should be analysed in accordance with the standard technique to obtain population numbers. Similarly, for each site and overall location, *M. fleayi* and *M. iterates* population numbers should be compared with previous results to detect any changes in populations.

THE HASTINGS RIVER MOUSE

Background

The Hastings River mouse (*Pseudomys oralis*) is currently listed as Endangered by the New South Wales *Threatened Species Conservation Act 1995* and by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. It is also listed as Vulnerable by the Queensland *Nature Conservation Act 1992*. With a previous range from north of Brisbane south to the New South Wales/Victoria border, the species is now restricted to between the Main Range and the Barrington Tops area. Recent genetics studies have found that the Hastings River mouse is divided into two populations or 'clades' – a southern clade and a northern clade. CERRA contains significant areas of Hastings River mouse habitat and many sites in which the species of both clades is known to occur fall within CERRA (NPWS, 2003). The Hastings River mouse is therefore a World Heritage Value to CERRA (iv.), and its existence contributes to and helps maintain the biodiversity values of CERRA.

Details

As a World Heritage Value of CERRA, it is desired that the Hastings River mouse populations be maintained and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored in order to estimate the status of the species population, and ultimately the condition and integrity of the biodiversity of CERRA.

Current Status

According to the New South Wales National Parks and Wildlife Service *Draft Hastings River Mouse Recovery Plan* (NPWS, 2002), standard monitoring procedures will be used to monitor Hastings River mouse management sites annually. Baseline data on the population dynamics will be established and monitoring may also be triggered by a disturbance event. A database will also be updated regularly.

Overall Approach

Surveys should be undertaken at each site via trapping. One to two grids of Elliot traps should be set at each site overnight for four consecutive nights. Total trapping effort for each survey should be no less than 1000 Elliot trap-nights. Individuals captured should be tagged, and information including age, sex and weight recorded, and released from point of capture.

Spatial Approach

Sites should be established based in the following areas in or close to CERRA:

- New South Wales:
  - Mount Royal – Forest site (private land);
  - Carrai Plateau – Oxley Wild River National Park (road site);
  - Dorrigo-Styx River – Mount Hyland Nature Reserve (Blicks River 4);
  - Styx River State Forest;
  - Gibraltar Range – Glen Elgin State Forest (Gibraltar 4);
  - Washpool East – Washpool National Park (Stewarts Creek 5);
  - Washpool West – Washpool (west) National Park (Boundary Creek); and
  - Border Ranges – Border Ranges National Park (Grady's Creek North).

- Queensland:
  - Lamington – Lamington National Park (Duck Creek Road- Freehold Land); and
  - Gambubal – Gambubal FR (Gambubal 1).

Temporal Approach

Monitoring should be undertaken annually in accordance with the recovery plan (NPWS, 2002). Full analysis and reporting on a CERRA-wide basis should be undertaken every three years.

Sampling and Analysis

For each site and overall location, the abundance and relative abundance of the Hastings River mouse should be determined in accordance with the technique proposed in the *Draft Hastings River Mouse Recovery Plan* (NPWS, 2002). Sites should be compared with previous results to detect change in Hastings River mouse populations. The Hastings River Mouse Database should be updated every year to coincide with the collection of annual data.

Notes

The number of sites and specific locations of sites cannot be confirmed or may be regularly updated. Presence and absence of the Hastings River mouse at a given location can vary, the reason for this is not understood. In addition, it is likely that there are significant populations of the Hastings River mouse that have not yet been located (see Recovery Plan). Therefore further research is required. There are provisions for this within the *Hastings River Mouse Recovery Plan* (refer to Page 17 in particular).

RUFOUS BETTONG

Background

The Rufous bettong (*Aepyprymnus rufescens*) is listed as Vulnerable by the New South Wales *Threatened Species Conservation Act 1995*. It is not listed by the Queensland *Nature Conservation Act 1992*. The species occurs patchily through eastern Queensland from Cooktown south to northeastern New South Wales, once more widely distributed from Coen in northern Queensland to central Victoria and west to the Murray-Darling Basin. Although poorly known, population isolates are likely in northeast New South Wales. The population in the Mount Royal-Barrington Tops Area, part of CERRA, appears clearly isolated. The Rufous bettong as a Vulnerable species is therefore a World Heritage Value of CERRA (iv.), and its existence contributes to and helps maintain the biodiversity values of CERRA.

Details

As a World Heritage Value of CERRA, it is desired that the Rufous bettong populations be maintained and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored in order to estimate the status of the species population, and ultimately the condition and integrity of the biodiversity of CERRA.

Current Status

The Rufous bettong has been identified in the New South Wales Fox Threat Abatement Plan (Fox TAP) as a species likely to be impacted on by fox predation. It is therefore currently monitored as part of the Fox TAP. This monitoring measures the response of Rufous bettong populations to fox control and shows whether the species is limited by fox predation. Importantly it allows for the detection of population trends.

Overall Approach

Monitoring of Rufous bettong populations will be undertaken as part of the Fox TAP.

Spatial Approach

Sites centred on the following locations in or close to CERRA:

- Yabbra (current monitoring as part of Fox TAP);
- Mount Royal National Park (site established but no current monitoring as part of Fox TAP);
- Koorelah National Park (site established but no current monitoring as part of Fox TAP);
- Tooloom National Park (site established but no current monitoring as part of Fox TAP); and
- Richmond Range (site established but no current monitoring as part of Fox TAP).

Temporal Approach

Monitoring should be undertaken annually as per Fox TAP monitoring.

Sampling and Analysis

For each site and overall location, the abundance and relative abundance of the Rufous bettong should be delivered in accordance with the technique used by the Fox TAP. Sites should be compared with previous results to detect change in Rufous bettong populations. Sites of particular concern or change, such as those affected by a major event like fire, for

example, should be monitored as well as compared with similar existing sites of the same habitat in the area.

NORTH COAST LEAF-TAILED GECKO

Background

The North Coast Leaf-tailed gecko (*Saltuaris swaini*) has been identified as a World Heritage Value (i.). It is one of the largest Australian geckos, and usually inhabits rainforest and wet and moist sclerophyll forests from close to sea level to over 1000 metres altitude. The species is confined to northeastern New South Wales and far southeastern Queensland. Isolated populations are likely given the patchy pattern and of its distribution. In New South Wales the species is protected under the *National Parks and Wildlife Act* 1974, however it is not listed in Queensland.

Details

As a World Heritage Value, it is desired that the North Coast Leaf-tailed gecko populations be maintained and enhanced where numbers have significantly decreased due to anthropogenic affects. Thus present population trends should be monitored and determined in order to understand the integrity of the species.

Current Status

In 1998, a vertebrate fauna survey was undertaken as part of the comprehensive regional assessments of forests in New South Wales. The project aimed to obtain comprehensive data on fauna distributions. There were four main objectives – collation and checking of existing data; identification of environmental, geographical and taxonomic gaps in existing data; systematic and targeted survey to fill the identified gaps; and entry and storage of final digital dataset. Systematic surveys were undertaken using standard techniques conducted at standard sites. Four hundred and fifty sites were systematically surveyed in northern New South Wales (the upper northeast and lower northeast CRA regions). These surveys provide a benchmark for monitoring in that they can be repeated to determine any deviations in population distribution and species assemblages.

Overall Approach

In surveying the North Coast Leaf-tailed gecko, a half-hectare plot (50 x 100 metres) should be sampled at each survey site. The census should be restricted to mid-morning or mid-afternoon to late afternoon. The area should be actively searched, and the search should be standardised to one-person hour at each site.

Spatial Approach

In accordance with Vertebrate Fauna Survey (NPWS, 1998)

Temporal Approach

Census should be undertaken at least every three years.

Sampling and Analysis

In accordance with Vertebrate Fauna Survey (NPWS, 1998)

ARBOREAL FAUNA

Background

There is a high proportion of Australian marsupials threatened with extinction. The main causes of extinction and decline have been identified and include the introduction to Australia of predators such as the red fox and feral cat, habitat destruction through land clearing and changed fire regimes (Maxwell *et al.* 1996).

Arboreal species within CERRA include:

- Brush-tailed Phascogale;
- Common Planigale;
- Common Dunnart;
- Northern Brushtail possum;
- Mountain Brushtail possum;
- Common brushtail possum;
- Feathertail Glider;
- Eastern Pygmy possum;
- Greater Glider;
- Yellow-bellied Glider;
- Sugar Glider;
- Squirrel Glider;
- Common Ringtail possum; and
- Koala.

These species are generally in the Lower Risk category on the IUCN Red List, however all populations of these species have declined by 10% to 50% (Maxwell *et al.* 1996).

Details

All marsupials are of Gondwanan origin and are thus a World Heritage Value (Hunter, 2003). Therefore, as representatives of arboreal species within CERRA, those species listed above should be monitored to ensure that the integrity of these species is maintained.

Current Status

In 1998, a vertebrate fauna survey was undertaken as part of the comprehensive regional assessments of forests in New South Wales. The project aimed to obtain comprehensive data on fauna distributions. There were four main objectives – collation and checking of existing data; identification of environmental, geographical and taxonomic gaps in existing data; systematic and targeted survey to fill the identified gaps; and entry and storage of final digital dataset. Systematic surveys were undertaken using standard techniques conducted at standard sites. Four hundred and fifty sites were systematically surveyed in northern New South Wales (the upper northeast and lower northeast CRA regions). These surveys provide a benchmark for monitoring in that they can be repeated to determine any deviations in population distribution and species assemblages.

It is understood that there is a program of repeated spotlighting at Dorrigo, however the survey approach has not been confirmed.

Overall Approach

To survey arboreal species, foot-based spotlighting should be used. These should be undertaken along a 2 kilometre transect running between and through the gully, misdone and ridge site within each stratum. All arboreal species seen or heard within 50 metres of the transect should be identified and recorded.

Spatial Approach

In accordance with Vertebrate Fauna Survey (NPWS, 1998).

Temporal Approach

Surveys should be undertaken at least every three years.

Sampling and Analysis

In accordance with Vertebrate Fauna Survey (NPWS, 1998).

FIRE

Background

Fire has been listed as an existing threat by Hunter (2003) and by various park management plans, some of which categorise fire as a major threat to the integrity of the Park. Rainforest species and vegetation are generally fire sensitive, but rainforest often abuts fire prone vegetation or is embedded in a landscape that is susceptible to fire events (Hunter, 2003). However, in other forest types, fire is essential for numerous ecosystem functions. Therefore an appropriate fire regime must be applied that suits both the rainforest patch and the ecology of the surrounding landscapes (Hunter, 2003). A fire management plan helps ensure the identification and application of an appropriate fire regime, as well as the identification and application of measures to protect the park and surrounds from wildfire.

Details

As a potential major threat and as an essential component of ecosystem function, it is important that fire activities across and around CERRA be monitored. This is to ensure that appropriate fire management is applied through the monitoring of unplanned fire, particularly that in fire sensitive forest, the origin of fires and the implementation of appropriate management plans.

Current Status

There is currently good Geographic Information System (GIS) coverage of fire in New South Wales, and Queensland uses a similar system. Fire mapping is thus a whole-of-CERRA activity and is expanding into off-park areas. A situation report includes the fire alert, extinguishing of the fire and then a GIS-based map of data recording of the event. (Cavanaugh, *pers. comm*.).

Overall Approach

Monitoring, from the GIS coverage of fire within and adjacent to CERRA, should cover (Key: ✓ Essential; • Worthwhile):

- ✓ The hectares of unplanned fire;
- ✓ The hectares of fire in fire-sensitive forest;
- ✓ The proportion of fires that start on-park and escape the park boundary to off-park areas, and the number of hectares burnt;
- • The proportion of fires that start off-park and escape the park boundary to on-park areas, and the number of hectares burnt.

In addition to the above, the following should also be monitored:

- ✓ Fire management plans per reserve;
- • An index of fire management plan implementation.

Note, in order to compile the results across both New South Wales and Queensland for CERRA, undertake an evaluation of the data collected, mapping parameters and data storage to ensure single whole-of-CERRA analysis can be undertaken.

Spatial Approach

Monitoring should cover all parks and reserves, and surrounding land where relevant.

Temporal Approach

Fire monitoring through GIS coverage should be undertaken annually, after each fire season. Monitoring of fire management plans and their implementation should be undertaken every three years.

Sampling and Analysis

Sampling is an ongoing process as part of current fire management of the CERRA reserves. A data set should be compiled every three years, and at least the above 'desirable' parameters requested for each year for each CERRA reserve.

WEED CONTROL

Background

Exotic plant species have been identified as a threat to the integrity of the CERRA World Heritage Values. There are a number of pest plant species within the reserves of CERRA, which are significant because of the extent of their distribution within rainforest or because of the severity of their impact (Hunter, 2003).

Details

Due to the threat that weeds pose to CERRA, the issue must be monitored in order to gauge the severity of the threat and the adequacy of management actions in addressing the issue. The overarching aim is to ensure that the integrity of the CERRA World Heritage Values are not degraded due to weed invasion.

Current Status

The New South Wales State of the Parks report requires a number of indicators relating to weed issues to be measured. These include quantitative and qualitative indicators.

Quantitative indicators:

- Number of weed issues on-park, where a weed species is likely to have a significant impact on heritage values within the park
    - o Proportion of weed biodiversity conservation issues for which there is an effective control program.

Qualitative indicators:

- Evaluation of weed management.

It is understood that an annual report on pest animals and weeds is produced for New South Wales National Parks each year.

Overall Approach

The evaluation of weed control should measure (Key: ✓ Essential; • Desirable):

- ✓ The species of weeds per reserve;
- ✓ The number of invasive species;
- ✓ The scale of infestation or degree to which weeds have penetrated the reserve; and
- • Weed control activities.

Spatial Approach

The evaluation of weed control should be undertaken within each reserve.

Temporal Approach

The evaluation of weed control should be undertaken every three years to coincide with the New South Wales State of the Parks.

Note

State of Parks is still being refined. Queensland does not participate in State of the Parks.

FERAL ANIMAL CONTROL

Background

Exotic animal species have been identified as a threat to the integrity of the CERRA World Heritage Values. There are a number of pest animal species within the reserves of CERRA, and major species include feral pigs, foxes and cats (Hunter, 2003).

Details

Due to the threat that feral animals pose to CERRA, the issue must be monitored in order to gauge the severity of the threat and the adequacy of management actions in addressing the issue. The overarching aim is to ensure that the integrity of the CERRA World Heritage Values are not degraded due to feral animal invasion.

Current Status

The New South Wales State of the Parks report requires a number of indicators relating to pest-animal issues to be measured. These include quantitative and qualitative indicators.

Quantitative indicators:

- Number of pest-animal issues on-park, where a vertebrate pest species is likely to have a significant impact on heritage values within the park.
    - Proportion of pest biodiversity conservation issues for which there is an effective control program.

Qualitative indicators:

- Evaluation of pest animal control.

It is understood that an annual report on pest animals and weeds is produced for New South Wales National Parks each year.

Overall Approach

The evaluation of feral animal control should measure (Key: ✓ Essential; • Worthwhile):

- ✓ The species of feral animals per reserve;
- ✓ The number of invasive species;
- • The degree to which feral animals have penetrated the reserve; and
- • Feral animal control activities.

Spatial Approach

The evaluation of feral animal control should be undertaken within each reserve.

Temporal Approach

The evaluation of feral animal control should be undertaken every three years to coincide with the New South Wales State of the Parks.

Note

State of Parks is still being refined. Queensland does not participate in State of the Parks.

BELL MINER ASSOCIATED DIEBACK

Background

Bell Miner Associated Dieback (BMAD) has been identified as a threat to the integrity of the CERRA World Heritage Values. It is currently spreading rapidly through forest ecosystems throughout Australia, thus it is of national significance (BMAD Strategy, 2004).

Eucalypt dieback is strongly associated with sap feeding insects. It is also sometimes associated with the native Bell Miner (*Manoria melanophrys*) and has become common in some parts of the birds range. Increases in Bell Miner populations and their distribution, in addition to other factors, have all been implicated in the spread of dieback. Effects of BMAD include extreme degradation of forest ecosystems, major disruption in ecosystem function and increased weed invasion. The potential impacts of BMAD on forest productivity and biodiversity cannot be overstated. Dieback occurs within both wet and dry sclerophyll forest communities (BMAD Strategy, 2004)

Details

The spread and intensity of BMAD must be monitored to gauge the affect it is having across CERRA, and enable the appropriate actions to be undertaken in the appropriate areas. Therefore the spread of BMAD in hectares should be tabulated, and the response to this threat measured over time. The overarching aim should be to ensure that BMAD does not degrade the integrity of the CERRA World Heritage Values.

Current Status

Currently a final draft BMAD Strategy (May, 2004) has been produced, which outlines an approach with key actions that need to be undertaken in order to develop effective management measures for BMAD. It only applies to BMAD affected and potentially affected areas of northern New South Wales due to a number of different interests in this area, including biodiversity value.

Identified key actions include establishing representative and long-term monitoring programs to detect change in extent and degree of BMAD over time, and supporting the development of accurate GIS mapping products to display the extent and severity of BMAD.

Currently there is no reporting system requiring ongoing evaluation of BMAD.

Overall Approach

Monitoring of BMAD should include (Key: ✓ Essential; • Worthwhile):

- ✓ Tabulating the extent of BMAD in hectares; and
- • Evaluating the response to BMAD.

Spatial Approach

The evaluation of BMAD should be undertaken within two tiers – each reserve, and CERRA as a whole.

Temporal Approach

The evaluation of BMAD should be undertaken every two years to allow detection of change within a time period that allows response before irreversible damage.

Note

Evaluation of BMAD through the BMAD Strategy requires expansion to encompass CERRA within the lower northeast New South Wales and southeast Queensland.

VISITATION

Background

As at 2003, approximately 2 million visitors visit the CERRA World Heritage Area annually – approximately 1.4 million visitors in Queensland, and approximately 0.6 million visitors in New South Wales (Periodic Report, 2003). At present, recreation and tourism are generally in the low risk category, and high risk category at activity/access nodes. However, recreation and tourism are considered a potential threat to the ongoing viability of the CERRA World Heritage Values, especially when coupled with other urbanisation and increasing population pressures (Environment Australia, 2003). Conversely, visitation provides significant economic revenue to the region. In 1995, Dorrigo National Park was estimated to contribute over $4 million to the regional economy (Powell and Chambers, 1995), and its recreational value estimated at $5.4 million per year (Bennett, 1995). Therefore while visitation is valued, if not needed for its economic input, it is of the utmost importance that it be monitored to ensure that it does not degrade the integrity of the CERRA World Heritage Values.

Details

In order to maintain and enhance visitation while protecting the integrity of World Heritage Values, a number of components must be monitored as part of the strategy. These include, but are not necessarily limited to traffic counts and/or visitor numbers as well as number of sites visited, visitor satisfaction and behaviour, and biophysical impacts.

Current Status

Currently a Visitor Data System (VDS) is being developed and implemented in both New South Wales and Queensland. The VDS has a traffic counter module including vehicle and pedestrian counts and a visitor survey module. The traffic counter module has been trialled and is now in the final stages of implementation. The visitor survey module is still in draft form, and has thus not yet been implemented.

Monitoring of biophysical impacts is undertaken in all parks and reserves, however these activities are generally not organised and standardised at the whole-of-CERRA level. Therefore monitoring is undertaken to varying degrees using a variety of methods. Examples of current biophysical impact monitoring include monitoring and assessment of lookouts in Limpinwood Nature Reserve, bush campsite monitoring in the Parks of the Scenic Rim, and general visitor activity impacts monitoring including camping, hiking and horseriding in Border Ranges National Park.

The number of visitors and the number of sites visited are reported on in the New South Wales State of the Parks Report in the quantitative component. Further, visitor numbers are required to be reported in the qualitative component and the Ecologically Sustainable Forest Management Report.

Overall Approach

The VDS should be implemented in all key visitor destinations. The traffic and pedestrian counters will provide monthly and/or periodic summaries as well as data describing visitation during public and school holidays. It will also provide executive summaries showing trends both within and between parks. The visitor surveys will provide information primarily concerning visitor satisfaction, awareness and economic value. Use of this standard survey and analysis through the VDS allows for comparisons within and between parks. The VDS should also be used to derive the number of sites visited and some indication of visitor impacts.

Spatial Approach

The VDS should be implemented within or near to the following CERRA reserves (sites in bold represent priority sites.

- Border Ranges National Park:
  - Bar Mountain (currently 3 vehicle and 1 pedestrian counter operational);
  - Sheepstation Creek (currently 4 vehicle counters operational);
  - Pinnacle Walking track (1 pedestrian counter operational?);
  - Tweed Range Scenic Drive (2 vehicle counters currently operational?);
  - Border Loop Lookout (1 vehicle counter currently operational?).
- Dorrigo National Park:
  - Dorrigo Rainforest Centre (currently 2 vehicle and 2 pedestrian counters operational).
- Barrington Tops National Park:
  - Barrington Trail (no counters currently operational);
  - Gloucester Tops (no counters currently operational);
  - Williams River (no counters currently operational);
  - Carries Peak Lookout (2 pedestrian counters currently not operational);
  - Honeysuckles Loop Walk (pedestrian and vehicle counter currently not operational);
  - Polblue camping (1 vehicle counter currently not operational).
- Nightcap National Park:
  - Minyon Falls (currently 2 vehicle and 2 pedestrian counters operational);
  - Minyon Grass (currently 2 vehicle and 2 pedestrian counters operational);
  - Walking tracks (8 counters priority);
  - Terania Creek (1 traffic counter operational?);
  - Mount Nardi (1 vehicle counter currently operational?).
- Gibraltar Range:
  - Mulligans Hut (1 vehicle counter currently not operational).
- Washpool National Park (currently 4 vehicle counters operational).
- Mount Warning National Park (currently 2 vehicle and 2 pedestrian counters operational).
- Koreelah National Park:
  - Koreelah Creek Camp (1 vehicle counter currently not operational).
- New England:
  - Pt Lookout Rd (1 vehicle counter not operational).
  - Horseshoe Rd (2 vehicle counters currently not operational).

- Werrikimbe National Park:
  - Mooraback (vehicle counter currently not operational).
  - Race Course (1 vehicle counter currently not operational).

- Oxley Wild Rivers National Park :
  - Gara (1 vehicle counter currently not operational);
  - Tia Falls (1 vehicle counter currently not operational);
  - Dangar Falls (1 vehicle counter currently operational?);
  - Apsley Falls (1 vehicle counter currently operational?);
  - Wollomombi (1 vehicle counter currently operational?);
  - Long Point (1 vehicle counter currently operational?);
  - Raspberry Rd (1 vehicle counter currently not operational).

- Iluka Nature Reserve:
  - Iluka Bluff Car park (currently 1 vehicle and 1 pedestrian counter operational).

- Queensland (these sites need to be established):
  - Lamington National Park;
  - Springbrook National Park;
  - Main Range National Park;
  - Mount Barney National Park;
  - Spicers Gap Conservation Park/Forestry Reserve;
  - Goomburra Forestry Reserve.

Temporal Approach

The VDS should be undertaken at least every three years.

Sampling and Analysis

Data from the counters should be analysed to give annual numbers, annual visitor trends and number of sites visited, where possible, for each reserve within which they are installed for each region and for CERRA as a whole. However where required, seasonal, monthly, weekly or daily trends should be derived to recognise peak times. The visitor survey should be analysed through the VDS.

IMPLEMENTATION OF MONITORING STRATEGY

GAP ANALYSIS

The following section sets out what has not yet been established and needs to be implemented to establish the Monitoring Strategy.

Coordination, Reporting and Analysis

The most fundamental gap in terms of current activity and what needs to be undertaken to implement a Monitoring Strategy for CERRA is an integrated coordination, reporting and analysis program. Further, there is not one metadata set of the monitoring programs, agencies and individuals involved, methods, site locations, results, analysis of trends and review of the efficacy of each monitoring indicator.

To avoid any doubt, the need of ongoing coordination, reporting and analysis is considered the major gap in being able to establish a monitoring program for CERRA which is likely to meet the proposed objectives. It is recognised that this will require additional (or a redirection of) resources.

Indicators

Most of the indicators selected for this Monitoring Strategy are currently or will be measured through other means, specifically through New South Wales State of the Parks reporting and Ecologically Sustainable Forest Management (ESFM) reporting. Species selected as indicators have been or are monitored, although rather sporadically across CERRA, through various plans such as the Fox Threat Abatement Plan and Species Recovery Plans. There are however, a number of significant gaps that need to be addressed. These include indicators without methods of measurement, indicators with the means for measurement that are not measured, and those which are measured but do not encompass the whole-of-CERRA. The following gap analysis will target and analyse these gaps so that they can be addressed in the necessary areas.

Essential Indicators Needing Development

The Monitoring Strategy has identified indicators that are Essential, Desirable or Worthwhile. Essential indicators are of the highest priority to be measured. Each Essential indicator must be measured in order to gain some understanding of the integrity of the CERRA World Heritage Values.

The following Essential indicators for CERRA needed to be investigated and methods developed for:

- Length of the boundary of CERRA with an intact natural ecosystem (more than 250 meteres) outside the reserve boundary.
- The percentage of forest cover in upstream catchments.
- Climate monitoring.
- *IKONOS* vegetation ‘transects’ on ecotones and at extremes of bioclimatic variables.

Without the development and use of these indicators, a significant hole in the Monitoring Strategy would result, particularly in regards to measuring climate change which, as a realistic potential threat, could devastate the values for which CERRA was inscribed on the World Heritage List.

Essential Indicators not Currently Monitored within CERRA

The following Essential indicators for CERRA are not currently monitored within CERRA:

- Arboreal fauna;
- North Coast Leaf-tailed gecko;
- Scale of infestation or degree to which weeds have penetrated each reserve; and
- Number of Threat Abatement Plans.

Methods to measure the above indicators have been developed and can thus be applied with relative ease, however they do need to be applied across CERRA in a coordinated manner. The above fauna need to be monitored in order to fill the suit of key species selected to adequately measure the integrity of biodiversity. Similarly, weeds and Threat Abatement Plans need to be monitored in order to measure the status of threats which compromise the integrity of the CERRA World Heritage Values.

Currently Monitored Essential Indicators Needing Additional Site Coverage

The following Essential indicators are monitored within CERRA, however not in the required whole-of-CERRA spatial approach (areas in brackets require monitoring):

- Percentage of CERRA in IUCN Category I or II (Queensland);
- Management Resources: Funding and Staff (Queensland);
- Number of extinct species (Queensland);
- Threatened and Endangered Taxa: Number of species in each of the IUCN categories (Queensland);
- Rufous scrub-bird (Queensland);
- Albert's lyrebird (Queensland and some parts of New South Wales);
- Rufous bettong (Queensland and some parts of New South Wales);
- Vegetation: Network of 20 x 20 metre plots at extremes of bioclimatic variables (southern areas of CERRA);
- Species of weeds per reserve (Queensland);
- Number of invasive species (Queensland);
- Species of feral animals per reserve (Queensland);
- Number of invasive feral animals (Queensland);
- Bell Miner Associated Dieback: Hectares affected (Queensland and some parts of New South Wales);
- Threatened Species Recovery Plans: Percentage of Recovery plans per number of species (Queensland); and
- Number of sites visited (Queensland).

Many of these indicators are being, or will be, measured in New South Wales through the requirements of State of the Parks and ESFM. Queensland however, does not have such reporting requirements, therefore there is no requirement to monitor these indicators. Integrity statements in the future may provide an avenue for monitoring, however this framework has not been developed.

In the event where the indicators listed above are not applied across CERRA, a relatively good understanding of the values of the New South Wales reserves can be gained. However, CERRA has been inscribed on the World Heritage List due to World Heritage Values of the reserves in both New South Wales and Queensland, all reserves together make up one World Heritage Area. Therefore, any deterioration of integrity of World Heritage Values in one area means that the integrity of the CERRA World Heritage Values as a whole are not being maintained. Thus, it is most important that Queensland, and other required areas of CERRA, are monitored equally so that conditions of integrity are met and CERRA as a World Heritage Area is conserved for generations to come.

The following Essential indicators are monitored across CERRA, however not in the required coordinated ongoing manner:

- Frogs: Stream dwelling frog species diversity and abundance;
- Spotted-tailed quoll; and
- Vegetation monitoring: Permanent one hectare plots.

In the case of the species listed above, there is, or has been at some point, quite extensive monitoring across all of CERRA. This monitoring is rather sporadic or not coordinated in such a manner that the results obtained can be easily translated to derive meaning that applies to CERRA as a whole. Similarly, permanent plots have been established in various parts of CERRA that have been and are monitored at various times by different researchers or agencies for various reasons.

Gap Analysis: Desirable Indicators

The following list of Desirable indicators are those in which there is a gap. Desirable indicators, although not essential to measure in order to gain some understanding of the integrity of the CERRA World Heritage Values, are essential for a good reliable understanding.

Desirable indicators which are not currently monitored within CERRA:

- Index for Strategic Plan implementation;
- Index for each Management Plan implementation;
- Number of different illegal activities;
- Freshwater crayfish;
- Key habitat integrity: Monitor the condition of selected species;
- Water quality monitoring: In streams in CERRA; at key pollution sites; and in streams flowing into CERRA;
- Number of re-vegetation/rehabilitation projects/activities;
- An improving awareness of and attitude towards the environment in the CERRA area; and
- Area of land outside of CERRA zoned for conservation purposes.

Desirable indicators monitored within CERRA, however not in the required whole-of-CERRA spatial approach:

- The extent to which institutional arrangements support the conservation and protection of CERRA (Queensland);

- Number of incidences of illegal activities (Queensland);
- Management Resources: In kind (Queensland);
- Fragmentation: Hectares of linear disturbance (roads/powerlines) through the reserves (Queensland);
- Habitat condition: Hectares of disturbed habitat (Queensland);
- Fire management plans per reserve (Queensland);
- Number of listed/recorded indigenous sites (Queensland);
- Number of listed/recorded non-indigenous sites (Queensland);
- Weed control activities (Queensland);
- *Phytophthora cinnamomi*: Hectares affected (some areas of CERRA);
- Hectares of active erosion within each reserve (Queensland); and
- Hectares of erosion control within each reserve (Queensland)

Most Desirable indicators listed above have methodologies available for measurement and have been monitored, and possibly still are. Therefore application could be undertaken with relative ease. However, it would be most efficient to apply those indicators currently measured in some areas of CERRA but not all. For most indicators, this entails measurement and reporting in Queensland.

Gaps in CERRA monitoring which this Monitoring Strategy endeavours to fill can ultimately equate to the requirement of further funds, time and effort. However this view should not be taken, rather any gaps in monitoring of particularly essential indicators should be viewed as a significant flaw in the management of CERRA, or any protected area for that matter. Without correcting this flaw, the protection and conservation of the CERRA World Heritage Values may be compromised. Therefore, in consideration, any means should be employed to fill these gaps, to enable monitoring of at least the essential indicators as described in this monitoring strategy.

Summary of Gap Analysis

The overall summary of the gap analysis is that there is a need to:

- establish monitoring coordination;
- establish a reporting and analysis program;
- establish a meta data program of CERRA monitoring;
- research potential application of new essential indicators; and
- extend many essential indicators to other areas not presently covered within CERRA (often Queensland).

STRATEGIES TO ESTABLISH A CERRA MONITORING PROGRAM

This section sets out the strategies required to implement a monitoring program that will meet the objectives for this Monitoring Strategy. The key aspects are:

- Monitoring Metadata;
- Monitoring Coordination;
- Monitoring of Essential Indicators;
- Monitoring Integration;

- Monitoring Analysis;
- Monitoring Reporting;
- Development of New Indicators; and
- Ongoing Review of Program.

Monitoring Metadata

Whilst the development of this monitoring strategy has attempted to undertake a compilation of current monitoring (and research which could form the basis for ongoing monitoring) a complete metadata set has not been developed. This is despite more than 60% of the effort for the development of this monitoring strategy being applied to identifying previous research and monitoring. In many cases details of methodology, sites, results and ongoing work are not documented in any published (or unpublished) form.

It is recommended that a metadata set be developed for the existing research and monitoring being undertaken in CERRA and that there be a modest program to maintain this metadata set.

Monitoring Coordination

Those essential indicators identified, which are monitored presently, are implemented by many and various agencies with a variety of imperatives (many not focussed on CERRA). The overall strategy is to harness this effort so that objectives of CERRA are met. Further, in accordance with the Gap analysis above, there are many indicators that need further development or need present work extended to other sites within CERRA. These are often in different jurisdictions (agency, state, region, tenure etc.).

In order to achieve an integrated monitoring program, it is recommended that there be a coordination system established for the CERRA Monitoring Program.

It is suggested that reasonable progress could be achieved in this monitoring coordination with a half time professional/research officer.

The CERRA Technical and Scientific Advisory Committee do presently provide a peer review and advisory role for CERRA management and monitoring coordination.

It is suggested that the TSAC have a formal role of oversighting the CERRA Monitoring Program coordination.

Monitoring of Essential Indicators

The actual monitoring of the essential indicators needs to be resourced. The establishment of monitoring is of necessity a long term commitment. Key strategies recommended are:

For essential indicators that are presently monitored in all required locations, attempt to ensure long term commitment to measuring the indicator.

For essential indicators that need research to develop indexes or approaches to monitoring the indicator, seek expertise and resources to research indexes, approaches and sites.

For essential indicators where there are appropriate indexes, methods etc. but additional sites need to be monitored, seek resources and if required expertise ti undertake the monitoring.

Monitoring Integration

The greatest power of the monitoring program will be where data collection and/or analysis can be integrated. This is already being undertake with the Fox Threat Abatement Plan and State of the Parks monitoring.

It is suggested that the implementation of the essential indicators be reviewed with a view to further integrating monitoring.

Monitoring Analysis

It is vital to undertake ongoing analysis of indicators as data is collected. Whilst reporting may be only every six years for the Periodic Report, it is pointless to undertake monitoring that is measured more regularly and not undertake analysis to ensure that reasonable data is being collected and to reconfirm that the power of the experimental design is relevant.

Each indicator should be reviewed in detail and as soon as practicable power analysis of results undertaken to give some confidence that the monitoring over time is likely to detect change.

Undertake analysis of data annually when the data is collected annually or more frequently.

Monitoring Reporting

Reporting of monitoring data is essential if adaptive management is to be possible.

Report annually against each indicator on the status of measurement and analysis in an Annual Monitoring Strategy Implementation Report (note this is not a "State of CERRA" report but rather a progress report of monitoring activity).

Where possible for indicators provide a report each year to CERRA including most recent data and analysis.

Compile an complete review of all monitoring data and the results of this including commentary about the power of the experimental design for each indicator, observed trends and suggestions for improvements at least each three years (Three Yearly Report)

Every six years for the Periodic Report, prepare a comprehensive integrated report which includes integrated analysis of data across and between indicators and further comments on potential changes as a part of a program of adaptive management for CERRA (a State of CERRA, report produced to coincide with the Periodic Report).

Development of New Indicators

In numerous instances new indicators are proposed, these are summarised in the gap analysis above.

Seek resources for research to establish and develop approaches for the new monitoring indicators.

Ongoing Review of Program

Any monitoring program should be reviewed regularly to confirm it is likely to detect the change expected.

Each six years submit the whole State of CERRA report and all the metadata of the monitoring indicators to overall and indicator specific peer review.

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APPENDIX ONE
RESEARCH AND MONITORING IN CERRA

Table 2: Research and Monitoring Provisions in Management Plans.

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
NEW SOUTH WALES			
Parks and Reserves of the Tweed Caldera Draft Plan of Management (2001)	Border Ranges NP Mebbin NP Nightcap NP Mt Warning NP Limpinwood NR Numinbah NR	– Fire regime – Visitation (in some of the reserves) – Weeds – Feral/pest animals (Bell Miners) – Potential threats to catchment values: human waste disposal, soil erosion and grazing stock	Monitoring includes: – Monitoring of the threatened herb, *Euphrasia sp.* at the Pinnacle Lookout – Monitoring as part of Threat Abatement Plans (TAP) (i.e. fox, cat) – Monitoring of water quality (a SCU student project in Nightcap NP) – Monitoring of biocontrol agents for lantana (Mt Warning NP) – Threatened species surveys for eastern bristle bird, rufous scrub bird, Fleay's barred frog frogs, Hastings river mouse and Coxen's Fig Parrot Visitor monitoring includes: – Traffic and pedestrian counters (current) – Standard visitor survey (to be implemented) – Detailed questionnaire (was trialled) – Monitoring of visitor impacts (camping, walking tracks, horseriding etc.) Research includes: – The long-term research study of forest succession in upper Sheepstation and Gradys Creeks in Border Ranges NP – Trial of the Brazilian moth, lantana biological control agent, in Limpinwood NR and Mt Warning NP – University student projects as approved on an annual basis General information: – Nightcap NP Pest Management Plan prepared November 2001 (incorporating restoration and weed) – Mt Warning Pest Management Plan prepared August 2003 – Restoration plan prepared for Limpinwood and Numinbah Nature Reserves in June 2000 Information Specific to Limpnwood Nature Reserve: – Monitoring and assessment of and rationalisation of lookouts in consultation with Queensland Parks and Wildlife – Monitoring of campsites (Queensland Parks and Wildlife Service) – Some groundsel control undertaken – Eradication of garden escapees and old fruit trees in the Billy Hut area The Plan Recommends: – Continuing the monitoring program for the endangered herb *Euphrasia* spp. aff. *bella* at The Pinnacle – Researching the impact and review the border rabbit fence in consultation with other relevant agencies – Conducting dingo genetic sampling in Border Ranges NP – Monitoring day use (visitation and associated activities) through traffic counts, visitor surveys and photographing site modification (and other techniques) on an annual basis – Preparing a research prospectus for Universities listing identified research priorities

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Parks and Reserves of the Northern Richmond Range Draft Plan of Management (2002)	Richmond Range NP Toonumbar NP Mallanganee NP	Key threats to biodiversity: – Fire – Weeds – Inappropriate human activities Other threats: – Soil erosion – Grazing Minor threats: – (Declining) water quality – (Reduced) vegetation cover Potential threats: – Bellminer associated dieback – Hybridising of eucalypts	General information: – Mapping of the extent of eucalypt dieback and researching management strategies with other agencies (Bell Miner Associated Dieback (BMAD) strategy completed, SFNSW completed aerial survey of extent) – Pest Management Strategies are in place in NPWS Northern Rivers Region and Richmond Range National Park – Restoration and Rehabilitation Plan prepared, and implementation has commenced in Mallanganee National Park – Control programs are in place for giant Parramatta grass and groundsel bush Plan recommends: – Undertaking rare plant surveys along roads, trails and tracks where required – Monitoring populations of the endangered native jute Corchorus cunninghamii – Assessing vegetation communities, habitats and species considered significant and revise management practices – Researching strategies to control eucalypt dieback – Preparing a research prospectus Note: Since plan's preparation Bellminer associated dieback now recognised as a key threat to biodiversity.
Tooloom National Park Plan of Management (1999)	Tooloom NP	Major threats: – Inappropriate fire regime – Feral animals Minor threats: – Erosion at Wallaby Creek Fire Trail due to disturbance Potential threats: – European honey bees	Past research listed in Appendix and includes: – 1994 – Fauna investigation for SFNSW, – 1995 – Flora survey for SFNSW – 1995-1997 – Population dynamics of Bowerbirds General information: – Some species have been studied over a number of years in this park, including macropods and the satin bowerbird – Park is a Fox TAP monitoring site – Weeds have been mapped Plan recommends: – Undertaking further research into what threatened species occur in the Park and, where appropriate, implementing recovery plans for threatened species as these plans become available – Where necessary, researching the relationships between flora and fauna in the Park to establish specific management requirements – Investigating and planning for the appropriate use of fire to maintain the range of flora and fauna communities – Monitoring the effects of park use and management on flora and fauna communities – Monitoring the health of World Heritage values – Encouraging research into the ecological effects of fire in the park, particularly the fire response of rare and threatened flora and fauna species, rainforest and wet sclerophyll forest and grasslands – Preparing and distributing a prospectus of priority research topics to relevant tertiary institutions – Developing and implementing a monitoring program which examines the impacts and effectiveness of key management activities – Monitor the effects of park use and management on flora and fauna communities – Update NPWS databases of flora and fauna species in the Park as further survey information becomes available

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Gibraltar Range Group of National Parks Draft Plan of Management (2002)	Gibraltar Range NP Washpool NP	– Inappropriate fire regime – Weeds (minor threat) – Feral animals (minor threat?)	General Information: – Detailed floristic surveys have been conducted in the planning area over the past twnety years (Fox 1983, Floyd 1990, Hunter 1998 and 2000, Sheringham &Hunter 2002, Benwell & Kooyman 2000) – A vegetation survey was undertaken by the northern tablelands region – Lantana mapping was undertaken – Visitor surveys, covering seasonal patterns, were undertaken during 1999-2000 (Griffin & Archer 2001) – Detailed visitor questionnaire trialled in Gibraltar Range – Economic impact study undertaken in Gibraltar Range Plan Recommends: – Researching World Heritage values and maintaining databases – Developing a program to assess the condition of World Heritage values – Identifying any significant areas of disturbance and implement measures to stabilise disturbance – Identifying and mapping sensitive vegetation communities and rare or threatened plants – Developing a program to monitor community for species composition and abundance and response to fire – Maintaining current monitoring programs and encouraging research into significant fauna, or those likely to suffer population decline and/or potential threats – Undertaking research that can enhance fire management in the planning area – Monitoring the spread of pines from adjacent forestry plantations and remove any seedlings that germinate within the planning area – Monitoring the occurrence and undertake control programs for wild dogs, feral pigs, goats, deer, foxes and cats – Undertaking research to determine the most effective methods of assisted regeneration of modified landscapes – Regularly monitoring visitor use, especially vehicle numbers – Preparing a prospectus of priority research projects in the planning area – Liaising with local universities to encourage research in priority projects in the planning area
New England National Park Plan of Management (1991)	New England NP	– Inappropriate fire regime – Minor threats include weeds, feral animals	General Information: – Vegetation survey noted senescence of banksia scrub on plateau section (University of New England) – Monitoring of weed invasion along road side on Point Lookout Rd (required by REF for road sealing) – Monitoring of revegetation in area of landslip on Eagles Nest Track and on closed forestry trails in new additions – Mistflower eradication occurring Plan Recommends: – Undertaking eastern bristle-bird survey – Preparing priority list of research needs

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Oxley Wild Rivers National Park, Cunnawarra National Park and Georges Creek Nature Reserve Draft Plan of Management (2002)	Oxley Wild Rivers NP Cunnawarra NP	– Inappropriate fire regime – Feral animals and straying stock – Weeds – Recreation – Erosion	General Information: – Fauna surveys have been carried out as part of the North-east Forests Biodiversity Study (NPWS 1994) and in CRA surveys – Water quality monitoring has been undertaken outside of Oxley Wild Rivers National Park, both upstream and downstream, findings: good quality downstream of park, not upstream = relatively undisturbed in park (Chris Lehman, Nth Tablelands region) – There has been some weed mapping and feral animal surveys – There is lantana control in dry rainforest (Ken Pines, Nth Tablelands Region) – Maintenance of dog fence, protects dingos from wild dogs – Goat control using judas goats, land-based spotters and aerial shooting. Goat numbers greatly reduced – A pest species management plan has been prepared for the Oxley Wild Rivers National Park – Rehabilitation of erosion at visitor facilities is included in works set out in Section 6.2 of Plan "Monitoring… will be undertaken as part of programs such as recovery plan requirements and visitor impact monitoring". The Plan Recommends: – Encouraging the Kempsey Speleological Society to monitor and report on use of the karst system – Monitoring natural revegetation of cleared areas within the planning area and take necessary steps to assist revegetation where needed – Continuing to record the distribution of threatened and significant fauna species – Continuing to support research programs into effective biological control of Lantana. In the interim, develop effective herbicide control techniques to suppress the further spread of Lantana, with priority to rainforest areas – Monitoring areas currently free of introduced species that are potentially susceptible to invasion – Undertaking regular monitoring of visitors (numbers, demographics, satisfaction etc.) – Monitoring the condition of popular remote tracks and campsites – Conducting and encouraging appropriate research and monitoring to provide information addressing management issues, with priority given to: o completion of vegetation community mapping o the ecology, status and distribution of rare communities o and rare and threatened plant and animal species o World Heritage values and possible threats to values o the effects of fire on plant and animal communities o the impacts of introduced species and potential control measures; o surveys of Aboriginal sites and other places of cultural heritage significance o visitor use, visitor expectations and visitor impacts – Encouraging research where it: o has the potential to facilitate better management o leads to a better understanding of conservation issues o and/or biodiversity/ecology o does not conflict with the objectives of management – Preparing and distributing a schedule of preferred research projects

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Dorrigo National Park Plan of Management (1998)	Dorrigo NP	– Weeds – Feral animals – Inappropriate fire regime	General Information: – Fauna surveys have been carried out in Dorrigo NP as part of the major North East Forests Biodiversity Study; one of the sites where invertebrates also studied by NPWS and the Australian Museum – Impacts of human visitation investigated (North Coast Region) – Visitation monitoring - digital counters – Feedback impressions recorded through visitors book – Monitoring of track erosion by University of New England students prompted sealing of entire Wonga Walk loop – A survey of water quality has been undertaken (North Coast Region) – University of New England student's biennial work (summer school in Park and Wildland Management – Ass. Prof. Nick Reid) o Monitoring of privet invasion on park edge o Qualitative surveys of park visitors regarding their experiences, impressions of signage, time spent in local community (non-standard questionnaire) o Permanent plot established by Chris Nadolny in mid 1980s on bench in booyong forest. Revisit of this site in 2002 showed very little change within the plot Plan Recommends: – The distribution of plant communities will be mapped – The location of rare or endangered species will be mapped and local staff made aware of the locations of such species – A prospectus will be prepared as a guide to preferred research projects in the park
Werrikimbe National Park Draft Plan of Management (2002)	Werrikimbe NP	– Inappropriate fire regime – Feral animals – Erosion at sites of disturbance (Racecourse and Spokes Trails) – Potential threat: *Phytophthora cinnamomi*	General Information: – There have been extensive fauna surveys undertaken throughout the park since its inception. Also systematic surveys have been conducted by the Australian Museum for over ten years at both Mooraback and the Forbes River – Monitoring of Hastings River Mouse – Monitoring of Rufous Scrub-bird – The NPWS Northern Tablelands and Mid-North Coast Regions Pest Management Strategies are in place – Urgent need for *Phytophthora* mapping Plan Recommends: – Mapping and monitoring occurrences of pygmy cypress pine within the park – Monitoring World Heritage values – Promoting scientific inquiry into the fauna of the park – Researching Phytophthora in the park – Monitoring environments currently free of introduced species – Undertaking and encouraging relevant fire research – Monitoring selected visitation activities (i.e. horseriding)
Captains Creek Nature Reserve Draft Plan of Management (2002)	Captains Creek NR	– Inappropriate fire regime Minor threats: – weeds and feral animals – erosion due to unauthorised vehicles, – horseriding, – illegal firewood collection	General Information: – Habitat modelling undertaken during the Regional Forestry Agreement (RFA) process – A Vegetation Restoration and Rehabilitation Plan has been prepared for the reserve along with Tooloom NP Plan Recommends: – Encouraging tertiary institutions to use the reserve for research to increase knowledge of species present and their management requirements – Undertaking surveys as required to ascertain the presence and abundance of threatened species

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Broadwater National Park, Bundjalung National Park and Iluka Nature Reserve Plan of Management (1997)	Iluka NR	– Inappropriate fire regime – Weeds – Feral animals	General Information: – Fauna surveys have been carried out in the planning area as part of the major North East Forests Biodiversity Study – There is monitoring of weed density and control programs, including effectiveness of spraying of Bitou Bush (Jeff Thomas, North Coast Region) – Monitoring of rainforest/sclerophyll forest boundaries (John Hunter, Northern Directorate) – Koala monitoring. – Digital counters in place for visitation monitoring Plan Recommends: – Monitoring impacts of recreation use and undertake measures to protect values – Preparing a scientific research prospectus for the planning area – Encouraging research into fire behaviour, hazard and risk assessment, and the impact of fire on plant and animal communities
The Castles Nature Reserve Plan of Management (2004)	The Castles NR	– Inappropriate fire regime – Weeds (potential threat – not in main body of reserve) – Feral animals (minor – only cats sighted)	General Information: – A vegetation survey was conducted within the brush component of the reserve by Floyd (1983) – A Pest Management Strategy has been developed for the region as a whole According to the Plan: – There has been no formal survey of weed species – There has been no formal survey of pest animals Plan Recommends: – Continuing to opportunistically carry out DNA – Sampling of dingo and wild dog populations, to gauge the effect of wild dog incursion on the dingo population – Encouraging or undertaking appropriate research into native plant and animal species, in particular to determine the reserve's World Heritage status and the occurrence of significant species – Monitoring, controlling, and where possible eradicating, introduced pest plant and animal species, in accordance with the Regional Pest Management Strategy – Encouraging or undertaking a survey of pest plant and animal species in the reserve – Undertaking, or encouraging, appropriate research to improve knowledge and management of natural and cultural values
Mount Seaview, Jasper and Koorebang Nature Reserves Plan of Management (2004)	Mount Seaview NR	– Inappropriate fire regime – Weeds – Feral animals – N.B. very little visitation, practically no infrastructure including roads. Terrain is rugged. Forest remains intact due to limited logging and infrequent fire	General information: – A recent review of geological information in the area has been completed (Myson 2001a-d) – Generally there has been minimal research and monitoring, with no flora or fauna surveys carried out in the past twenty years The Plan recommends: – Undertaking flora and fauna surveys, including an amphibian survey with emphasis on the giant barred frog – Encouraging research into the distribution and abundance of pest animal species in the reserves – Developing a research prospectus to encourage higher education studies in the reserves with a focus on the following: o inventory data on the distribution and abundance of native and introduced plant and animal species and groups o distribution, abundance and biology of threatened species with emphasis on the endangered giant barred frog o identification of Aboriginal cultural heritage values o identification of World Heritage values with emphasis on Koorebang NR

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Barrington Tops National Park ***Plan of Management in preparation and not available***	Barrington Tops NP	– Weeds – Feral animals – Inappropriate fire regime – *Phytophthora* (infestation on plateau in Water-gauge trail area). – Illegal activities (trail bikes and 4WDs) – Increasing visitation	General Information: – Visitation monitoring - digital counters – Water flow and quality assessment (Hunter Region) – Annual plant surveys have been undertaken since 1998 (Source: SoP Report) – Phytophthora mapping – Broad-toothed Rat monitoring – Biological control of European broom – Fire management Plan has been prepared
Mount Hyland Nature Reserve ***Plan of Management in preparation and not available***	Mount Hyland NR	– Inappropriate fire regime – Feral animals – Stray stock (southern additions of reserve are bounded by unfenced creeklines next to grazing leases)	General Information: – Research and ongoing monitoring of Dorrigo Daisy Bush (see recovery plan) – State Forests of New South Wales monitored bait stations in the area – cats quite common – A long time ago, there was monitoring of water quality in Obeloe Creek Identified management challenges: – Maintaining an appropriate disturbance regime for Dorrigo daisy bush (along roadsides in rainforest areas) and Hastings River mouse
Koreelah, Mt Clunie and Mt Nothofagus National Parks ***Plan of Management in preparation and not available***	Koreelah NP Mt Clunie NP Mt Nothofagus NP	– Inappropriate fire regime – Straying stock – Bell Miner Associated Dieback	General Information: – Flora and fauna survey before the REF for the improved camping ground

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
QUEENSLAND			
Springbrook National Park Draft Plan of Management (1999)	Springbrook NP	– Weeds (localised weed problems of concern in some areas) – Feral animals Minor/ potential threat: – park visitors Historical threat: – former land use practices Part of the Park is in catchment of water supply. Management practices within the park and on surrounding areas can affect water quality	General information: – Recent surveys on visitor use and behaviour (DNR, 1998; Harris and Webster, 1990; Hockings, 1993; Springbrook Mountain Community Association Inc, 1992) – The Department is currently developing a fauna and flora database to provide information on many aspects of the park's natural values – The park was part of the Gold Coast Hinterland Asset Audit 1999 (Jan Warnken) – A freshwater recreation health survey was undertaken in 2000 (Ian Stewart, Glen Shaw, University of Queensland) – The dynamics of lantana invasions was undertaken in 2001 (Stock, Griffith University) – Weed mapping was done in 2001-2002 The Plan recommends: – Establishing a research project to study the reproductive ecology, population dynamics and appropriate fire regimes for noteworthy and indicator species such as *Callitris monticola*, *Eucalyptus oreades*, *Ceratopetalum apetalum*, *Nothofagus moorei*, *Eucryphia jinksii* and *Lepidozamia peroffskyana* – Maintaining established fire monitoring sites to study the relationship of fire to the floristic structure and diversity of montane heath, warm temperate rainforest dominated by Ceratopetalum apetalum, tall open forest dominated by Eucalyptus oreades , tall dense layered eucalypt forest with Lepidozamia peroffskyana in the understorey – Setting up monitoring sites along selected sections of the walking tracks to determine the extent of erosion caused by visitor use – Establishing a research project on the biology and ecology of glowworms (*Arachnocampa flava*) and their ability to recover from visitor impacts – Encouraging scientific research on native plants and animals, where minimal impact research methods can be demonstrated – Encouraging public involvement through community based conservation and natural history groups in the monitoring of native species populations – Encouraging post graduate and university studies into natural resource management – Increasing the use of data bases to improve access to available information, monitor species populations and ecological processes and raise awareness of the park's values among visitors – Managing educational and scientific use of the park in conjunction with recreational and other uses of the park to ensure that impacts remain within defined, acceptable limits and that the range of educational and scientific opportunities are maintained – Ensuring that educational and scientific research activities are appropriate, in terms of their intended purpose, and their potential impact, to the particular management setting in which they take place – Encouraging educational and scientific users to provide the precise location of sites used, to allow staff to monitor use, protect habitats supporting significant conservation values and minimise user impacts

Plan of Management	CERRA Reserve Incorporated	Threats to Integrity of World Heritage Values	Monitoring/Research and Other Activities
Lamington Draft Plan of Management (1999)	Lamington NP	– Habitat disturbance – Inappropriate fire regime – Weeds – Increasing visitation – N.B. annual visitation is estimated to be approximately 500,000	General Information: – Several long-term projects investigating aspects of rainforest regeneration with the University of Queensland (believed to be the longest continuing study of rainforest species dynamics in the world) – Several projects into the reproduction, ecology and genetics of individual species – Ongoing monitoring of the environmental impacts of bushcamping at remote camping sites – Monitoring of on-site sewerage treatment required as part of EPA licence – Southern section of park an important scientific reference area due to its wilderness condition The plan recommends: – Establishing a research project to study the reproductive ecology, population dynamics and fire regimes for noteworthy and indicator species – Maintaining established fire monitoring sites to study the relationship of fire to the floristic structure and diversity of montane heath, open forest, rainforest ecotones and other communities – Setting up monitoring sites along selected sections of walking tracks to determine the extent of erosion caused by visitor use. The plan notes the potential for overuse of the park for scientific studies.
Western Scenic Rim Draft Management Strategy (2001/2002)	Mt Barney NP Main Range NP Spicers Gap CP Goomburra FR Spicers Gap FR Emu Vale FR Teviot FR Gambubal FR Alford FR Burnett Creek FR	– Inappropriate fire regime – Weeds – Feral animals – Visitation near important habitats of threatened species – Future population pressures – Illegal activities	General Information: – There has been a fauna survey in Main Range National Park (George Krieger QPWS 2003) – The park is part of the Eastern Scenic Rim Fire monitoring – The park is included in the campsite monitoring of the Scenic Rim Parks The strategy recommends: – Establish programs, including community partnerships, to monitor the status and condition of Western Scenic Rim's communities, noteworthy species, significant geological features and water quality (this will usually be associated with ecological integrity reporting). This information will form part of the periodic reports on the state of conservation of CERRA's World Heritage values. – Support research on management issues and the ecology of species to add to the knowledge of World Heritage values and QPWS research priorities. – Maintain databases on plant and animal records, including invertebrates, and incorporate new location information in a systematic and timely manner. – Monitor impacts (eg. Erosion) on walking tracks on Dalrymple Creek system and maintain/upgrade to a high standard to prevent environmental degradation. – Monitor visitor use and regularly maintain campgrounds and other high-use areas (involving local community). – Promote community-based monitoring programs and support university and departmental research on park.

Table 3: Research and Monitoring Provisions of Select Species Action/Recovery Plans.

Species	Threats	Monitoring/Research
BIRDS		
Albert's Lyrebird (*Menura alberti*) Status: Vulnerable (NSW), Rare (Qld) Considered Vulnerable in Action Plan	– Weeds: Lantana in disturbed habitat areas – Inappropriate fire regime	Commonwealth Action Plan (Recovery Outline) – A study of the habitat distribution and population density has been completed – A study *Dispersal strategies of Albert's Lyrebird* Lamington National Park was completed by David Putland in April 2002 – Monitoring sites in NSW include Wollumbin, Mebbin, Mt Jerusalem, Nightcap and Goonengerry NP – An indicator species for the Fox TAP in Northern Rivers Region
Australasian Bittern (*Botaurus poiciloptilus*) Status: Vulnerable (NSW) Considered Vulnerable in Action Plan	– Main threats: diversion of water for irrigation, and salinisation or drainage of permanent swamps – Other threats: overgrazing by stock, and inappropriate fire regimes	Commonwealth Action Plan (Recovery Outline) – The Plan required the identification of principal breeding wetlands, however there is no other research or monitoring mentioned – This species is an indicator species for the Fox TAP, however these sites do not fall within CERRA
Barking Owl (*Ninox connivens connivens*) Status: Vulnerable (NSW) Considered Near Threatened in Action Plan	– Major threats: habitat loss and degradation (includes: clearing of native vegetation; continued net loss of native hollow bearing trees and coarse woody debris; removal of dead wood, dead trees and logs) – Other threats: competition from feral honeybees (for habitat) – Possible threats: predation by the fox; the feral cat; goanna; DDT and other chemicals	Draft NSW Recovery Plan – Surveys for the owl have been conducted in NSW in the Bungawalbyn catchment on the North Coast (Stuart 1995); in state forests of northern, central and southern NSW (Kavanagh 1995, Kavanagh and Bamkin 1995, Kavanagh *et al.* 1995b, Kavanagh and Stanton 1998); on the Northern Tablelands and north-west slopes (Debus 2001); and in eastern NSW by NPWS as part of the CRA/RFA process – One pair on the Northern Tablelands was monitored opportunistically over three years for territory occupancy, breeding success and dietary data (Debus 1997; Debus *et al.* 1998, 1999). – Radio-tracking of a Barking Owl at Goonoo State Forest (Schedvin *et al.* 2001) was undertaken in the central west of NSW NPWS, under the Draft Recovery Plan, will: – Assess the size, viability and status of the Barking Owl population in NSW – Establish a program to monitor the NSW Barking Owl population and study its demographics – Support biological, ecological and population genetics studies

Species	Threats	Monitoring/Research
Black-breasted Button-quail (*Turnix melanogaster*) Status: Vulnerable (Commonwealth, Qld), Endangered (NSW)	– Grazing and other disturbance by cattle, horses, feral pigs and wallabies, which have increased as a result of partial clearing – Introduced predators (known to be killed by feral cats)	Commonwealth Action Plan (Recovery Outline) – Detailed surveys have been conducted in Qld – Monitoring sites in NSW: Tweed and Richmond Range – Assessment of conservation status of Black-breasted Button-quail in NSW by John Martindale (CPPD), areas: Tweed Shield Volcano Group and NSW Focal Peak Group The Action Plan requires: – The determination of the status of remaining sub-populations in NSW – A survey of likely habitat for Black-breasted Button-quail before licensing clearing, burning, logging, roading and grazing, if legislative power exists
Black-necked Stork (*Ephippiorhynchus asiaticus australis*) Status: Endangered (NSW), Rare (Qld), not listed by Commonwealth	– Has been classified as least concern, however populations in NSW are small and have been relatively threatened by clearing, although they are fairly resilient	Commonwealth Action Plan (Taxon Summary) – No activities, only future monitoring of the NSW pops recommended in Plan – A study was undertaken *Threatened spp of waterbirds in NSW and their movements* by Richard Kingsford
Bush-stone Curlew (*Burhinus grallarius*) Status: Endangered (NSW)	– Feral animals: red fox, cat, dog – Inappropriate fire regime – Human disturbance, particularly around nest site – Removal of ground litter and fallen timber – Land tenure – only approx. twenty percent of population in Protected Areas	Draft NSW Recovery Plan – It is an indicator for the NSW Fox TAP – Specific surveys undertaken by NSW Bird Atlassers, the Australian Bird Count and the Birds Australia 2nd Atlas – Records collected in 2002 from a community survey throughout the species range. The community survey is ongoing – see the NPWS web-site NPWS, under the Recovery Plan, will: – Identify local and regional populations for further investigation of management and research requirements – Investigate the Bush Stone-curlew populations identified to gain information from which future management and conservation activities can be planned – Develop monitoring protocols and annual monitoring of the populations identified – Undertake research into Bush-stone Curlew ecology and management activities – Encourage research into the impact and amelioration of threatening processes – Encourage studies into sustainable land management and agricultural practices of relevance to Bush Stone-curlew habitat

Species	Threats	Monitoring/Research
Coxen's Fig-Parrot (*Cyclopsitta diophthalma coxeni*) Status: Endangered (NSW, Qld and Commonwealth)	– Inadequate extent and quality of habitat – Loss of connectivity between summer and winter areas – Fragmentation of habitat – Disturbance to some suspected ecotonal breeding areas – Disjunct feeding grounds – Low population number – Intermittent food discontinuity – Increased competition – Weed degradation of feeding and nesting habitat – Potential change to social structures following population decline – Disease – Stochastic events, such as drought, which may have severe impacts upon low populations – Illegal egg collectors and aviculturalists	Approved NSW Recovery Plan and Commonwealth Recovery Plan (2001-2005) – RAOU, ANCA and Currumbin Wildlife Sanctuary review of records and field survey of NSW/Qld border area in 1985/86 (Martindale 1986) – A survey was conducted in 1987-1989 in Qld and NSW and a summary of known biology and ecology was prepared (Holmes 1990) – Targeted surveys were undertaken by Martindale (1986, 1996), Holmes (1990, 1995), Gynther (1996ab; 1997a,b), Gynther and O'Reilly (1997), and more general community surveys in NSW and Qld (Martindale in prep., Gynther in prep.) – Many surveys etc. but no observation of individual birds – More recent monitoring in NSW: three broad areas (Richmond Range, Mebbin, Nightcap)? NPWS, under the Recovery Plan, will: – Conduct nest site and food tree surveys – Analyse potential predators' prey remains to indicate the existence of the Fig-Parrot – Use decoy birds to locate wild populations – Collect ecological data for predictive modeling – Operate a formal records appraisal system – Develop and maintain a records database – Undertake predictive modelling of distribution – Implement an ecological monitoring strategy at occupied sites – Undertake a field study of the Red-browed Fig-Parrot to examine life history details of direct relevance to Coxen's Fig-Parrot. – Undertake remote surveys – Map the distribution of rainforest and other suitable habitat in the Coxen's Fig-Parrot's range – Investigate the distribution and phenology of probable Coxen's Fig-Parrot food plants

Species	Threats	Monitoring/Research
Eastern Bristlebird (northern) (*Dasyornis brachypterus monoides*) Status: Endangered (Commonwealth), Endangered (Qld, NSW) Considered Critically Endangered by Action Plan.	– Main threats: inappropriate fire regime, feral pigs – Secondary threats: grazing, weed invasion, predation by cats and foxes, and the disruption of breeding by bird-watchers who use taped calls to attract birds	Commonwealth Action Plan (Recovery Outline) – Surveys of known sites and other suitable habitat are being undertaken – All known territories in Qld are mapped on a Geographic Information System – Vegetation monitoring sites have been established at most currently occupied sites – Eastern scenic rim eastern Bristlebird habitat monitoring in Lamington National Park- Sylvia Millington QPWS (2003?) – Western scenic rim eastern Bristlebird habitat monitoring in Main Range National Park - Wayne Kington QPWS (2003?) – A study *Eastern Bristlebird population monitoring and habitat mansgement in north-eastern NSW* was completed in Border Ranges National Park by David Charley, Northern Rivers Region (Competitive Regional Stream Border Ranges Hotspot project) – An investigation into the implementation of the recovery plan was undertaken by David Stewart, QPWS – Species and habitat monitoring is currently undertaken in both Qld and NSW across its known range at least once a year (Stewart and Charley, pers. comm.)
Little Tern (*Sterna albifrons*) Status: Endangered (NSW) Migratory Species (Commonwealth)	– Predation of eggs and chicks by a range of species including foxes, silver gulls, ravens and whimbrels – Human disturbance by coastal recreational activities – adults leave nests when approached – 4WDs, trail-bikes and walkers may crush nests, eggs and chicks – Coastal development – Availability of food affected by modification of drainage patterns including damming of tidal creeks and destruction of seagrass beds, mangroves and saltmarsh – Potentially susceptible to pesticides and contamination of estuaries	Approved NSW Recovery Plan – Nesting sites in northern NSW were monitored from 1979/80 to 1982/83 (Clancy 1979, 1980a, 1980b, 1981, 1982, 1983, 1987) – Statewide surveys were carried out in 1984/85 (Martindale 1985, Morris 1985), 1989/90 (Starks 1992), and in 1993/94 and 1994/95 (Smith 1995c) – In Yamba, pre-1963, there is no data – Very few studies/monitoring in CERRA area, however it is an indicator species for the Fox TAP NPWS, under the Recovery Plan, will: – Monitor individual colonies – Analyse monitoring data and prepare a status report – Conduct and promote research on the Little Tern in NSW in order to increase the biological, ecological and cultural knowledge of the species
Osprey (*Pandion haliaetus*) Status: Vulnerable (NSW)		No Action or Recovery Plan – A study *Monitoring of Osprey (seabird) breeding success in the Clarence Valley* (includes Iluka) was undertaken by Mark Williams, Nth Coast Region – A review of breeding sites in NE NSW was completed by Peter Ekert in 2004.

Species	Threats	Monitoring/Research
Pied oyster catcher (*Haematopus longirostris*) Status: Vulnerable (NSW)		No Action or Recovery Plan – An indicator species for the Fox TAP – various sites on the NSW north coast but not within CERRA
Red Goshawk (*Erythrotriorchis radiatus*) Status: Endangered (NSW, Qld), Vulnerable (Commonwealth)	– Major threats: deforestation and stochastic events, such as drought and fire – Minor threats: fire regime, predation by foxes, illegal robbing of nests for eggs, young and adults (shooting), disease, pesticides (DDT etc.)	Approved NSW Recovery Plan – A six-month survey of the Red Goshawk was undertaken in north-east NSW in 1987–88 (Debus ,1993). – A study *In search of the Red Goshawks* (southern and central Qld) was undertaken by Harry Hines QPWS (2003?) The Red Goshawk working group, under the Recovery Plan, will: – Assess the current conservation status of the species throughout its range – Review survey method utilised during previous surveys for Red Goshawks and subsequently formulate standardized survey methods for the species. These methods will be promoted for use during future surveys for the species – In conjunction with NPWS, develop and implement appropriate nest site monitoring and security measures in order to minimise or eliminate human interference at nests, and monitor the outcome of breeding attempts NPWS, under the Recovery Plan, will: – Develop and implement a procedure through which any reports of potential sightings of Red Goshawks in NSW are referred to the Red Goshawk working group in order to determine the accuracy of the record – Coordinate a research program under which birds that have either been trapped or rehabilitated are opportunistically radio-tracked
Regent Honeyeater (*Xanthomyza Phrygia*) Status: Endangered (Commonwealth, NSW, Qld)	– Clearance of habitat – Competition, displacement – Noise Miner (*Manorina melanocephala*)	Commonwealth Action Plan (Recovery Outline) – Surveys of range and abundance are conducted annually – Monitoring includes Oxley Wild River National Park – Peter Croft, Nthern Tablands Region The Action Plan Requires: – A population monitoring program at the three main breeding areas – The use of the existing sightings database and Birds Australia Atlas Project to determine trends

Species	Threats	Monitoring/Research
Rufous Scrub-bird (northern) (*Atrichornis rufescens rufescens*) Status: Endangered (NSW), Vulnerable (Qld) Considered by Action Plan to be Endangered	– Potentially threatened by inappropriate burning and logging practices	Commonwealth Action Plan (Recovery Outline) – Monitoring Project including both northern and southern species involving a six-year monitoring period (1999-2004). With the major aim of providing an initial assessment of the distribution and abundance of the species, so that later in the period the relative abundance can be monitored. In 2000 Barrington Tops and Border Ranges were surveyed, overall 383 individual surveys were conducted by a number of people, including 38 volunteers, NPWS staff and the Birds Australia Co-ordinator (contact Andrew McIntyre CPPD?). In 2003 surveys were conducted in Border Ranges, Gibraltar Range, Washpool, Barool and Barrington Tops National Parks and New England and Dunggir Nature Reserves. – Similar surveys have been undertaken by NPWS in Werrikimbie NP in 1999/2001/2002.
Rufous Scrub-bird (southern) (*Atrichornis rufescens ferrieri*) Status: Endangered (NSW) Considered by Action Plan to be Near Threatened	– Potentially threatened by inappropriate burning and logging practices	Commonwealth Action Plan (Taxon Summary) – Monitoring Project including both northern and southern species involving a six-year monitoring period (1999-2004). With the major aim of providing an initial assessment of the distribution and abundance of the species, so that later in the period the relative abundance can be monitored. In 2000 Barrington Tops and Border Ranges were surveyed, overall 383 individual surveys were conducted by a number of people, including 38 volunteers, NPWS staff and the Birds Australia Co-ordinator (contact Andrew McIntyre CPPD?). In 2003 surveys were conducted in Border Ranges, Gibraltar Range, Washpool, Barool and Barrington Tops National Parks and New England and Dunggir Nature Reserves. – Similar surveys have been undertaken by NPWS in Werrikimbie NP in 1999/2001/2002.
Swift Parrot (*Lathamus discolor*) Status: Endangered (Commonwealth, Qld, NSW)	– Competition – availability of hollow nests – Fragmentation	Commonwealth Action Plan (Recovery Outline) – Monitoring includes Oxley Wild River NP- Peter Croft Nthern Tablands Region
MAMMALS		
Broad-toothed rat (*Mastacomys fuscus Thomas*) Status: Endangered Population at Barrington Tops (NSW)	– Predation by the fox and cat – Invasion of weeds into areas of suitable habitat – Competition from other rodents and herbivores such as the rabbit – Climate change	Endangered Species Listing – Monitoring in Barrington Tops NP (Barrington Tops Area Manager Terry Evans, and John Martindale CPPD) – An indicator species for the Fox TAP in Hunter Region – "NPWS will conduct surveys annually… The data collected will assist in both monitoring the population and evaluating the effectiveness of the fox control programs" (NPWS media release- 02/04/2002).

Species	Threats	Monitoring/Research
Brush-tailed Rock Wallaby (*Petrogale penicillata*) Status: Endangered (NSW), Vulnerable (Commonwealth, Qld)	– Predation by foxes – Habitat degradation due to goat, sheep and rabbit grazing. Also possibly due to changes in fire frequency and predation by feral cats and wild dogs – Historical hunting	Recovery Outline (Commonwealth) – Monitoring in Qld in Main Range National Park – An indicator species for the Fox TAP – University of New England students study(ied) the Oxley Wild Rivers National Park population – Two studies have been completed, *Brushtail rock wallabies extent of study area* by Justine Murray (University of Qld) in June 2001, and *Brushtail rock wallaby distribution, abundance and habitat preference within south-east Qld* (Main Range, Mt Barney) by George Krieger QPWS. Recovery Outline Requires: – An assessment of distribution and abundance throughout range – A study of the diet of *P. penicillata* and other sympatric herbivores, including seasonal changes and documentation of diet over time, to assess effects of introduced herbivores – Genetic analyses of remaining populations and preparation of a genetic management strategy if warranted
Hastings River Mouse (*Pseudomys oralis*) Status: Endangered (NSW and Commonwealth), Vulnerable (Qld)	– Disjunct, genetically distinct populations – Fire – Grazing – Loss of habitat – edge effects – Predation – fox, cat	Draft NSW and National Recovery Plan: – Over 218 surveys have been conducted for the Hastings River Mouse between 1969 and February 2002 (NPWS database) – Recent surveys have included the Border Ranges National Park (Keating 2000; Townley 2000c) – Surveys conducted in Lamington National Park in January 2001 and 2002 failed to located the Hastings River Mouse on a site where they have previously been recorded (I. Gynther) – In NSW, SFNSW are required to undertake surveys for the Hastings River Mouse as part of their pre-roading and pre-logging surveys according to the Upper North East Region and Lower North East Region IFOAs – NPWS is required to undertake surveys for the Hastings River Mouse in areas of potential habitat prior to undertaking certain activities, including hazard reduction burns NPWS, under the Recovery Plan, will: – Monitor the Hastings River Mouse annually in Oxley Wild Rivers National Park, Mt Hyland NR, Gibraltar Range, Washpool east and west, Border Ranges, Lamington and Gambubal, all with or near to CERRA – Establish a database which will contain site records, habitat description, tenure, management regimes and disturbance history. This database will be updated on a regular basis

Species	Threats	Monitoring/Research
Koala (*Phascolarctos cinereus*) Status: Vulnerable (NSW, South-east Qld)	– Habitat Loss and Fragmentation – Habitat degradation – Road kills – Dog attacks – Fire – Disease	Draft NSW Recovery Plan – The Australian Koala Foundation's Koala Habitat Atlas (KHA) use outcomes of field research and data analyses to produce GIS-maps that delineate and rate koala habitat. The field surveys also provide an indication of the distribution and likely status of koala populations within each study area. – The NPWS Northern Directorate prepared fauna habitat quality models in 1998 for the Upper and Lower North-East Comprehensive Regional Assessment (CRA) Region. The koala model has been further refined to produce the *Recommended Koala Habitat Assessment Process Regional Vegetation Management Plans in Upper and Lower North-east NSW* (NPWS, in prep., b) which guides RVCs in the preparation of RVMPs by predicting areas likely to have koala habitat, thereby triggering further sitebased assessment. – Koala habitat and distribution has been mapped in a number of other locations through a combination of field and community surveys. – Examples of community surveys and habitat mapping are those conducted in Iluka (Lunney *et al.*, in press) and Coffs Harbour (Lunney *et al.*, 2000a) in 1990, in Gunnedah in 1991 (Smith, 1992). NPWS, under the Recovery Plan, will: – Coordinate the mapping and/or modelling of koala habitat throughout the species' distribution in NSW – Identify koala strongholds for active management, monitoring and conservation, and will approach key stakeholders to negotiate conservation outcomes. – Identify small and isolated koala populations at risk of extinction, develop strategies for active management, monitoring and conservation and approach key stakeholders to negotiate conservation – Coordinate surveys on the northern, central and southern tablelands of NSW to determine primary and secondary food tree species and assess the status of koala populations in these areas. – The Koala Recovery Team will design and implement a program to monitor changes in the status of koalas and koala habitat and evaluate the success of recovery actions in improving the conservation status of koalas in NSW.
Platypus (*Ornithorhynchus anatinus*) Status: Not listed		No Recovery or Action Plan – There has been an assessment of Platypus populations in Barrington Plateau-Hunter Region.
Rufous Bettong (*Aepyprymnus rufescens*) Status: Vulnerable (NSW)		No Recovery or Action Plan in NSW – Monitoring in Tooloom and Yabbra National Park as part of the Fox TAP program

Species	Threats	Monitoring/Research
Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) Status: Endangered (Commonwealth), Vulnerable (NSW, Qld)	– Loss, fragmentation and degradation of habitat through clearing of native vegetation and subsequent development, logging and frequent fire – Loss of large hollow logs and other potential den sites – Competition for food and predation by foxes and cats – Spread of epidemics, such as a parasitic protozoan, by cats to the Quolls – Historically (and currently) this species was extensively persecuted by humans following perceived predation on stock and poultry – Baiting of dingoes results in direct poisoning of Spotted-tailed Quolls and changes the composition of predators: reduced dingo numbers favours foxes which compete with quolls	Threatened Species Information – Monitoring in Qld: Scenic Rim; in NSW: Werrikimbe National Park, The Castles Nature Reserve, Oxley Wild Rivers National Park, Washpool National Park. – Andrew Marshall (Mid Nth Coast Region) has done some research. – A PhD project is currently underway in Qld section of CERRA - Stephanie Myer-Gleaves.
Yellow-bellied Glider (*Petaurus australis*) Status: Vulnerable (NSW) Qld and Commonwealth only list the northern subspecies, not the subspecies occurring in CERRA.	– Wildfire – Historical threat: heavy logging of forests managed for timber production and clearing of forests for agriculture and urban development	Approved NSW Recovery Plan – Research and associated surveys have been undertaken in most regions of NSW where the Yellow-bellied Glider is found (e.g. Mackowski 1988; Kavanagh and Peake 1993; Kavanagh *et al.* 1995; Kavanagh and Bamkin 1995; Goldingay and Daley 1997; Kavanagh and Stanton 1998) – Surveys have also been carried out to assist with Regional Forest.Agreement processes – The NPWS Atlas of NSW Wildlife contains records for the species in 121 National Parks, Nature Reserves and state recreational areas (Appendix 3 of plan) NPWS, under the Recovery Plan, will: – Consolidate survey results and records, including existing records that do not appear in the NPWS Atlas of NSW Wildlife, to identify the status of the Yellow-bellied Glider on privately-owned and public forested land – Identify significant Yellow-bellied Glider populations and the specific management issues associated with them. The NPWS will support monitoring of these populations and, where possible, implement appropriate management – Liaise with research institutes, tertiary institutions, State government agencies and other public authorities to facilitate strategic ecological research that is relevant to the conservation of the Yellow-bellied Glider

Species	Threats	Monitoring/Research
REPTILES		
Bellinger River Emydura (*Emydura macquarii*) Status: Common, however the Bellinger River Emydura is possibly one of the rarest turtles in Australia (Cann, 1998) and it is likely to become endangered (NSW Scientific Committee, 1997).	– Predation of nests by foxes – Competition for food and other resources with the Bellinger River Elseya – Introduction of captive or pet Emydura macquarii, into the Bellinger River population – Minor or potential threats: offsite activities causing water pollution and increased river sediment load	Approved NSW Recovery Plan – Opportunistic searches have been undertaken over a 20 year period, resulting in the discovery of the taxon at only one confirmed site – A targeted survey of areas of potential habitat in the Bellinger River and tributaries and the Kalang River has identified one additional site of occupance (Spencer and Thompson 2000). The two sites are located along a one kilometre stretch of the Bellinger River upstream of Thora – Monitoring is also undertaken as part of the Fox TAP program and a PhD research program NPWS, under the Recovery Plan, will: – Monitor the recruitment of juveniles and subadults into the population (undertaken in conjunction with the Fox TAP program) – Undertake long term studies to determine specific habitat requirements – UndertakeDNA analysis to determine if the Bellinger River Emydura is a distinctive sub-group of Emydura macquarii or if it has been introduced from elsewhere – Extended dietary analysis of the Bellinger River Elseya and the Bellinger – River Emydura, including prey availability and ecology – Support monitoring and protection of water quality in the upper Bellinger River catchment
INVERTEBRATES		
Lamington Spiny Cray (*Euastacus sulcatus*)		The distribution and abundance of Esulcatus- Sth Coast Districts Parks was studied by James Furse, Griffith Uni, Nov 2000
Freshwater Crayfish (*Euastacus gumar*)		– Monitored in Qld: Lamington National Park; and in NSW: Border Ranges National Park, Richmond Range National Park and Focal Peak area (but all possibly one-off student projects?) – Opportunistic sightings in Lamington NP- from 1999-2003?
Glow worms (*Arachnocampa richardsae*)		Monitoring in Qld: Natural Bridge section of Springbrook NP and in Main Range, (Dr David Merritt-QPWS, Uqld. Griffith?) – Opportunistic sightings Oct-Nov, 1996-2003 in Limpinwood Nature Reserve?

Species	Threats	Monitoring/Research
AMPHIBIANS		
Stream frogs: Fleay's barred-frog (*Mixophyes fleayi*) Status: Endangered (NSW, Qld and Commonwealth) Giant barred-frog (*Mixophyes iteratus*) Status: Endangered (NSW, Qld and Commonwealth) Cascade treefrog (*Litoria pearsoniana*) Status: Endangered (Qld), not listed by NSW or Commonwealth New England Treefrog (*Litoria subglandulosa*) Status: Vulnerable (Qld, NSW)	– Disease – Other threats: clearing, introduced fish, mammals and weeds, forestry activities, agriculture, mining, tourism, domestic stock and hydrological changes – Possible threats: UV-B radiation, chemical pollutants, climate change, or some synergistic or cumulative effect of multiple agents	Recovery Plan for Steam Frogs of South-East Qld 2001-2005 – Surveys and monitoring have been undertaken across the geographical and environmental range of each species – Collaborative projects with universities have been to carry out research into the ecology of, and threats to, the frogs – For *M. iteratus* and *M. fleayi* (and *M. balbus*): Barrington Tops, Werrikimbe, Nth Washpool (Coombadjha Creek site in the southern part of Washpool discontinued due to low numbers), Yabbra (near Richmond Range/ Toonumbar) and David Newell's sites in the Nightcap and Border Ranges National Parks, and Harry Hines' sites in south-east Qld are monitored 2-3 times each season – A biogeographic analysis of Wet Forest Lizards and Frogs within south-east Qld and north-east NSW (Main Range Lamington Plateau, Tamborine, Springbrook) was undertaken by Adrian Moussali and others in Dec 1999 – The phytogeography of the Eastern Wet Frogs has/is being undertaken as part of assessing the evolutionary history of CERRA. Frog groups/complexes covered include leaf-green frogs, mountain frogs and whistling tree frogs, and Assa darlingtoni and Lechriodus fletcheri – Under the Recovery plan, the stream frogs of south-east Qld will be monitored three ways: o intensively (mark-recapture over several years to determine population dynamics and ecology); o extensively (to assess the status of species over a broad geographical area) and by; o surveys (in remote or unsurveyed areas to locate new populations and to determine trends in distribution patterns). – The Recovery Plan recommends research into: o The role of disease in frog declines o The genetic structure of populations o Population dynamics; and o Habitat usage

Species	Threats	Monitoring/Research
FLORA		
Bertya ingramii Status: Endangered (Commonwealth, NSW)		No Recovery or Action Plan – Monitored at Dangar Falls at Oxley Wild Rivers NP by Gross (UNE)
Elaeocarpus spp. (Rocky Creek (syn *E.* sp. 2 'Minyon') (Minyon Quandong) Status: Endangered (NSW and Commonwealth)	– Fungal pathogens – Reproductive failure – Poaching – Invasive species – Inappropriate fire regime – Lack of knowledge of life history	Approved NSW and National Recovery Plan – In 1998 the NPWS conducted targeted field surveys for undiscovered populations with very limited success (McKinley *et al.* 1998) – Surveys for new locations of E. sp. Rocky Creek and tree health assessments were undertaken in 1999, 2000 and 2001 (Kooyman 1999, 2001) – Only one population has been recently monitored- possibly in NSW: Nightcap (Mt Jerusalem NP and Snows Gully NP?) by TSU, Northern Directorate, and also Sthern Cross uni apparently NPWS, as part of the recovery plan, will: – Undertake and document systematic surveys of potential E. sp. Rocky Creek habitat – Establish a working group to investigate the cause/s of tree deaths, particularly the potential role of fungal pathogens, at Site 1 in Whian Whian State Forest – Undertake a demographic study of the population affected by tree mortality in Site 1. The study will include several other populations (e.g. Mt Jerusalem National Park and other sites in Whian Whian State Forest where tree deaths are not currently occurring) – Carry out research on recruitment that will investigate the lack of reproductive success of some populations. – Regularly monitor the population structure at the seven sites to detect any variations in population dynamics and the species' response to a range of disturbance regimes. – Monitor tree health on a regular basis. – Assess the potential success of translocation programs through monitoring the existing cuttings, particularly those planted in Mt Jerusalem National Park. – Monitor the effects of the vine removal from E. sp. Rocky Creek trees in Mt Jerusalem National Park and Snows Gully Nature Reserve.

Species	Threats	Monitoring/Research
Elaeocarpus williamsianus Status: Endangered (NSW and Commonwealth)	– Fragmentation- edge effects – Disturbance causing erosion – Weeds – Loss of genetic diversity and genetic isolation – Inappropriate fire regime – Pathogens (potential)	Draft NSW and National Recovery Plan – Monitoring of populations has been undertaken at most sites to identify threats to the population and the response to recovery actions such as weed control activities. However, only one population has been recently monitored The DEC, under the Recovery Plan, will: – Coordinate targeted surveys. – Coordinate a census of all known populations. – Develop standard survey and environmental assessment guidelines and distribute them to all relevant consent authorities. – Investigate the need to declare Critical Habitat. – Encourage and facilitate scientific investigation into the key aspects of the biology and ecology of *Elaeocarpus williamsianus* that are likely to provide information valuable to the recovery of the species. – Support the development of a project proposal for an in-situ trial to investigate the reproductive potential of *Elaeocarpus williamsianus.*
Eidothea hardeniana (Nightcap Oak) Status: Endangered (NSW), Critically Endangered (Commonwealth)	– Climate change – Small population size – Fire regime- however no prescribed burning is planned for Nightcap National Park. – Indirect threats from logging and roads (fragmentation- edge effects). – Possible threats from tourism/recreation.	Draft NSW Recovery Plan – Extensive targeted surveys of potential habitat were undertaken in 2001 (Kooyman 2001). These surveys indicate that Eidothea hardeniana is restricted to a limited area. – Floristic, environmental and ecological data have been collected from a range of sites (Kooyman, 2001). NPWS, under the Recovery Plan, will: – Develop standard survey and environmental assessment guidelines, these will be distributed to all relevant consent authorities where there is potential for development. – Investigate the listing of critical habitat, and pursue it if appropriate. – Undertake a targeted survey during resource inventory work. – Develop a population monitoring program to be undertaken on a regular basis. – Investigate the amount and distribution of genetic variation within Eidothea hardeniana, using microsatellite analysis.

Species	Threats	Monitoring/Research
Endiandra floydii (Crystal Creek Walnut) Status: Endangered (NSW, Qld and Commonwealth)	– Low numbers – Habitat clearing and fragmentation- edge effects – Human development- edge effects, deliberate damage – Weed competition – Unskilled weed-clearing- it may be mistaken for weed Camphor Laurel – Grazing – Fire – Poor regeneration – Genetic problems- inbreeding – Lack of information about threats	Draft NSW and National Recovery Plan – Surveys were conducted during the Comprehensive Regional Assessment, and associated with Environmental Impact assessments for the Pacific Highway Upgrades between Brunswick Heads and Chinderah with route selection for the Pacific Highway upgrade and duplication (Chinderah to Brunswick sections). Also the Yelgun to Chinderah Upgrade (Stewart 1999, 2000). The DEC, under the Recovery Plan, will: – Review existing knowledge of known populations, identify information gaps, prioritise and arrange site surveys where necessary. – Develop and distribute standard survey and environmental assessment guidelines to all relevant DEC and QPWS staff, consultants and consent authorities. – Initiate a program of repeated census data collection, and observations of flowering and fruiting patterns, from representative sites. – Encourage research into genetics and reproductive biology. – Ensure that all records generated by research, surveys or management commissioned by the DEC are entered on the Atlas of NSW Wildlife.
Endiandra hayesii (Rusty Rose Walnut) Status: Vulnerable (NSW, Qld and Commonwealth)	– Clearing and fragmentation of known and potential habitat for agriculture, development and infrastructure remains an ongoing threat- edge effects, long term genetic problem – Low numbers – Weeds at previously logged sites – Unskilled weed clearing – Lack of information about threats	Draft NSW Recovery Plan – As above, and the Pacific Highway Upgrade from Brunswick Heads to Yelgun (Sinclear Knight Merz 1998, Connell Wagner 2002). – The DEC, under the Recovery Plan, will: – Initiate a program of taxonomic study, to establish the status of the species and other closely related taxa, and to develop reliable methods of separation suitable for field and herbarium use with fertile and vegetative material. – Coordinate surveys for known sites where identity remains unknown, and/or where basic site data is not available. – Use the results of initial taxonomic, genetic and survey assessments to determine the immediate need for further assessment and genetic management. – Initiate a program of repeated census data collection and flowering and fruiting records from representative sites. – Encourage research into genetics and reproductive biology.
Eucalyptus oreades		No Recovery or Action Plan, or Taxon Summary – Monitoring of *Eucalyptus oreades* communities has been undertaken in Binna Burra by Bill Flenady, QPWS
Euphrasia bella (Lamington eyebright) Status: Endangered (Qld), Vulnerable (C'th, NSW)		No Recovery or Action Plan, or Taxon Summary – Monitored at The Pinnacle walking track in Border Ranges National Park.

Species	Threats	Monitoring/Research
Fontainea australis Status: Vulnerable (Commonwealth, NSW, Qld)		No Recovery or Action Plan, or Taxon Summary – Monitoring in Qld in Springbrook National Park and in NSW in Nightcap National Park, Limpinwood Nature Reserve and Numinbah Nature Reserve
Grevillea beadleana (Beadle's Grevillea) Status: Endangered (Commonwealth, NSW)	– Inappropriate fire regime (Oxley Wild Rivers National Park), however more research is required – Known or likely to be threatened by goats (proposed key threatening process declaration)	Approved NSW and National Recovery Plan – In 2001 a targeted survey was undertaken in northern NSW, with an emphasis on potential *G. beadleana* habitat and areas where no previous surveys had been undertaken. No new *G. beadleana* populations were located during the survey, however extensive data about locations where *G. beadleana* is known not to occur was obtained. This data will be used to revise the predicted distribution of *G. beadleana* . NPWS, under the recovery plan, will: – Undertake surveys and threat assessment at known populations and those areas likely to contain *Grevillea beadleana* – Assess known sites to determine whether declaration as Critical Habitat within the meaning of the TSC Act is warranted. – Continue population studies at all known sites. – Continue research into seedbank and fire ecology. – Develop appropriate management strategies and make recommendations about the need for further research programs.
Grevillea obtusiflora subsp. *fecunda* Status: Endangered (Commonwealth, NSW)	– Direct damage by vehicular access – Inappropriate fire regimes – Roadside management activities such as grading and weed spraying	Approved NSW Recovery Plan prepared before discovery of species in Oxley Wild Rivers NP – A number of field trips have been conducted to examine the habitat of the taxa, search for further sites, determine numbers of plants and to gain knowledge of the plant's ecology. These field searches have defined the parameters of existing sites and searched other areas of suitable habitat. No other sites have been found to date. Details of the sites are shown in Appendix 1 of recovery plan. – Literature and herbarium searches have been undertaken. NPWS, under the Recovery Plan, will: – Formulate and implement a program to identify areas of potential habitat, and undertake a survey of the identified potential habitat. The participation of the local community and educational institutions will be encouraged in this program. – Formulate and implement a program to monitor the condition of populations, and maintain records of factors that are acting as threatening processes. The monitoring data will be used to review management actions as more knowledge is gathered. Monitoring will assess: o Seedling/ramet recruitment and survival o Age to reach reproductive maturity, and o The effects of any disturbance events – Encourage research into aspects of the ecology that is likely to provide information valuable to the recovery of the taxon. – Encourage research into the understanding of essential aspects of the ecology of *G. obtusiflora.*

Species	Threats	Monitoring/Research
Isoglossa eranthemoides Status: Endangered (Commonwealth, NSW)		Recovery Plan in Preparation (Commonwealth) – Monitoring at Mt Warning NP (Maria Matthes CPPD).
Nothofagus moorei (Antarctic Beech)		No Recovery or Action Plan, or Taxon Summary Two studies have been undertaken: – An *Investigation of environmental factors limiting the distribution of Nothofagus moori* in Barrington Tops National Park being undertaken by Alison Basden, Macquarie University. – *Genetic comparisons of populations of Nothofagus moorei across its range - Barrington tops to Lamington/Springbrook* (all areas are within CERRA) by Katie Taylor and John Hunter, NPWS.
Olearia flocktoniae (Dorrigo Daisy Bush) Status: Endangered (Commonwealth, NSW)		(Commonwealth) Recovery Plan adopted under *Endangered Species Protection Act*. New Recovery Plan (National and State) in preparation – Monitoring in NSW is/was undertaken in Dorrigo and East Dorrigo areas (Mt Hyland NR is one site)
Uromyrtus australis (Peach Myrtle) Status: Endangered (Commonwealth, NSW)	– Low numbers – Fire (precautionary) – Minor threats: grazing, disease, weeds and road-side slashing – Potential: climate change	Draft NSW and National Recovery Plan – Stewart and McKinley (1998) surveyed a representative range of Uromyrtus australis sites and documented abundance, distribution, sitecharacteristics and threats at these sites – Kooyman (2000a) sampled additional sites and surveyed potential habitat to assist understanding of *U. australis* distribution, population numbers and habitat. – Kooyman (2000b) designed a monitoring program to determine whether wild populations of *Uromyrtus australis* are declining spatially and/or numerically and implemented the initial stages of the program. – An *Investigation of the distribution, habitat and life history of the threatened plant Uromyrtus australe* was undertaken by TSU Northern Directorate. – Monitoring to assess status (also survey to asses threats) in Nightcap was undertaken by TSU, CPPD. NPWS, under the Recovery Plan, will: – Develop and distribute standard survey and environmental assessment guidelines for *Uromyrtus australis* to all relevant NPWS staff and consent authorities. – Develop and implement a marking system for roadside occurrences of *Uromyrtus australis* in areas under its management. – Review and update records on the Atlas of NSW – Ensure that the collection of population dynamics data from monitoring sites continues, and opportunistically monitor the impact of disturbance events. – Encourage research into genetics and the reproductive biology of *Uromyrtus australis*. – Coordinate the marking and recording of the boundaries of the larger *Uromyrtus australis* populations. – Coordinate opportunistic surveys of those areas of suitable habitat in the western Nightcap and Mt Jerusalem areas that are yet to be surveyed, and record new occurrences of *Uromyrtus australis*.

APPENDIX TWO
OTHER MONITORING APPROACHES

EVALUATING EFFECTIVENESS

A Framework for Assessing the Management of Protected Areas (Hockings *et al.* 2000)

The common uses for this evaluation are for promoting adaptive management, improving project planning and promoting accountability. Its primary purpose is to assist managers in their work.

In evaluating management, all aspects of the management cycle must be included, starting with the context within which management takes place. The results of the evaluation can be fed back into different parts of the management cycle. Figure 1 presents the framework in which management may be evaluated.

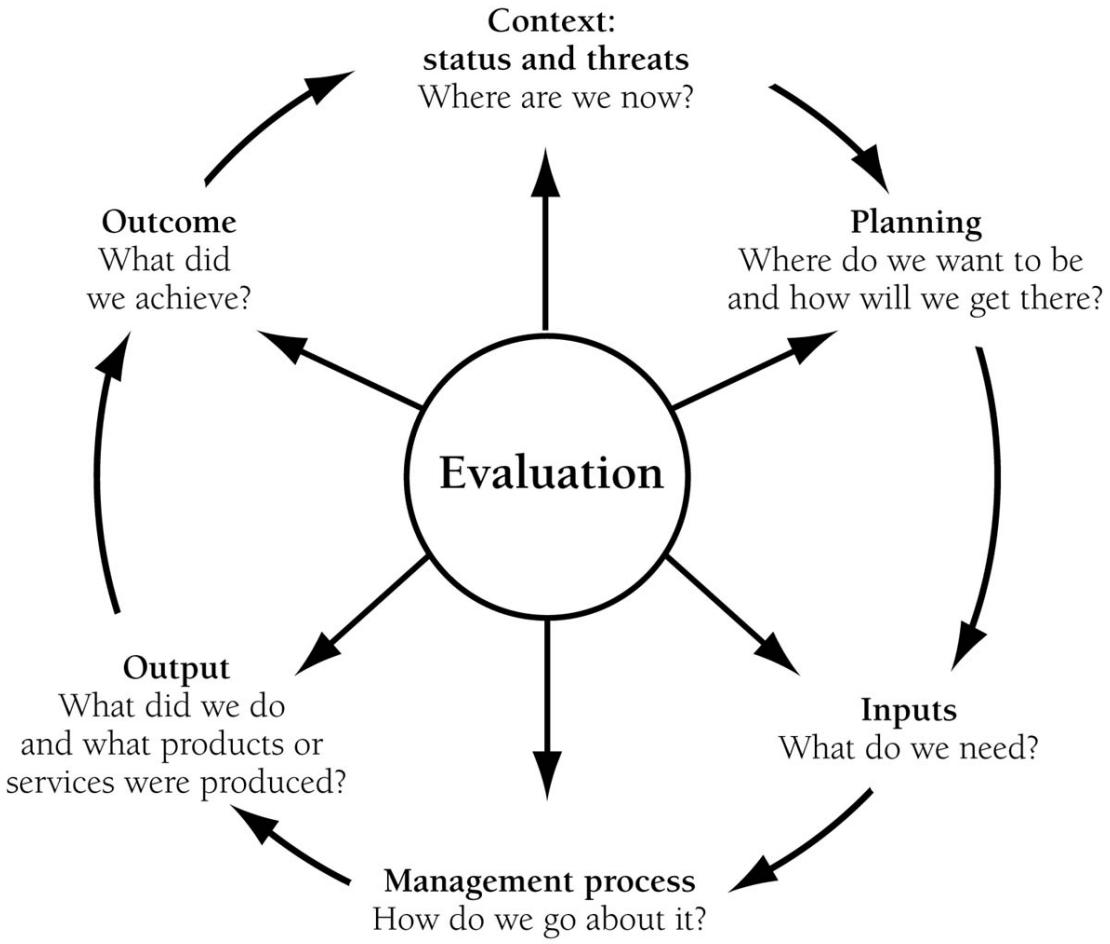

Figure 1: The Evaluating Management Effectiveness (WCPA) Framework.

Design Issues

Context – Where are we now?

This stage looks at the current state of management and the protected area. It provides information that helps put management decisions into context, it also helps to provide information about management focus.

Planning – Where do we want to be, and how are we going to get there?

This stage focuses on the intended outcomes, the vision. Assessment may consider the appropriateness of legislation, policies, planning, the design of the protected area(s) and plans pertaining to its management. The Indicators are especially selected to suit the purpose of the assessment and characteristics of the protected area(s).

Appropriateness of Management Systems and Processes

Inputs – What do we need?

This stage addresses the adequacy of resources in relation to the management objectives, based on measures of staff, funds, equipment and facilities required.

Process – How do we go about it?

In this stage management standards are established. Current management is continually examined and compared to these standards so that management may be continually improved and obtain the set objectives.

Delivery of Protected Area Objectives

Outputs – What did we do and what products and services were produced?

This stage focuses on an evaluation of what has been done by management and the extent to which targets, work programmes or plans have been implemented. Progress and results in relation to a set time-frame is examined rather than the actual deliverables.

Outcomes – What did we achieve?

This stage is an assessment of management success with respect to the objectives of the management plan, national plan and ultimately the aims of the IUCN category of the protected area. It involves long-term monitoring, and in the final analysis, outcome evaluation is the true test of management effectiveness, thus the selection of indicators to be monitored throughout the whole process is critical.

In summary, the framework provides a structure and an approach to developing systems to evaluate protected area management. Within the framework a number of different methodologies can be adopted and applied at a variety of levels, from broad and quick assessments to detailed and long-term assessments, accommodating different needs and circumstances. For all evaluations however, the guiding objective should be “to improve conservation and management effectiveness of protected areas- both for protected area systems and individual protected sites, and general principles should be adhered to”.

Table 4: Selected Examples of Indicators from Evaluating Effectiveness.

Objective	Measurement/Indicator
To preserve habitats, ecosystems and species	Population estimates of key species and populations
To maintain genetic resources in a dynamic and evolutionary state To maintain established ecological processes	Indicators selected to reflect key processes for the particular ecosystem involved
To secure examples of the natural environment for scientific studies, environmental monitoring and education, including baseline area	Numbers of scientific studies and monitoring programmes carried out in the reserve (site level) or reserves (system level)
To minimise disturbance from various activities	Extent of disturbance from various activities (authorised/unauthorised)
To maintain the essential natural attributes and qualities of environment over the long term	Indicators selected to reflect key processes for the particular ecosystem involved (site level) or extent of ecosystem stresses (system level)
To maintain the diversity of landscape and habitat, and associated species and ecosystems	Extent of change in habitat areas or populations of key species (site level) or extent of ecosystem stresses (system level)

The Enhancing Our Heritage Toolkit (Book 2) (Hockings *et al*. 2001)

The Enhancing Our Heritage Toolkit (Hockings *et al*. 2001) accompanies Evaluating Effectiveness: A Framework for Assessing Management of Protected Areas (Hockings *et al*. 2000). It addresses the practical side of the evaluating management effectiveness framework. It includes methodologies for evaluating the ecological integrity of biodiversity targets and the status of threat abatement, as part of the outcomes assessment of the framework

Biodiversity Health Assessment

The assessment of Biodiversity Health Outcomes is a crucial aspect of management effectiveness. In this model, the assessment focuses on whether the ecological integrity of a site is being maintained by monitoring the long-term healthy persistence of focal biodiversity management targets.

The Nature Conservancy has developed a set of biodiversity health measures and an approach to their measurement that are universally applicable to biodiversity. The methodology provides for three measures of biodiversity health: size; condition; and landscape context. These measures divide the various attributes of the ecology of the focal management targets for qualitative assessment as Very Good, Good, Fair or Poor.

Assessment is based on the ideas that there are a number of key factors within each measure that drive the system, that these are critical for the maintenance of the biodiversity within the ecological system, and that these naturally vary in extent and character over space and/or time. For biodiversity focal management targets to be considered ‘conserved’, the key factors should remain intact and functioning within acceptable limits.

Identification of key factors (established in the context review of the framework): This relies on understanding how the ecological systems operate. As knowledge gaps should not hinder the assessment, factors are chosen using the best available information.

Ranges of variation and thresholds for key factor measurement: The status of the key factors identified within each measure are assessed and natural variations established. Through this

process a minimum integrity threshold can be determined, this threshold is the status of the factor beyond which the ecological system suffers a loss of integrity.

Rating Size, Condition, and Landscape Context: A focal target will usually have several key factors functioning simultaneously that are in combination critical to the system's integrity. For the target's Size, Condition, or Landscape Context to be considered viable and healthy, all these key factors must be within their natural range of variation. The status of these key factors together is the criterion for distinguishing a Size, Condition, or Landscape Context basic rating of Good or Fair. The biodiversity health measures seek to further distinguish good as Good or Very Good, and fair as Fair or Poor.

Separating Good and Very Good: This is determined by how closely all the target's key factors are within their natural ranges of variation, and whether they reach the preferred goals that were set for their status.

Separating Fair and Poor: This is determined by whether, and with what level of intervention, a target occurrence's key factors that are outside their acceptable range of variation can be restored so that they all lie within their minimal integrity thresholds.

The Biodiversity Health Assessment requires careful monitoring of field-based indicators that provide real data on the status of the management targets. Only the most critical biological indicators, critical to the health and integrity of the focal management targets, should be measured. In addition, the methods and monitoring priorities must be integrated within a site-based monitoring plan for the focal management targets.

Table 5: Examples of Biodiversity Health Assessment Indicators from Enhancing our Heritage Toolkit.

Key Factor	Indicator
Size	
Sufficient size for viable populations of area-sensitive species	Aerial photos and monitoring of populations of species X
Minimum Dynamic Area necessary for recovery from natural fire disturbance	Aerial photos and fire monitoring by park personnel
Condition	
Natural succession after disturbance	Survey plots of mycorrhizae, monitoring of succession patterns in disturbed and more natural forest plots
Seed dispersal	Population size, reproduction, and distribution of seed dispersers
Natural physical structure of forest vegetation (size and stratification)	Vegetation plots; mapping of vertical structure
Natural distribution of community patch types	Riparian forest widths, composition, and disturbance; aerial photo imagery
Landscape Context	
Climate regime (vertical and horizontal precipitation)	Climate monitoring stations for temperate, rainfall (vertical and horizontal)
Fire Regime	Tree cores, aerial photos and fire monitoring by park personnel
Connectivity of forest patches	Aerial photos

Threat Status

Threats to protected areas are often multiple, and typically involve a complex web of causes and consequences. Thus it is important to understand the threat context early in the monitoring and evaluation process, as it frames the context of monitoring efforts and guides managers toward priority needs in management.

The long-term abatement of priority threats to the World Heritage site values is an important and desired result, or outcome, of effective site management. Therefore, the assessment of the status of threats and how this changes as a result of site management is also dealt with as part of the outcome assessment.

Current threat status is a combined measure of the stressors to the focal management targets and their sources. *Stressors* are the types of destruction or degradation affecting the integrity of a focal management target and reducing its viability. *Sources* of stress are the human activities that cause this destruction or degradation. Each stress has at least one source and stressors often have multiple sources. Focus should be given to the highest priority, most critical stress-source combinations that have the greatest negative impact on the focal management targets at the World Heritage site. Another aspect of threat status is the measurement of the potential threat status to biodiversity values.

Identifying Threats

For each focal management target, stressors should be identified that impair the target's integrity. This should be based on an understanding of what that target needs to persist in the long-term. The workbook provides a list of potential stressors. A list of potential threats can be drawn up by considering the social, political, cultural, legal and demographic trends at the site and that are at least likely to occur. This likelihood should be weighed against the need for management action.

Assessment of Threats

The methodology for assessment of threats is based on the stressors and sources of stress identified in the context review. The assessment follows a number of steps which are outlined in the workbook. The final steps of the process give an overall threat ranking to each focal management target, an overall threat ranking to each site, and an overall threat ranking of the World Heritage Area.

PRESSURE-STATE-RESPONSE

The Pressure-State-Response (PSR) model (see Figure 2) conceptualises that human activities exert pressures on the environment, changing the quality and quantity of natural resources. These changes alter the state, or condition, of the environment. The human responses to these changes include any organised behaviour, which aims to reduce, prevent or mitigate undesirable changes (Bell, 2000).

The PSR Framework, or modified versions of it, is being used worldwide as a reporting tool, it is generally viewed as the best conceptual framework for indicators and state of the environment reporting. It enables the performance of government policies to be monitored against actual environmental outcomes. The framework is utilised in Australia for both State of the Environment reporting and State of the Parks reporting (in Victoria). The Australian work on state of the environment reporting puts more emphasis on the *responses,* or what we can do about the condition of the environment, leading to implications for future management (Bell, 2000).

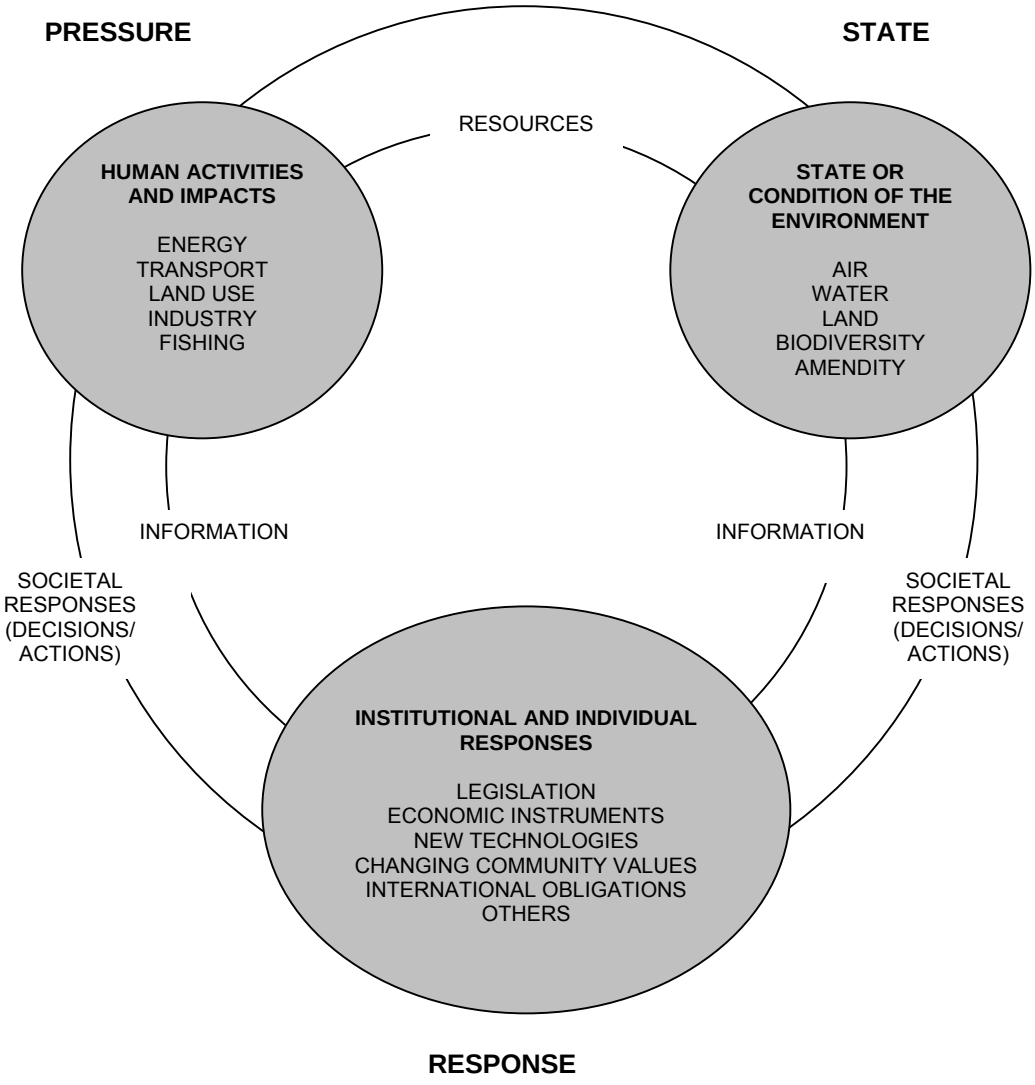

Figure 2: The Pressure-State-Response Framework.

Pressures

- pressures are defined as human induced;
- inappropriate human responses to natural conditions (e.g. variability and natural hazards such as droughts) are also pressures;
- lack of action can be a pressure.

States

- natural conditions are primarily states (e.g. soil salinity, climate variability, soil nutrients, topography and natural hazards);
- states reflect pressure and the effectiveness of responses.

Responses

- . responses can be aimed at both pressures and states;
- appropriate responses reduce pressures.

THE FIVE-S FRAMEWORK FOR SITE CONSERVATION (THE NATURE CONSERVANCY, 2000)

In order to adopt an eco-regional approach, The Nature Conservancy developed the Five-S Framework. The framework provides more sophisticated methods for site-based conservation, and measures progress towards the conservation goal. It represents a set of guiding principles for making strategic conservation decisions and measuring conservation success at sites. The logic underlying the framework is to maintain viable occurrences of identified conservation targets. Thus conservation strategies must abate critical sources of stress (threat abatement) and directly reduce persistent stresses (restoration). The measures of conservation success assess the effectiveness of the strategies at abating critical threats (Threat Status and Abatement measure) the response in the viability of the conservation targets (Biodiversity Health measure), and provide the feedback for revising strategies.

Each of the five-S's is a step towards measuring conservation success. They include:

- Systems: the conservation targets occurring at a site, and the natural process that maintain them, that will be the focus of site-based planning;
- Stresses: the types of degradation and impairment afflicting the system(s) at a site;
- Sources: the agents generating the stresses;
- Strategies: the types of conservation activities deployed to abate the sources of stress; and
- Success: measures of biodiversity health and threat abatement at a site.

The framework guides the identification of focal conservation targets and the stresses reducing their viability. As described by Hockings (see above), the stresses are ranked and compiled with the similarly identified and ranked sources to produce a "Threat-Status" for the site. The conservation strategies are specifically identified or designed to address critical threats in the most viable way using three complementary strategic approaches. The strategies listed are also ranked using a given criteria, and a small number of highly ranked strategies are chosen for immediate implementation. The final S measures the success of these strategies in maintaining the viability of the focal conservation targets by measuring biodiversity health and threat abatement (both described by Hockings- Workbook 2- see

above). In addition, using specific indicators, three key factors, which are project leader support, strategic approach and adequate funding, are measured to score the overall Capacity at a site. Building these capacity factors, in turn allows strategies to be implemented that abate critical threats and enhance or maintain the conservation targets.

INTEGRITY STATEMENTS

Queensland is proposing a system of integrity statements for its system of protected areas. The following strategic actions from the Queensland Parks Masterplan (Queensland Government 2001) relate to monitoring the park estate:

"2.1 Prepare a strategy for maintaining natural integrity on parks. This strategy will include criteria for the preparation of natural integrity statements for individual parks, which will recognise natural values and threatening processes… It will identify strategies to minimise the effect of threatening processes and to maximise the conservation role of the park in the surrounding landscape" (p. 21).

"2.2 Introduce and trial this strategy throughout the state, and complete natural integrity statements for selected key parks in the short term. In the longer term, every park will have natural integrity statements and implemented action plans for the maintenance of natural integrity" (p. 21).

To date no integrity statements have been prepared for any Queensland Parks (ie. including CERRA parks) (F. Leverington *pers. comm*.).

RAPID ASSESSMENT

QPWS conducts a RAPID assessment every few years to measure the status of a number of plans within each reserve aggregation. This includes a measure of a plan being draft, approved or implemented and to what extent it is implemented. RAPID assessment covers issues such as management plans, fire, feral, weed, visitor and cultural management plans (Chris Mitchell *pers comm*).

CASE STUDY: A REGIONAL MONITORING PROGRAM FOR THE WET TROPICS OF QUEENSLAND WORLD HERITAGE AREA (WTQWHA)

(Crome, 1995)

The purpose of this ambitious monitoring program was for regional monitoring of World Heritage values in the WTQWHA. The monitoring was to focus on biodiversity and system health, as well as the taxa for the WHA was listed. This rationale was used to determine what Attributes of Interest (AoIs) were included in the program. There were to be two types of AoIs: things of value that are of primary interest; and the stressors that impact upon them but only insofar as they relate to the former. There were also three levels of attributes, as given in the following table.

The monitoring program was envisioned to be a screening program, not a diagnostic program. It was only to identify where diagnosis would need to take place.

Although never implemented, this proposed program informed the selection of indicators used in the State of the Wet Tropics Report.

Table 6: Indicators listed in "A Regional Monitoring Program for the Wet Tropics Of Queensland World Heritage Area".

Attribute of Interest	Measurement/Indicator
Stressor Level Attibutes	
Human population and movement	– Population size – Population distribution – Traffic through the WTQWHA
Tourism	– Number of visitors – Number and size of tourist businesses – Number of tourist facilities – Number of removals of tourist facilities
Infrastructure/roads	– Length of roads – Road widening – Wet Tropics Management Authority funds diverted to road maintenance and widening in forest areas – Length of roads closed
Utility corridors	– Length of power lines and communications corridors – Length of corridors regenerated and/or revegetated
Dams and water storages	– Length of pipelines – Water consumption – Number and area of water storages
Built facilities	– Number and area of built facilities
Pests, weeds and diseases: weeds	– Number of species of weeds known – Area affected by weeds – Species regarded to become problems in near future – Area planted to species of fast growing exotic trees
Pests, weeds and diseases: diseases	– Number of plant and fauna diseases – Area of forest affected by dieback
Pests, weeds and diseases: exotic invertebrates	– Number of species of exotic insect pests of plants and number of outbreaks – Number of hives operated in the WTQWHA
Pests, weeds and diseases: exotic vertebrates	– Number of species of feral animals – Level of infestation of feral pigs – Number of domestic cats in far north Queensland
Inappropriate fire	– Number and extent of fires reported in fire sensitive forest types
Waste disposal	– Number of industrial and other facilities with licenses to discharge into streams running through the WTQWHA – Number of solid waste disposal sites – Number of dairies discharging into streams flowing into the WTQWHA
Agricultural chemicals	– Volumes of agrochemicals landed at Cairns
Special activities: grazing	– Number of grazing leases and total area
Special activities: agriculture	– Area devoted to agriculture and horticulture

Attribute of Interest	Measurement/Indicator
Special activities: dwellings and urban expansion	– Area of urban and rural residential lands with and abutting the WTQWHA
Landscape Level Attributes	
Forest cover	– Area of rainforest – Area of each rainforest type – Area of each sclerophyll type
Planning zone changes	– Amount of land re-zoned classified according to transition
Fragmentation	– Number of patches of forest – Frequency distribution of patch size classes – Length of edge WTMAs GIS
Biodiversity: extinct taxa	– Number of species reported by workers as extinct or probably extinct – Number of endemic species extinct or probably extinct
Biodiversity: rare and endangered taxa	– Number of taxa in the six WWF vulnerable categories
Biodiversity: total diversity	– Diversity of groups selected for the system/community measures
Streams and wetlands: vegetation	– Length of vegetated vs. unvegetated river banks – Length of streams revegetated in tree planting schemes
Streams and wetlands: stream condition	– Aggregate of stream condition measures from system/community measures
Streams and wetlands: wetlands	– Area of wetlands
Regeneration	– Area of cleared land that is regenerating – Area of forest (all types) free from different disturbance – Length of closed roads closed or become unusable – List of regeneration problems and their likely extent eg. Arrested successions – Number of native trees planted and the area – Area of forest beyond a certain distance from usable road – Area of forest free of tourist infrastructure development – Area of forest beyond a certain distance from utility corridors

Attribute of Interest	Measurement/Indicator
Community attitudes	– An improving attitude towards the environment within Nth Qld – An increasing amount of land within the shires of the WT devoted to conservation purposes – Membership of natural history, conservation, tree-planting groups etc. – Area of land outside the WTWHA zoned for conservation purposes
System/Community Level Attributes	
Rare and endangered plant taxa	– Number of survey sites at which taxon occurred – Changes in population of a taxon – Proportion of survey sites at which a taxon was abundant, rare or absent – Number of taxa in the IUCN endangerment categories as determined by experts at a five yearly assessment workshop
Forest condition: weeds and invading native plant species	– Number of weed species along survey drives – Length of infestations along survey drives – Number of weed species in survey sites – Scale of infestation at survey sites
Forest condition	– Number of successional areas within survey sites in which the regeneration has progressed, regressed or stayed the same – Amount of canopy closure in logged areas – Amount of regeneration along snig tracks and access roads – Numbers of species in the regeneration along snig tracks and access roads – Amount of survey site affected by dieback or other obvious diseases
Birds, mammals, Scarabaeidea and native amphibia: diversity	– Number of species – Changes in rank abundance of species – Species occurrences at survey areas – Proportion of survey areas at which particular taxon or group of taxa are abundant, rare or absent
Birds, mammals, Scarabaeidea and native amphibia: habitat groups	– Representation of habitat groups in communities – Number of species in each habitat group – Mean (distribution) of species rankings within each group
Birds, mammals, Scarabaeidea: guild structure	– Representation of guilds in communities – Number of species in each guild – Mean (distribution) of species rankings in each guild
Birds, mammals and native amphibia: rare and endangered taxa	– Number of sites at which a taxon occurred – Changes in detection rates of a taxon – Proportion of survey areas at which a taxon was abundant, rare or absent – Number of taxa in the IUCN endangerment categories as determined by experts at a five yearly workshop

Attribute of Interest	Measurement/Indicator
Stream condition (using aquatic invertebrates)	– James Cook University has/is developing the methodology
Exotic species: pigs	– Number of feral pigs seen along survey drives – Length of fresh pig rooting along survey drives – Number of feral pigs seen on area searches – Amount of fresh rooting by feral pigs on area searches
Exotic species: cane toads	– Number of toads seen on walks and drives in survey sites in the wet season – Degree to which toads penetrate undisturbed habitats
Exotic species: *Pontoscolex corethrurus*	– Presence of exotic earthworms in various habitats within survey sites

CASE-STUDY: STATE OF THE WET TROPICS REPORT 2002-2003 (WET TROPICS MANAGEMENT AUTHORITY, 2003).

The Wet Tropics reporting is an annual statutory requirement under a number of relevant Acts. The report adapts the pressure-state-response framework: The *state* of the natural values and integrity of the World Heritage Area, the *pressures* impacting on the World Heritage Area and what *responses* are being taken to address these pressures. The report also focuses on the role of the World Heritage Area on the life of the community. As a means of reporting 'trends' the report typically employs indicators.

The report discusses the state of the Wet Tropics by focusing on the state of:

- landscape diversity;
- vegetation diversity;
- ecosystem diversity;
- aquatic ecosystem diversity; and
- species diversity with special reference to rare and threatened species.

It also includes some reference to and comparisons with other parts of Australia to highlight the relative importance of the Wet Tropics to Australia's biodiversity.

The pressures on the World Heritage Area have been separated into those described as 'underlying drivers' of change and those classed as 'direct pressures'. The underlying drivers, predominantly originating outside of the World Heritage Area, create the demand for resource use that result in activities that may threaten the Property's natural values. Most of these processes, apart from climate change, have been found to be strongly influenced by regional development demands and changes in regional land use. The pressures falling into the 'underlying drivers' category include regional population growth; changes in regional land use increasing demand for natural resources; demand for community and other infrastructure (easements); tourism and recreation demand for access and infrastructure; economic development and technological advances; and climate change (see Table 7).

The report describes each of the pressures, including causes and effects, using the best available information. Specific data discussed include regional trends in population, tourism, land clearing and agricultural production, and current levels of community infrastructure in the WHA. Climate change and the potential changes affecting the Property's biota, both directly and indirectly, have been given special attention.

The range of human-induced activities (direct pressures) within the Property, that have the potential to impact negatively on the condition of the World Heritage values, have been identified as clearing, fragmentation, altered drainage patterns, pest species and undesirable habitat alteration.

The range of human-induced activities (direct pressures) within the Property that have the potential to impact negatively on the condition of the World Heritage values have been identified along with direct pressure indicators. These are:

- clearing: linear service corridors, impoundments, patch clearings, boundary anomalies;
- fragmentation: powerlines, roads, railways, impoundments, cableways;
- altered drainage patterns and flow regimes: drainage of swamps and low lying areas, water extraction and impoundments, stream fragmentation and environmental flows;
- environmental pests: environmental weeds, invasive exotic animals, exotic plant and animal diseases, translocated native species; and
- undesirable habitat alteration/degradation: forest dieback, altered fire regime.

The responses have similarly been separated in accordance with the pressures, as given in Table 7. The responses to the *underlying drivers of change* include statutory protective measures, staffing and financial resources provided to the Wet Tropics Management Authority and research.

The responses to *specific pressures* include management of community services infrastructure, of clearings and fragmentation, of pests, fire and visitation.

The final section of the report discusses fostering a role of the Property in the life of the community. The following areas are being addressed in order to achieve the desired outcome where the World Heritage Area provides benefits and essential services to the community:

- Aboriginal interests in land;
- Community attitudes;
- Community conservation activities;
- Wet Tropics Management Authority consultative and liaison groups;
- Education, interpretation and awareness raising;
- Wet Tropics visitor centres;
- Aboriginal tourism;
- Ecosystem goods and services.

Table 7: Indicators used for the State of the Wet Tropics Report 2002-2003.

Pressures/Threats	Response Measurement/Indicator
Underlying Drivers of Change	
– Regional population growth – Tourism and recreation – Regional land use – Tenure within the World Heritage Area – Regional clearing patterns and trends – Community services and infrastructure – Climate change	– Statutory protective measures o National legislation and controls o State legislation and controls o Wet Tropics Management Plan – Regional strategies land use planning – Local government planning – Changes in land ownership and/or legal status – Wet Tropics Management Authority staffing and financial resources – Improved management through research
Direct Pressures	
– Clearing and fragmentation	– Community services infrastructure management o Codes of practice o Environmental management plans o Clearings and fragmentation management – Conservation on private land outside the World Heritage Area o Voluntary acquisition of land o Rehabilitation o Powerlines o Roads
– Altered drainage patterns and flow regimes	– Drainage and flow regime management
– Environmental pests	– Environmental pest management o Pest plants o Pest animals
– Undesirable habitat alteration/degradation o altered fire regime o forest dieback	– Altered/degraded habitat management o Fire management o Forest dieback
– Tourism and recreation	– Tourism and recreation management
– Pressure and threats to species and ecosystems	– Threatened species and ecosystem management

CASE STUDY: TASMANIAN WILDERNESS WORLD HERITAGE AREA

"When the first management plan for the Tasmanian Wilderness World Heritage Area (TWWHA) was being developed, an insistent question kept emerging: "How would we know if management under the plan was actually achieving its objectives?" To address this question, the Parks and Wildlife Service set out to develop a practical system for monitoring and evaluating the effectiveness of the management plan. The result was a management evaluation system that integrates monitoring, evaluation and reporting into the overall management cycle for the area." (Jones, in press). This was achieved by integrating a structured approach into the new (1999) management plan. The management evaluation system is illustrated in Figure 3.

Figure 3: Management cycle for the Tasmanian Wilderness World Heritage Area.

Key desired outcomes are articulated from the management objectives in the management plan, to clarify what on-ground results would be expected if the objectives were fully realised. From the key desired outcomes, a range of performance indicators, that could potentially be measured to reveal whether management is working well or not, are identified. Through monitoring the identified indicators, management effectiveness may be evaluated and the subsequent findings and recommendations fed back into the management cycle to enhance effectiveness.

Therefore a key document that supports the management evaluation system for the TWWHA is the management plan, which includes: the management objectives, clear statements of key desired outcomes from each objective; prescriptions for management strategies and actions to achieve the objectives; requirements for performance monitoring, evaluation; and reporting, and requirements for review of the management plan. A second key document also supports this system, a linked 'State of the TWWHA Report', which evaluates the

effectiveness of the management under the plan. This report includes: evidence of management effectiveness; stakeholders' assessments of management performance; and proposed actions for enhancing management performance. It is this latter report that provides a tool that supports adaptive management and continuous improvement in management performance.

The main inputs to the evaluation of management performance are: scientific data and other measured evidence about performance indicators; information and professional opinions of experts; the views of the general public and on-site visitors; and assessments and critical comment on management performance by internal and external stakeholders associated with the TWWHA.

"Performance evaluation and reporting contributes to broader community understanding and involvement in management, and thereby paves the way for effective, community-supported management of protected areas" (Jones, in prep).

CASE STUDY: STATE OF THE PARKS NEW SOUTH WALES

A State of the Parks report was first completed for New South Wales in 2001 (NPWS, 2001). In the following years, the underlying rationale for this reporting was changed from simple reporting to providing feedback for management, to better inform the managing agency (the National Parks and Wildlife Service (NPWS), now part of the NSW Department of Environment and Conservation).

Specifically, the NSW State of the Parks reporting system is being re-developed to improve the quantity and quality of information available to people about their natural and cultural heritage values. This includes information about pressures on heritage values and the role of the parks system in heritage conservation. It will systematically monitor, over time, the status of conservation values at both state and park level. The approach taken is aimed at "learning by doing" where the results of management are monitored and assessed against clear objectives (Fleming, 2004).

In 2003, a trial of quantitative State of the Parks (SOP) indicators was undertaken for 22 parks, including the CERRA parks of Border Ranges and Barrington Tops. This was followed in early 2004 by a more qualitative questionnaire, which was applied in all 639 protected areas in the NSW national parks system. These developments were applauded by the NSW Audit Office, in its performance review of the management of natural and cultural heritage in national parks (Audit Office of NSW 2004). It recommended that the SOP reporting and other such initiatives be given high priority so that a comprehensive system to measure and evaluate, and improve reporting on, NSW Parks and Wildlife Service's reserve management be in place.

The Audit Office also recommended that the SOP reporting and other such initiatives be given high priority so that a comprehensive system is put in place to measure, evaluate and improve reporting on the NPWS's reserve management.

Currently, the SOP program is being fine-tuned, with an emphasis on ensuring that the more qualitative survey is applied in future years. The next SOP report is due to be launched in December 2004.

Table 8 lists the indicators used in the SOP. Please note that this is a general summary and is not comprehensive.

Table 8: Indicators used by New South Wales State of the Parks (post 2001).

SOP QUANTITATIVE INDICATORS (2003)	
Indicator	**Measurement**
Heritage Values occuring on-park	
Number of threatened species / endangered populations / endangered ecological communities occurring on-park	Proportion of threatened species / endangered populations / endangered ecological communities for which Recovery Plans have been endorsed
	Proportion of endorsed recovery plans for which recovery actions have been implemented
Number of Sites of Geological Significance on-park	Proportion of Sites of Geological Significance for which a conservation plan or Plan of Management has been endorsed
	Proportion of plans for which identified management actions have been implemented
Number of cultural heritage items and places occurring on-park	Proportion of cultural heritage items and places for which a significance assessment has been undertaken
	Proportion of significant cultural heritage items and places that have an endorsed cultural heritage management plan
	Proportion of cultural heritage management plans for which identified management actions have been implemented
The area of recognised cultural heritage landscapes on-park	Proportion of recognised cultural heritage landscapes on-park for which a significance assessment has been undertaken
	Proportion of significant cultural heritage landscapes on-park which have an endorsed Conservation Management Plan
	Proportion of Conservation Management Plans for which identified management actions have been implemented
The area and percent of terrestrial ecosystems, including wetlands, protected in reserves statewide and by IBRA bioregion	Proportion of terrestrial ecosystems which are a) largely unmodified (<30% of total statewide area altered), and b) highly modified (>70% of total statewide area altered), that are represented in the reserve system
Sustainability of Heritage Values	
Trends in population size or abundance of threatened (or other nominated) species	
Trends in area occupied / distribution and/or integrity (viability) of endangered (or other nominated) populations and endangered (or other nominated) ecological communities	
Trends in the condition of identified Sites of Geological Significance	
Trends in the condition of identified cultural heritage items and places	
Trends in the extent and duration of selected wetlands	
Number of water quality monitoring programs and/or related environmental studies undertaken	Proportion of critical water quality factors (e.g. phosphorus, nitrogen, pH and turbidity) falling outside the desired range of variability
	Proportion of parks demonstrating positive contribution to catchment water quality (case study)

Table 8 (cont'd).

SOP QUANTITATIVE INDICATORS (2003) – CONT'D	
Indicator	**Measurement**
Contribution to national and international conservation initiatives	
A list of relevant national and international treaties or agreements in heritage management that are applicable on-park	Proportion of these treaties or agreements for which specific management actions have been implemented
Provision of recreational and educational opportunities	
Number and range of park facilities available	Proportion of facilities specifically designed to provide access for elderly, less mobile and disabled visitors
	Proportion of facilities specifically designed to provide for visitors with a non-English speaking background (
	Proportion of land within the parks system which is a) declared wilderness; b) natural landscape with some trails and signage; and c) modified natural landscape
Number of visits to parks	
Number and range of recreational activities undertaken	
Number and range of educational, interpretive and other (e.g. entertainment) visitor programs	Proportion of cultural heritage activities that are conducted by local community members or their descendants
	Proportion of education programs, on-site interpretive services and infrastructure, and other visitor programs, that are consistent with an Interpretation and Education Plan
Number of education program participants on-park	Proportion of education program participants who are first-time participants, repeat participants and school groups
Number of activities undertaken to reduce risks to users	Proportion of Extreme or High Risks identified in Risk Management Plans for which Risk Treatment Plans have been developed
	Proportion of Risk Treatment Plans that have been implemented
Provision of community access for appropriate cultural purposes	
Number and range of agreements (written) between NPWS and community groups allowing continuity of use for cultural purposes	
Engagement of the community in Park management	
Number and range of key on-park management and planning activities undertaken	Proportion of key on-park management and planning activities that have involved formal consultation with representatives of key community groups
	Proportion of determinations on key on-park management and planning activities that reflect the interests of the community (Regional Advisory Committee members)
Number of joint NPWS / community tourism, pest control and fire management programs	
Number of volunteer person days	
Positive contribution to the social and economic wellbeing of local communities	
Number of concessions, leases and tour operators operating on-park	
Total salary ($) of staff on-park	
Socio-economic (case studies)	

Table 8 (cont'd).

SOP QUANTITATIVE INDICATORS (2003) – CONT'D	
Indicator	**Measurement**
Minimisation of the impact of pests and weeds	
Number of pest-animal and weed issues on-park, where a vertebrate pest or weed species is likely to have a significant impact on heritage values within the park	Proportion of pest and weed biodiversity conservation issues for which there is an effective control program
	Proportion of pest and weed cultural heritage issues for which there is an effective control program
Number of pest and weed issues on-park, where a pest or weed species is likely to have a significant impact on values in neighbouring properties	Proportion of pest and weed issues affecting neighbouring properties for which there is an effective control program
Maintenance of appropriate fire regime	
Area of park burnt in bushfire and hazard reduction burning	Proportion of parks with fire regimes compatible with biodiversity conservation
	Proportion of NPWS land zoned for the protection of neighbours and assets which has fuel managed to levels as specified in an adopted Fire Management Plan or approved by the relevant Bush Fire Management Committee
Number and source of on-park fire ignitions	Proportion of fires that start on-park, by natural, human or unknown causes, that escape the park boundary and the number of hectares burnt off-park
	Proportion of fires that start off-park that escape onto park and the number of hectares burnt on-park
Protection of soil and water resources	
Area of park affected by: a) erosion; b) acidic soils; and c) salinity.	Proportion of erosion, acidic soils and salinity issues having an adverse impact on heritage values for which successful remedial action has been undertaken
Minimisation of visitor impacts	
Number of incidents of deliberate or accidental damage (eg vandalism, overuse) to heritage values	
Number and cost of restorative or preventative projects undertaken to rectify adverse impacts	Deferred maintenance liability for asset management
Increase in the knowledge base used to inform conservation and management	
Number of visitor nodes that have required remedial work at higher than predicted rates, due to visitor impacts	Deferred maintenance liability for asset management
Number of research projects and visitor surveys undertaken to increase the knowledge base of heritage and society values on-park, for conservation, management and educational purposes	Proportion of existing parks and new acquisitions that have had natural and cultural heritage baseline surveys
Total expenditure	
Total budget for the protection of heritage	
Cost ($) per ha for reserve management	Proportion of planned management expenditure diverted to respond to large-scale unpredictable events
	Amount ($) of revenue generated from Business Activities and expenditure on capital works ($)

Table 8 (cont'd).

SOP QUANTITATIVE INDICATORS (2003) – CONT'D	
Indicator	**Measurement**
Maintenance of adequate staffing levels	
Numbers of staff	Proportion annual staff retention
	Number of field-based staff per hectare of land managed
Maintenance of adequate skill levels of staff	
Numbers of staff who have participated in training programs	Proportion of budget spent on skills development of staff
	Proportion of staff who have undergone training in cultural heritage issues and Aboriginal cultural awareness
	Proportion of staff who have tertiary qualifications in heritage conservation and/or management
SOP QUALITATIVE INDICATORS (2004)	
Indicator	**Measurement**
Management Resources	Staff Budget Revenue
Management Plans	Number of management plans prepared or in preparation incorporating fire management, weed control, horse management, cultural heritage management etc.
Important Reserve values	List up to five values with a category value and sources of information on values
Threats	List of up to five threats and the negative impact, extent and sources of information on threats
Visitor numbers	
Number of neighbouring properties	
Identification and use of reserve values	Extent of identification of values
Management planning	Extent of documented management directions and implementaiton
Work programming	Evaluation of annual work plan
Natural resource information	Evaluation of information available
Aboriginal heritage information	Evaluation of information available
Non-indigenous heritage information	Evaluation of information available
Information about park visitors	Evaluation of inoformation available
Park management issue: weeds	Evaluation of weed management
Park management issue: pest animals	Evaluation of pest animal control
Park management issue: fire	Evaluation of fire management: Ecological and cultural heritage; and life and property
Park management issue: visitor impacts	Evaluation of visitor impact management programs/activities
Park management issue: Aboriginal cultural heritage management	Evaluation of Aboriginal and cultural heritage management
Park management issue: non-Indigenous cultural heritage management	Evaluation of non-indigenous cultural heritage management
Law enforcement	Evaluation of law enforcement effectiveness
Built infrastructure and asset maintenance	Evaluation of maintenance

Table 8 (cont'd).

SOP QUALITATIVE INDICATORS (2004) – CONT'D	
Indicator	**Measurement**
Community consultation and involvement	Extent of community involvement in the management of the reserve; and extent of Aboriginal involvement in the management of the reserve
Visitor facilities	Evaluation of the appropriateness and adequacy of visitor facilities
Park identification and visitor orientation	Evaluation of park information in meeting management and visitor needs
Awareness/education programmes	Evaluation of awareness and education programmes in meeting management needs and visitor needs/expectations
Condition of natural values	Evaluation of the condition of reserve biodiversity/ecological values
Condition of Aboriginal places and sites	Evaluation of the condition of Aboriginal places and sites
Condition of non-indigenous values	Evaluation of the condition of non-ingigenous values
Condition of values other than natural and cultural values	Evaluation of the condition of other important values of the reserve
Monitoring and evaluation of aspects of park management	Extent to which a monitoring and evaluation strategy is in place

CASE STUDY: ECOLOGICALLY SUSTAINABLE FOREST MANAGEMENT (ESFM) (ESFM REPORT FOR UPPER AND LOWER NORTH EAST NSW APRIL 2000)

The ESFM monitoring system is the application of the Montreal Process, an international agreement, required by the Commonwealth Regional Forests Agreement (RFA) legislation and thus the RFA for north-east New South Wales, which was signed in 1999.

NSW National Parks and Wildlife Service are required to report against criteria established to monitor the ecological sustainability of current forest management. However, it is a top-down system, and not all criteria and indicators are suited to the CERRA World Heritage Area.

Table 9: Criteria and Indicators used by the ESFM Monitoring System.

Indicators by Forest Agreement regions for NPWS reporting	
Criteria	**Indicator**
Biodiversity	Extent of area by forest type and tenure
	Area of forest type by growth stage distribution by tenure
	Fragmentation of forest types
	A list of forest dwelling species
	The status (threatened, rare, vulnerable, endangered, or extinct) of forest dwelling species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment
	The status of endangered populations and ecosystems as determined by legislation or scientific assessment.
Maintenance of productive capacity and sustainability of forest ecosystems	Area and percent of harvested area of native forest effectively regenerated
Maintenance of ecosystem health and vitality	Area and percent of forest affected by processes or agents that may change ecosystem health and vitality (narrative as interim)
Conservation and maintenance of soil and water resources	Area and percent of forest land covered by comprehensive Road Management Plans which include an assessment of the extent of the existing road infrastructure, processes for ongoing improvement, targets and milestones
	(Interim) Area and percent of forest land systematically assessed for soil erosion hazard, and for which site-varying scientifically-based measures to protect soil and water values are implemented
Maintenance of forest contribution to global carbon cycles	(Category B) Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages
	(Category B) Contribution of forest products to the global carbon budget
Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of society	Number of visits per annum
	Change in condition and number of recorded places, artefacts, sites, buildings or other structures
	(Category B) Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment
Legal, institutional and economic framework for forest conservation and sustainable management	(Narrative) Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests
	(Narrative) Extent to which the institutional framework supports the conservation and sustainable management of forests
	(Narrative) Capacity to measure and monitor changes in the conservation and sustainable management of forests

Indicators by Forest Agreement regions for NPWS reporting	
Criteria	**Indicator**
	(Narrative) Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services