The Natural Heritage Significance of Cape York Peninsula

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DISCLAIMER

This report was based on available published documentation and contributions by invited specialists. The project brief did not allow for any new data collection, though the authors did undertake where possible some new analyses using existing data to address identified information gaps.

The major part of the data and information used was derived from the CYPLUS study, a joint Australian Commonwealth and Queensland Government initiative which has developed a substantial data base on natural attributes of Cape York Peninsula.

All care was taken to locate relevant studies and papers but time and other limits may have resulted in some documentation not being identified. However these are unlikely to significantly change the overall conclusions reached in this report.

This report was prepared for ANUTECH Pty Ltd under commission from the Queensland Environmental Protection Agency. The views expressed in this report are those of the authors and do not necessarily represent the views of the Queensland Environmental Protection Agency, the Government of Queensland or ANUTECH Pty Ltd.

ANUTECH Pty Ltd and the authors accept no responsibility (other than to the Queensland Environment Protection Agency under the terms of the commission) for any use of or reliance on any information in this report by any person.

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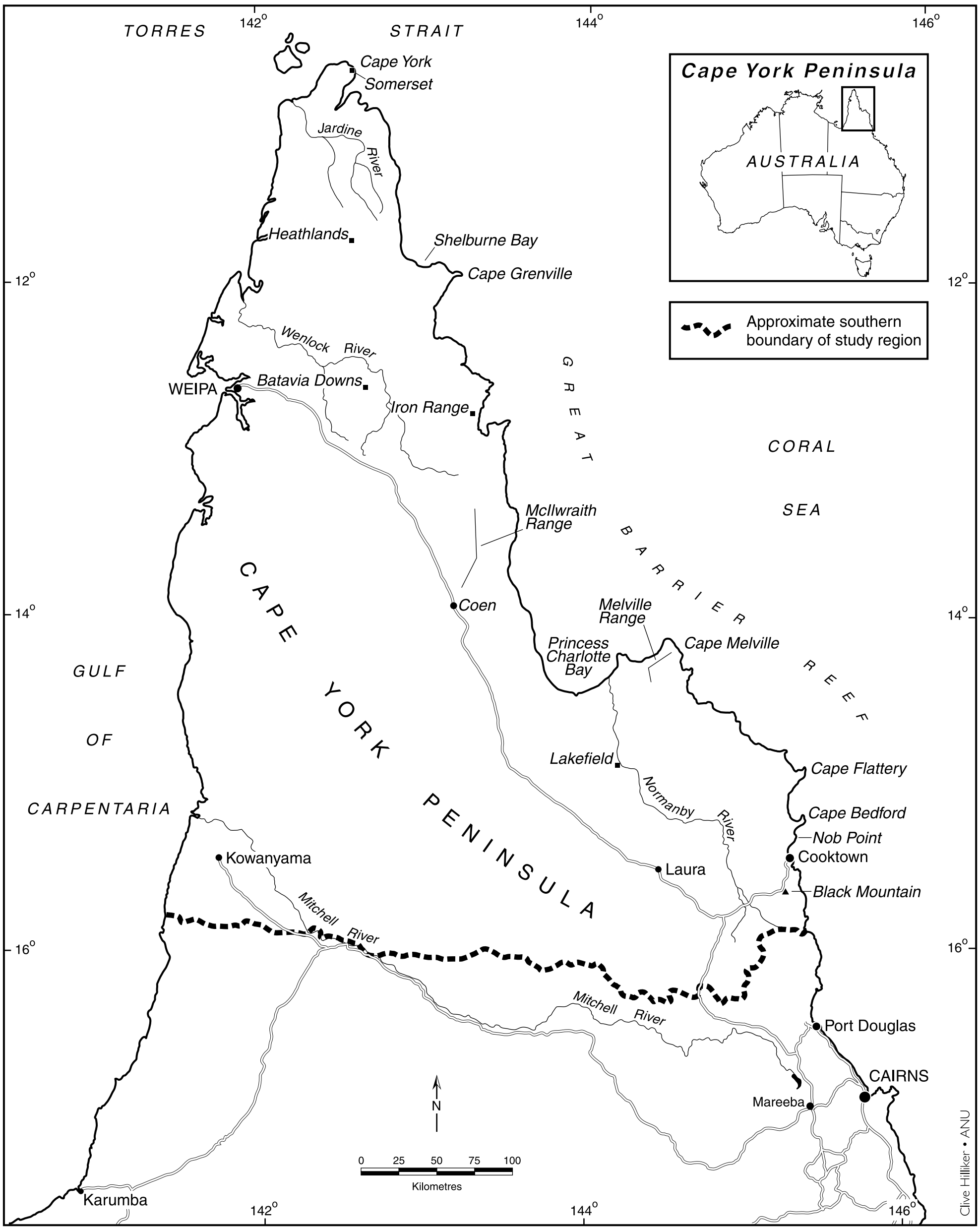

Map 1. Location of study region

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1 INTRODUCTION

1.1 BACKGROUND

This report presents an assessment of the Natural Heritage Significance of Cape York Peninsula. The study region is that area defined by the Cape York Peninsula Land Use Strategy (CYPLUS). As defined, Cape York Peninsula does not include the more developed pastoral, agricultural and urban/industrial areas at the base of the Peninsula. The southern boundary of CYPLUS is approximated by -16 degrees south latitude. Thus, for the most part, it is the more remote, undeveloped northern sector, that is least disturbed by modern technology. Exceptions are the bauxite mining operations and township at Weipa and very limited areas of agricultural development at Lakeland Downs and closer to Cooktown, the administrative centre for Cape York Peninsula. Indigenous townships are at Kowanyama, Porumpuraw, Aurukun, Bamaga, Lockhart River and Hopevale. Very small service centres exist at Laura and Coen, and a sizeable service centre at the tip of Cape York on nearby Thursday Island.

Where appropriate, the assessments presented here draw upon scientifically based data and knowledge. However the concept of natural heritage owes as much, if not more, to culturally-based social values as it does to hard science. This report is therefore not a purely scientific document. Rather, the assessments reported here are unavoidably qualitative, though every effort has been made to ensure they are informed by scientific understanding of natural phenomena.

1.2 PURPOSE

In June 1999 ANUTECH Pty Ltd signed a contract with the Environmental Protection Agency/Queensland Parks and Wildlife Service (EPA/QPWS) to undertake an assessment of the natural heritage significance of Cape York Peninsula.

Key tasks included:

- Compile relevant assessment criteria and produce draft criteria for assessing the natural heritage significance of Cape York Peninsula
- Evaluate the adequacy of the existing inventory for applying these criteria
- Complete inventory where required from existing data and information and evaluate its adequacy against the relevant criteria
- Apply draft criteria to the completed inventory to prepare a draft *Statement of Natural Heritage Significance*
- Identify an appropriate expert panel to review the draft, and conduct an expert panel workshop
- Redraft the report incorporating recommendations from the expert panel workshop
- Arrange a peer review of the report by internationally recognized experts, and finalise the report giving due consideration to their comments.

This natural heritage significance assessment of Cape York Peninsula will complete the first stage of a critical recommendation of the Cape York Peninsula Land Use Study (CYPLUS) stage two final report (section 6.2.12) drawing from all relevant data in CYPLUS stage one and two. The CYPLUS stage two report anticipated that the development of specific criteria, against which Cape York Peninsula's natural values could be assessed, would need to be developed and applied early in the stage three implementation process. The natural heritage significance assessment will also enable the implementation of a key recommendation (clause 13) of the Cape York Heads of Agreement (Land Use) signed in February 1996.

The Statement of Natural Heritage Significance will be presented to the Tenure Resolution Group and other committees involved in CYP 2010, the Cape York Natural Heritage Trust Plan process, and the property planning process, and will be a significant planning tool in guiding policy and land use decision making in Cape York Peninsula. The completion of the natural heritage significance assessment partly fulfils the objectives of strategy six under the Cape York Natural Heritage Trust Plan in that it provides an assessment of the Peninsula's natural values against local, continental, regional and global criteria. An assessment of the Peninsula's cultural values was not undertaken as part of this consultancy.

The consultants were guided by a steering committee composed of representatives from the Australian Conservation Foundation, the Wilderness Society, the Cairns and Far North Environment Centre, the Cape York Property Planning Technical Group, EPA/QPWS and the office of the Minister for Environment and Heritage and Minister for Natural Resources.

1.3 OVERVIEW

The report is structured as follows.

Chapter 2

Defines and explains the new set of criteria used in this report to assess natural heritage significance.

Chapter 3

Reviews the data and information available for assessing natural heritage significance provided by the various CYPLUS (Cape York Peninsula Land Use Study) reports.

Chapter 4

Discusses the application of Criteria 1 (Geoevolution) and 2 (Geodiversity).

Chapter 5

Discusses the application of Criteria 3 (Bioevolution) and 4 (Biodiversity).

Chapter 6

Discusses the application of Criteria 5 (Natural Integrity) and 6 (Ongoing Natural Processes).

Chapter 7

Discusses the application of Criteria 7 (Contribution to Knowledge) and 8 (Aesthetics).

Chapter 8

Is a summary of main points from this report and forms the basis of an Executive Summary that is being published separately as a public document by the Environmental Protection Agency.

It proved easier to consider the criteria in congruent pairs rather than individually. This reflected a natural clustering of relevant concepts and information. It was difficult if not impossible to apply the criteria consistently because they varied in terms of (a) the extent to which the concepts surrounding their definition were well defined in theory, (b) the availability of the required data, and (c) the existence of established and tested methodologies. Thus Chapters 4-7 vary in how they approach the task of examining and applying these criteria.

Of necessity then, a different approach was taken in applying each set of criteria. Within the constraints of the project we were unable to obtain the desired level of context for Criteria 1 (Geoevolution) and 2 (Geodiversity). Thus Chapter 4 is based on what is known about the geoevolutionary history of the study area, and the location of special geological/geomorphological features of interest known to exist within the area. Extensive data at a range of scales were available in support of Criteria 3 (Bioevolution) and 4 (Biodiversity). Hence, Chapter 5 presents a more quantitatively based, integrated assessment. The whole conceptual schema for assessing Natural Integrity and Natural Processes had to be reviewed and developed before Criteria 5 and 6 could be applied. Substantial data were available and at a range of scales to support new analyses in Chapter 6. Finally, both Criteria 7 (Contribution to Knowledge) and 8 (Aesthetics) demanded development of a new conceptual synthesis. Accordingly, Chapter 7 was based on a more exploratory and descriptive assessment.

1.4 ROLE OF CYPLUS REPORTS AND ACKNOWLEDGEMENTS

This report draws extensively upon the data, information, literature reviews, and assessments undertaken and documented by the CYPLUS project. The Cape York Peninsula Land Use Strategy (CYPLUS) is a joint initiative between the Commonwealth and Queensland Governments. Stage 1 involved data collection, issues identification and analysis of opportunities and constraints. This stage commenced in early 1992 and was completed in 1995. A major achievement of Stage 1 was production of 21 reports on Cape York Peninsula's natural resources, plus additional reports on land use, including an assessment of conservation and natural heritage significance, and reviews of animal and weed pests. A list of these CYPLUS reports is given in Table 1.1.

The reports provided an invaluable foundation for our efforts. First, the authors compiled available and new data (based on field surveys conducted as part of CYPLUS Stage 1). Second, the authors extensively reviewed and integrated the available published literature. Our access to the extensive CYPLUS data base enabled new analyses to be undertaken in support of some of the natural heritage criteria. Our task was further simplified by being able to refer the reader to literature cited in the CYPLUS reports.

We thank the many researchers and authors who contributed to the extensive set of publications produced by CYPLUS Stage 1. We recommend these reports, together with their extensive literature reviews, to all those interested in the natural environment of Cape York Peninsula. We are grateful to various people within the Queensland public service who facilitated our access to and use of the CYPLUS data base.

The authors would also like to acknowledge the many people who have contributed to this report by offering their expert advice, comments on draft sections, and bringing our attention to important literature. An early draft of this report was subject to analysis by an expert panel at a one day workshop held in October in Cairns. This final version benefited from the rich dialogue that emerged at the workshop, and the many insights that participants so willingly shared.

Table 1.1 List of CYPLUS reports

(http://www.environment.gov.au/states/cyp_on_l/st1detlist.html)

INDIVIDUAL REPORTS – NATURAL RESOURCES		
Report no.	**TITLE**	**Author(s)**
NR01	Vegetation survey and mapping of CYP	V.J. Neldner and J.R. Clarkson
NR02	Soil survey and agricultural suitability of CYP	A.J.W. Biggs and S.R. Philip
NR03	Terrestrial vertebrate fauna of CYP	J.W. Winter and P.J. Lethbridge (with appended work by D.C. McFarland)
NR04	Mineral resource inventory of CYP	T.J. Denaro
NR05	Geology and minerals of CYP	J.H.C. Bain
NR06	Marine vegetation of CYP	K.F. Danaher
NR07	GIS creation/maintenance	I. McNaught
NR08	CYPLUS GIS development and Qld coordination	G. McColm and I. Beitzel
NR09	Wetland definition and fauna assessment of CYP	P.V. Driscoll
NR10	Freshwater fish and aquatic habitat survey of CYP	B.W. Herbert, J.A. Peeters, P.A. Graham and A.E. Hogan.
NR11	Environmental regions of CYP	M. Cofinas and M.P. Bolton
NR12	Regolith-terrain mapping of CYP	C.F. Pain, J.R. Wilford and J.C. Dohrenwend
NR14	Coastal environment geoscience of CYP	R.V. Burne and T.L. Graham
NR15	Airborne geophysical data for CYP	I.G. Hone and R. Almond
NR16	Groundwater resources of CYP	A.M. Horn, E.A. Derrington, G.C. Herbert, R.W. Lait and J.R. Hillier
NR17	Insect fauna survey of CYP	P. Zborowski, I.D. Nuamann and T.A. Harwood
NR18	Flora data and modelling for CYP	M. Cofinas, M.P. Bolton, A.J. Bryett, D.C. Crossley and A.L. Bull
NR19	Fauna distribution modelling for CYP	D.G. Glasco, M.P. Bolton and A.J. Bryett
NR20	CYPLUS data into the NRIC directory of databases facility (Findar)	P. Shelley
NR21	Ecology and conservation of the Golden-shouldered parrot	S.T. Garnett and G.M. Crowley

Table 1.1 Continued

INDIVIDUAL REPORTS – LAND USE	
TITLE	**Author(s)**
Aspects of commercial and non-commercial fisheries of CYP	R. Tilbury
Areas containing significant species or habitats outside existing national parks and reserves network on CYP	D.A. Whisson and P.A.R. Young
An assessment of the conservation and natural heritage significance of CYP	H. Abrahams, M. Mulvaney, D. Glasco and A. Bugg
Land use strategy models	Focus Pty Ltd and Kim Campbell Town Planning Pty Ltd
Current administrative structures on CYP	J. Stanley and K. Campbell
Economic assessment and secondary and tertiary industries of CYP	B. Knapman, C. Ramm and L. Cross
Animal and weed pests of CYP	J. Mitchell and H. Hardwick
Fire on CYP	G.M. Crowley
Survey of forest resources of CYP	B. Wannan
Indigenous management of land and sea and traditional activities in CYP	J. Cordell (Ed.)
Land degradation in CYP	Australian Geological Survey Org., Bureau of Resource Science, Qld Dept. of Primary Industry
Land tenure system and issues of CYP	M. Hardy, R. Nelson and J.H. Holmes
Mineral resource assessment	T. J. Denaro and G.R. Ewers
Mining industry issues and impacts	
Management of pastoral holdings in CYP	G.F. Cotter
Pastoral industry of CYP	R. Walker
Population characteristics of CYP	D. King
Other primary industries (non-pastoral, non-forestry) of CYP	D. Hanlon, S. Sloss, A.J.W. Biggs, S.R. Philip and S. Golden
Services and infrastructure of CYP	M. Winer
Energy and resource needs of CYP	
Surface water resources of CYP	A.M. Horn
Tourism study of CYP	P.C. James and J. Courtenay
Transport services and infrastructure of CYP	Gutteridge Haskins and Davey Pty Ltd
Values, needs and aspirations study of CYP	L. Roughly and D. Elliott

2 CRITERIA FOR ASSESSING NATURAL HERITAGE SIGNIFICANCE

2.1 BACKGROUND

Assessment of the Natural Heritage significance of Cape York Peninsula required the development and adoption of a set of criteria against which the heritage values of the study area could be assessed. One possibility was to simply adopt existing criteria. However, our collective experiences in working with heritage criteria both within Australia and internationally had convinced us that no existing set encompasses all the necessary and sufficient conditions. Rather, it was necessary to derive a new set of universal heritage assessment criteria.

The development of these criteria was undertaken independent of the data gathering process and completed before the data analysis stage. In this way the criteria reflected 'best practice' and the experiences of the authors, and hence were not unduly influenced by the type or detail of available data. In developing these criteria we drew upon existing heritage assessment criteria in use both nationally and internationally. In addition, we were informed by advances in ecological understanding about the conservation significance of natural ecosystem processes, and relationships between environmental determinants of biotic response, habitat, community organisation, and disturbance regimes. Our recommended criteria reflect a synthesis of these sources.

In this chapter we first describe the methodology employed to arrive at the new set of heritage criteria for Cape York Peninsula. This is followed by a review of existing heritage criteria. We conclude with an account of the recommended set of Cape York Peninsula criteria.

2.2 METHODOLOGICAL OVERVIEW

In developing criteria for assessing natural heritage significance we followed the following steps:

- The meaning and scope of natural heritage were defined
- Established world and national natural heritage criteria were reviewed and evaluated, and deficiencies identified
- A new set of universal criteria was developed

A fundamental premise adopted in this report is that natural heritage assessment demands that the target region (Cape York Peninsula) be placed in appropriate geographic context. The natural heritage significance of a region cannot be assessed at a single geographical scale. Rather, analyses are required at a range of scales - global, regional, continental and local. As used here, *regional* refers to the Australia/PNG/South Pacific region, and *local* is defined by Cape York Peninsula.

It follows that *ad hoc*, small-scale, property-level assessment, while critical for devising planning and management prescriptions, cannot provide the necessary information base and context for natural heritage assessment. Rather, systematic data are needed across the geographical region defined by each target scale of analysis. Systematic data are required in order to enable a comparative evaluation of the natural heritage values of the region relative to other locations. These comparisons to be definitive must be based on data that describe the total distribution of the target phenomena at the specified scale. Systematic comparisons enable an assessment to be made of the extent to which phenomena are geographically unique (or in biological terms, endemic), or share features and processes with other locations. Unique features are generally considered significant. Shared features or processes can be significant for a variety of reasons, for example: a location might be a critical geographical link in a regionally scaled pattern of species migration; or a feature may not be unique to a location, but may represent its most significant expression.

2.3 DEFINING NATURAL HERITAGE

The first step in development of criteria for assessment of the Natural Heritage Significance of Cape York Peninsula was to define *Natural Heritage* and *Natural Heritage Significance*. Natural Heritage is a term widely used, but not often well defined. Heritage can be broadly defined as *anything that is or may be inherited* (Oxford English Dictionary). However, the more precise definition presented in the Oxford English Dictionary is:

> *A nation's historic buildings, monuments, countryside, etc.,*
> *especially when regarded as worthy of preservation*

though this has a decidedly English flavour to it with a clear bias towards cultural heritage.

In one sense, natural heritage can be defined negatively as that which is not cultural heritage. However, to Australian indigenous people this would be entirely inappropriate as they consider what is commonly defined as *natural heritage* to be part of a cultural landscape and hence fall within their definition of cultural heritage[1]. Natural Heritage could also be defined in more positive terms. Based on the definition of *Natural Heritage (Significance)* adopted in the Australian Natural Heritage Charter, natural heritage might be defined as:

> *Those ecosystems, biological diversity and geodiversity that we value and thus are regarded as worthy of conservation or preservation.*

This definition arguably is too narrow by virtue of its apparent limitation to the biodiversity, ecological and geodiversity categories. Addition of the term *landscape* would introduce a greater sense of an holistic definition, albeit less precise. This definition also lacks any implicit or explicit purpose for conservation or preservation. Extrapolation of the dictionary definition of heritage, suggests that the definition of natural heritage should contain some sense of purpose. Addition of words to the effect for *transmission to future generations* provides some sense of purpose, thereby improving the definition.

Our recommended working definition of *natural heritage* is:

> *Those elements of biodiversity, geodiversity, and those essentially natural ecosystems and landscapes which are regarded as worthy of conservation or preservation for transmission to future generations in terms of their existence value or for their sustainability of life and culture.*

Notwithstanding the above working definition of *natural heritage* there is always a possibility that in development of significance criteria, some elements of the spectrum of natural heritage may be overlooked. Table 2.1 is a classification of natural heritage values developed as an inventory check list of natural heritage for the purpose of testing the scope of the proposed natural heritage criteria.

2.4 DEFINING NATURAL HERITAGE SIGNIFICANCE

Based on the above definition, natural heritage significance can be considered as all those things which meet the definition but which also need to meet some predefined threshold. Natural heritage significance is therefore a term of relativity and cannot be absolute. Nor is it just about meeting a minimum threshold, but may include a measured rating of significance above the threshold.

The Australian Natural Heritage Charter (Cairnes 1996) does not define natural heritage significance *per se,* but does define *Natural Significance* which, for the purpose of this study, was considered a comparable term:

> *Natural significance means the importance of ecosystems, biological diversity and geodiversity for their existence value, or for present or future generations in terms of their scientific, social, aesthetic and life-support value. (Australian Natural Heritage Charter)*

1 The authors acknowledge their adoption of a conventional Euro-centric approach to natural heritage assessment, and recognise that local indigenous peoples and others may have a different approach to defining the boundary between natural and cultural heritage and also to how natural heritage is assessed.

Our recommended working definition of *natural heritage significance* is:

> *The relative importance of biodiversity, geodiversity, and those essentially natural ecosystems and landscapes which are regarded as worthy of conservation or preservation for transmission to future generations in terms of their existence value or for their sustainability of life and culture*.

This means that for assessment of the natural heritage significance of Cape York Peninsula, the precise identification and delineation of what constitutes *natural heritage* is not critically important. What is critically important however, is assessment of the relative natural heritage significance. Accordingly, the assessment criteria are directed not at what constitutes *natural heritage,* but at an objective assessment of the relative natural heritage significance of Cape York Peninsula as a whole and of particular features found on Cape York Peninsula.

2.5 EVALUATION OF EXISTING HERITAGE CRITERIA

2.5.1 GLOBAL HERITAGE CRITERIA

The only global criteria for the identification and assessment of natural heritage at the global level and in regular use are those used by UNESCO for assessment of World Heritage for listing on the World Heritage List. The UNESCO criteria find their roots in the definition of *natural heritage* in the World Heritage Convention (2000), the popular name for the *Convention Concerning the Protection of the World Cultural and Natural Heritage*. The Convention defines natural heritage with a set of statements which are *de facto* criteria:

> *In accordance with Article 2 of the Convention, the following is considered as natural heritage: natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation; natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.*
>
> (Quoted in Section 43 of the Operational Guidelines of the World Heritage Convention. 1997)

The Operational Guidelines, which are non-statutory guidelines for implementation of the Convention, continue:

> *44. A natural heritage property - as defined above - which is submitted for inclusion in the World Heritage List will be considered to be of outstanding universal value for the purposes of the Convention when the Committee finds that it meets one or more of the following criteria ...*
>
> *(i) be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; or*

(ii) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; or

(iii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance; or

(iv) contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

Each of the global (World Heritage) criteria were then evaluated for relevance and application in the Cape York assessment.

...(i) be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features...

The main focus here is on *earth's history* which by convention is divided into various eras. While not limited to geological and physiographic features, this criterion clearly addresses the physical diversity or geodiversity (of the world). It embraces the past (history), contemporary and future (on-going) temporal classes and so appears to be fully comprehensive and appropriate. It can be readily adapted to a regional, continental and local context.

...(ii) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals...

The focus of this criterion is ecological and biological processes and is clearly expressed. It would make an excellent contribution to a set of universal criteria.

...(iii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance...

The focus of criterion (iii) is essentially anthropocentric - human emotional and spiritual responses to the natural environment - in particular beauty and aesthetics, but also includes *superlative natural phenomena* which may go beyond the bounds of a lay appreciation of what constitutes *natural phenomena*. The term superlative is equally applicable to all levels/scales of assessment in which case the application of this term would need to be adjusted to match the geographical context.

...(iv) contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation...

This criterion is aimed at the more important aspects of biodiversity, including rare and threatened species. This criterion has on occasions been misinterpreted or misrepresented as applying only to species of *outstanding universal value...* which is not the case. It applies to all aspects of biological diversity, not just threatened species and certainly not just to threatened species of outstanding universal value. Hence it also applies to whole landscapes, ecosystems and biological communities. Subject to correct interpretation, it makes a useful contribution to development of a set of universal criteria.

2.5.1.2 DISCUSSION

The World Heritage criteria, with some refinement over the years, have withstood the test of time as being both useful and sufficiently comprehensive to deal with all aspects of assessment of *in situ* global heritage, in both terrestrial and marine environments. Tested against our recommended definition of natural heritage for the Cape York Peninsula study, all elements of the definition appear sufficiently explicit. Indeed, the scope of the criteria, arguably, are more comprehensive than the definition, which can only be beneficial. Accordingly, the criteria applied for the assessment of World Heritage appear adequate for the task of assessing at least the global heritage significance of Cape York Peninsula.

Many heritage assessment criteria in use fail to accommodate the dynamics of the natural world. An important attribute of the global criteria is that they are not limited to the present or 'snap-shot' assessment, but do accommodate the dynamics of natural processes and the temporal status of a feature or area - that is, they accommodate past (history), present and future (on-going).

One remaining question is whether the global criteria are sufficiently comprehensive. For example, over the last decade, scientific research into global change has reinforced the role played by biodiversity (that is, the biota together with the communities and ecosystems they form) in defining and regulating local, regional, and global environmental conditions. For example, natural vegetation/soil ecosystems are now recognized as playing major regulatory roles in the water and carbon cycles (Gorshkov 1995, Taiz and Zeiger 1991, Briggs and Smithson 1985, Odum 1971). The World Heritage criteria do not explicitly address the functional roles that biodiversity plays in these critical ecological life support systems. Given this, there is a need for additional criteria that will address the contribution that biodiversity makes to the integrity of the functioning of landscape-, regional-, and global-scaled life support systems.

2.5.2 EVALUATION OF NATIONAL/CONTINENTAL HERITAGE CRITERIA

The only current Australia-wide heritage assessment criteria applicable to natural heritage are the criteria used in the assessment of places for listing in the National Estate Register under the Heritage Commission Act 1975 (Environment Australia 2000). The criteria contained in the Act are for both natural and cultural heritage:

> (1) For the purpose of this Act the national estate consists of those places, being components of the natural environment of Australia or the cultural environment of Australia, that have aesthetic, historic, scientific or social significance or other special value for future generations as well as for the present community.
>
> (1A) Without limiting the generality of subsection (1), a place that is a component of the natural or cultural environment of Australia is to be taken to be a place included in the national estate if it has significance or other special value for future generations as well as for the present community because of any of the following:
>
> (a) its importance in the course, or pattern, of Australia's natural or cultural history;
>
> (b) its possession of uncommon, rare or endangered aspects of Australia's natural or cultural history;
>
> (c) its potential to yield information that will contribute to an understanding of Australia's natural or cultural history;
>
> (d) its importance in demonstrating the principal characteristics of:
> (i) a class of Australia's natural or cultural places; or
> (ii) a class of Australia's natural or cultural environments;
>
> (e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
>
> (f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
>
> (g) its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
>
> (h) its special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history.
> (Australian Heritage Commission Act 1975)

Several of the criteria above, in particular criteria (f), (g) and (h), are limited to cultural heritage and need not be further considered.

In day to day application of the legislated criteria, the Australian Heritage Commission uses a derived set of sub-criteria. A copy of those sub-criteria which are relevant to natural history are given at Table 2.2. The legislated criteria were evaluated in the first instant, followed by evaluation of the sub-criteria or *operational criteria* as a cross check.

2.5.2.1 EVALUATION OF RELEVANT NATIONAL ESTATE CRITERIA

(a) ***Importance ...natural ...history***

As a criterion this is vague. It does contribute to the concept of *importance*, but gives no guidance beyond that. Although vague, it is not inconsistent with the World Heritage criteria. The sub-criteria used by the Australian Heritage Commission greatly improves the interpretation of Criterion (a).

(b) ***...uncommon, rare or endangered aspects of Australia's natural ...history***

Para (b) introduces the concept of 'uncommonness, rarity and endangerment' - all quite valid for any universal heritage assessment criteria. This is also consistent with the global criteria. The sub-criteria are a useful elaboration of Criterion (b).

(c) ***...contribute to an understanding of Australia's natural ...history***

Para (c) introduces the concept of an area or place being valued for the contribution it makes or could make to an understanding of *Australia's natural history*. Implicit in this is that the information which the area or place may (i.e. potentially) yield will contribute to understanding of natural history elsewhere in Australia. The concept of valuing a place for the contribution that it could make to knowledge and understanding of natural history is not a primary component of the global (World Heritage) criteria, though may be considered implicit. The concept is considered a valid component of natural heritage and also valuable in development of universal criteria at all levels/scales of assessment.

The one sub-criterion relevant to natural history neither elaborates on or improves the interpretation of Criterion (c).

(d) ***...demonstrating the principal characteristics of:***

(i) *a class of Australia's natural ...places; or*

(ii) *a class of Australia's natural ...environments*

This para introduces the concept of valuing a place based on *demonstrating ...principal characteristics* or a class of natural environment or places. Given the abstract wording of para (a) and the absence of any reference in the criteria to *outstanding examples*, this para could be interpreted as being a conservatively worded or even muted form of *representative example*, or even *outstanding example* of some class of natural heritage. The wording of the global (World Heritage) criteria is much less ambiguous and is preferable to the more abstract *demonstrating principal characteristics*.

The global criteria might also be interpreted to be more selective though Criteria (i) and (ii) seek only *outstanding examples*, not *the most outstanding*. The concept of *outstanding examples* is considered superior to para (d) of the National Estate criteria.

The one sub-criterion relevant to natural history neither elaborates on nor improves the interpretation of Criterion (d).

(e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group

Para (e) is consistent with the World Heritage criteria and is also logical in terms of dealing with natural scenic landscapes. The one sub-criterion relevant to natural history neither elaborates on, nor improves, the interpretation of Criterion (e).

2.5.2.2 SUMMARY OF NATIONAL CRITERIA EVALUATION

Given the obscure language and lack of clarity in the Australian Heritage Commission Act criteria, it is not surprising that the Australian Heritage Commission uses a derived set of criteria in everyday assessments. Not only do these so-called sub-criteria clarify the legislated criteria, but subdivision makes for ease of application.

In summary, the contribution made by criteria contained in the Australian Heritage Commission Act 1975, in so far as they apply to natural heritage, are:

- Para (a) is abstract and contributes little to development of a universal set of criteria though the sub-criteria do make a contribution in the form of valuing *richness* and *diversity*
- Paras (a), (b), and (e) are substantially consistent with the World Heritage criteria
- Para (c) contributes a concept additional to the World Heritage criteria, that of *contribute to an understanding*, valuing an area for the contribution it can make through study/research/investigation to understanding natural history, especially the natural history of other places. This not inconsistent with the World Heritage criteria but would represent an enhancement if incorporated
- Para (d) is not inconsistent with the World Heritage criteria but could contribute a new dimension to the World Heritage criteria by introducing the concept of *demonstrating principal characteristics of a class...* which is a potentially valuable contribution to natural heritage conservation.

Therefore, both Para (c) (contribute to an understanding), and Para (d) (demonstrating principal characteristics of a class...) of the criteria contained in the Australian Heritage Commission Act could potentially make a valid contribution towards the proposed universal criteria.

The Australian Heritage Commission is presently developing a set of criteria for the proposed National Heritage List, but these appear to be developed, quite inappropriately, around a series of pre-ordained themes. Objective criteria are only introduced at a later stage of detail. Nomination of themes in advance of assessment against objective or systematic criteria will tend to encourage a search for data to fit the theme instead of a systematic and objective search and assessment. The National List approach, by application of cultural oriented themes for natural heritage assessment is considered flawed and is not further considered here.

A thematic approach may be appropriate to the search and identification of potential heritage places, but has no role in assessment of nominated places or regions. In the case of the natural heritage significance assessment of Cape York Peninsula, the very act of nominating a theme would preempt the outcome and risks diversion of searching for supportive data instead of a systematic identification of attributes and values.

In considering the notion of classes of natural heritage, careful attention must be played to the complexity inherent in the concept of biodiversity. A simple list of known species is a necessary but insufficient set of classes. Co-locating species form various community relations defined by ecological factors such as food webs and successional pathways. Furthermore, species can exhibit varying growth forms and life histories in response to prevailing environmental conditions. Fluctuations in environmental regimes at seasonal, year-to-year, and decadal time scales, can influence plant phenological responses and optimal photosynthesis and carbon allocation strategies dominant in a landscape, with cascading effects throughout the ecosystem (Stafford Smith and Morton 1990). In identifying and comparing classes of biodiversity for natural heritage evaluation, it is critical that due recognition be given to not only taxonomic diversity, but the complex physiological, life history, and growth form responses that arise in different environmental settings.

2.5.3 EVALUATION OF SUB-NATIONAL CRITERIA

The only sub-continental heritage assessment criteria potentially applicable to Cape York Peninsula are those pertaining to the Queensland Heritage Act 1992. However, the criteria are clearly limited to cultural heritage:

> *The Queensland Heritage Register is a list of places or buildings of cultural heritage significance in Queensland. Developed under the Queensland Heritage Act 1992, the Register recognises the value of Queensland's cultural heritage...* (EPA Homepage.)

2.5.4 SUMMARY OF EVALUATION OF GLOBAL, CONTINENTAL AND SUB-CONTINENTAL CRITERIA

Given that the Queensland heritage criteria are limited to cultural heritage, only the global (World Heritage) criteria and the national (Australian Heritage Commission, National Estate) criteria are relevant to the development of a core set of universal heritage assessment criteria.

The global (World Heritage) criteria are comprehensive and comprehensible. They can be interpreted to cover most, if not all, of the biological and geophysical spectrum of environments which may form *in situ* natural heritage. The national (Register of National Estate) criteria lack the clarity of the global criteria, but have been expanded into a more meaningful set of sub-criteria. These criteria are mostly consistent with the global criteria, but do extend into two concepts not readily apparent in the global criteria. These extensions are:

- *contribute to an understanding*
- *demonstrating principal characteristics of a class...*

The concept of a place being valued according to its potential to *contribute to an understanding*, is a valid concept for the purpose of identifying and assessing natural heritage. A place which has already contributed to or has irrefutable potential to contribute in a significant way to an understanding of natural heritage, (either of that place or area) or more importantly, of places or areas beyond, would be universally recognized as having heritage value in its own right. While such a place may not contain any exemplary, outstanding, rare or threatened natural features or processes, other characteristics such as accessibility, ease of study or important interactions may make the area valuable for the pursuit of knowledge of natural heritage values.

The concept of *demonstrating principal characteristics of a class...* is not immediately evident in the Global (World Heritage) criteria though by some interpretations may be implicit. The concept could be articulated as representing *excellent example*(s) - with emphasis on *example* - of a nominated class or type of natural environment or natural heritage. This is not inconsistent with the concept of *outstanding example* contained in criteria (i) and (ii) but contrasts with the concepts of *superlative*, *exceptional* and *most important* contained in criteria (iii) and (iv) of the World Heritage criteria. The intent of the application of *demonstrating principal characteristics of a class...* in the National Estate criteria is consistent with criteria (i) and (ii) of the World Heritage criteria so does not conflict with criteria (iii) and (iv). Under the circumstances there is nothing to be gained by specifically adding the concept to the global criteria in the quest for universal heritage assessment criteria.

In summary, the evaluation of the National (National Estate) criteria reveals only one worthwhile enhancement of the global (World Heritage) criteria for development of a universal heritage assessment criteria, that of the concept of *contribute to an understanding*. Rather than a place being outstanding in its class, it is proposed that the emphasis should be on the contribution to understanding; that is a *significant contribution to an understanding*.

The additional criterion proposed is:

> *Be examples of geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena, the study of which has contributed to, or has irrefutable potential to contribute significantly to an understanding of natural history beyond that place.*

As indicated in 3.1 above, the classification in Table 2.1 was adopted as a template for testing the coverage of natural heritage by the criteria. The global criteria were found to adequately cover Biodiversity (1.0), Geodiversity (2.0) and Natural Processes (3.0). With recent interpretations and amendments of the Operational Guidelines for the World Heritage Convention, the highest values in the *Landscape and Recreational* class (4.0) are adequately covered by the criteria. On the other hand, *Education and Scientific* (5.0) is not well addressed in the World Heritage criteria, but would be fully addressed by the recommended additional criterion developed from the National Estate concept of *contributing to understanding*.

The global and national criteria were found to be inadequate in addressing the natural heritage values associated with:

- The role played by biological communities in regulating, landscape-, regional-, and global-environmental conditions, i.e. the life support systems associated with Earth’s energy balance, and water, carbon, nitrogen and other nutrient cycles
- The complexity within the concept of biodiversity that relates to community organisation, growth form, life history, and strategies and process rates associated with ecological phenomena such as phenologies and primary productivity. To this list we can also add the other cryptic dimensions of biodiversity associated with intra-species genetic diversity and microbiota, in particular soil biota (Wilson 1992).

Incorporating these considerations in natural heritage evaluation has considerable implications. For example, two landscapes may have similar dominant vascular plant floristics, but represent very different ecological conditions, and hence constitute two significantly different classes of phenomena. Furthermore, the condition of the biota/soil ecosystems in a landscape becomes critical to an evaluation of its natural heritage significance. Again, by way of example, two places may have similar dominant vascular plant floristics, but one may be severely degraded due to land use history.

The concept of natural integrity is discussed further in Chapter 6, where we develop the argument that all other things being equal, large areas relatively unperturbed by modern technological society, have relatively high levels of integrity value, which in turn has profound ecological significance. Criteria are therefore needed that enable this integrity value to be incorporated into an assessment of natural heritage significance.

2.6 THE REVISED CRITERIA

Given the above, we can identify a revised set of criteria which are essentially those of the World Heritage Criteria but with two additional primary criteria:

1.0 Be outstanding examples representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.

2.0 Be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.

3.0 Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.

4.0 Contain the most important and significant natural habitats for *in situ* conservation of biological diversity, including those containing rare or threatened species of outstanding (universal/regional/continental/local) value from the point of view of science and conservation;

5.0 Be examples of geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena, the study of which has, or is continuing to, contribute significantly to an understanding of natural history beyond that place.

6.0 Significance as an area, or ecologically related group of areas, of outstanding ecological integrity at landscape, regional and global scales.

2.7 DEVISING CRITERIA FROM FIRST PRINCIPLES

Having evaluated existing natural heritage assessment criteria, we went 'back to basics' for further testing and enhancement of the revised criteria noted above.

The following alternative way of defining and classifying natural heritage, and hence an alternative route for developing criteria for identification of natural heritage, was developed. The classification is derived from the joint application of two concepts:

(a) *custodianship vs. anthropocentrism*;

(b) classification according to *temporal status*, i.e. snapshot vs. on-going process.

Based on the application of these two concepts, the primary classification would be:

AN ALTERNATIVE NATURAL HERITAGE CLASSIFICATION

Past Processes (Evolution in Past)

1. Evidence of Earth (Geophysical) Evolution
2. Evidence of Biological Evolution

Contemporary (Present)

3. Natural Diversity (existing) Bio-diversity and Geo-diversity
4. Existing Natural Condition/Integrity

Future Processes (Evolution in Future)

5. Natural Processes - On-going (Geo and Bio)

Human Appreciation

6. Contribution to Knowledge
7. Aesthetics

The initial step was to ensure that natural heritage valuation was based on the full temporal spectrum represented by the *past*, *present* and *future*.

The *past* can be classified as *evolution* and is conveniently divided into physical and biological forms of evolution, or more precisely, as geo-evolution and bio-evolution. The global World Heritage criterion (i), though not fully explicit, is usually interpreted to include both categories. Less explicit in the derived criterion is the bio-evolution category, represented only as *including the record of life*. Given the importance attached to both bio-evolution and geo-evolution it was decided to divide this criterion into two new criteria.

In the *present*, features or places may have a contemporary value, with or without a knowledge, understanding or valuing of the past or future processes. This includes the same two strands as evolution, i.e. biotic and abiotic. By convention these would be translated to biodiversity and geodiversity. However this binary classification is not as clean a division as it may first appear, because the concept of biodiversity includes ecological phenomena which are the result of the interactions between the biota and physical processes. Thus landscape and ecosystem pattern and process are encompassed in this concept of biodiversity.

Furthermore, the need to recognise the value of ecological integrity coincides with the value placed by the contemporary community on intact or minimally altered ecosystems and landscapes that are relatively unperturbed by modern technological society. This creates the need to incorporate a third and separate strand in the classification of contemporary values.

The class of *future* values is conceptually harder to deal with, but essentially constitutes those processes which may or may not have a present or contemporary value, but are particularly valued for the expectation that they will be on-going and valued for that. Again, for convenience, these can be classified into biological/ecological processes and geophysical processes. A biological example would be those vegetation communities that are rare under the prevailing environment, but that may become dominant in the landscape with relatively minor changes to future climate.

Classes 1, 2, 3 and 5 group together since they are based on human *custodianship* of the planet. This ethic respects the intrinsic value of the total Earth system, independent of its utilitarian value to humans. But the natural landscape and natural heritage can be valued from an anthropocentric perspective that reflects culturally-based human values. Use-values include the functions that natural phenomena play in providing resources for goods and services, providing services that can be directly consumed, assimilating waste, and maintaining life support systems (Common and Perrings 1992). Thus ecological systems help clean air, purify water, cycle nutrients, sequester wastes, maintain carbon balance, as well as delighting the senses!

Human-centered use-values can also encompass what, by common sense, we would call non-use (Randall 1991). For example, the contributions that features or places make to human knowledge and understanding of natural history. Valuing the existence of a wild species (such as whales) is another example. The derivation of such value is often via scientific research and education. This category of values can be characterised as *Contribution to Knowledge*. Value also derives from human appreciation of aesthetics, beauty and from natural phenomena which invoke a shared and positive response in a community. The responses and appreciation are often based on visual sensing, but may also be based on one or more other senses, including learning from documentation, where the learning is often vicarious and not dependent on direct visitation or viewing of the place. Such appreciation is only a short step from what is termed spiritual appreciation of nature. We can characterise this category of values as *Aesthetic*.

Based on the above simple alternative classification of natural heritage, a new set of criteria were developed as follows:

1. The Geo-evolution criterion based on World Heritage Criterion (i) deserves to be subdivided to make it more explicit that evidence of Biological Evolution is a highly valued category. This results in two new primary criterion to substitute for the Global World Heritage Category (i):

CRITERION 1.0 GEO-EVOLUTION
Be outstanding examples representing major stages of Earth's evolutionary history, including significant geological processes which have contributed to the development of landforms, or significant geomorphic or physiographic features.

CRITERION 2.0 BIO-EVOLUTION
Be outstanding examples representing major stages of Earth's biological evolutionary history, including the record of life.

2. The amended World Heritage Criterion (iv) closely corresponds with at least part of the *Natural Diversity* category and is proposed to be retained in its present form but re-numbered as 3.0. However, Criterion (iv) needs to be duplicated to specifically address geo-diversity as a new criterion 4.0:

CRITERION 3.0 BIODIVERSITY
Contain the most important and significant natural habitats for *in situ* conservation of **biological diversity**, including those containing rare or threatened species of outstanding (universal/regional/continental/local) value from the point of view of science or conservation.

CRITERION 4.0 GEODIVERSITY
Contain the most important and significant lands for *in situ* conservation of **geodiversity**, including those containing rare or threatened features of outstanding (universal/regional/continental/local) value from the point of view of science or conservation.

None of the global or national criteria adequately and specifically address the value attached to natural condition and natural integrity. World Heritage Criterion (iv) contains elements in referring to *the most important and significant natural habitats* but this is not usually the primary focus of that criterion. The World Heritage assessment process addresses natural integrity in the form of *Conditions of Integrity* which are applied only if the primary criterion is met.

A need was identified to more specifically address *condition* and *integrity* as values, with the result that two new primary criteria were identified:

> **CRITERION 5.0 NATURAL INTEGRITY**
> Contain ecosystems and landscapes which exhibit outstanding ecological and geophysical integrity.

> **CRITERION 6.0 ON-GOING NATURAL PROCESSES**
> Contains the essential elements to allow or maintain significant on-going ecological and geophysical evolutionary and life-support processes.

which are followed by,

> **CRITERION 7.0 CONTRIBUTION TO KNOWLEDGE**
> Contains examples of geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena, the study of which has contributed, or has irrefutable potential to contribute significantly to an understanding of natural history beyond that place.

> **CRITERION 8.0 AESTHETICS**
> Contain superlative natural phenomena or areas of exceptional natural beauty or aesthetic value.

Note: *Aesthetic* is defined in the Oxford Dictionary as *the appreciation of beauty,* but for the purpose of this criterion is expanded to include natural phenomena which may be a source of inspiration for the human spirit (e.g. manifest as art and literature) but not necessarily conform to the narrower meaning of beauty.

2.7.1 EVALUATION OF NEW CRITERIA

The new criteria embrace a wider spectrum of natural heritage than do the current World Heritage criteria. Furthermore, the new criteria are more explicit and systematic than the World Heritage criteria. Therefore they are more readily sub-divided to sub-criteria level. Having eight primary criteria rather than six should increase the analytical resolution of the natural heritage data for Cape York Peninsula.

2.8 PROPOSED UNIVERSAL HERITAGE SIGNIFICANCE ASSESSMENT CRITERIA

The criteria proposed for adoption as universal heritage significance assessment criteria for application to Cape York Peninsula are given in Table 2.3. In practice, the criteria that relate to evolution and diversity are difficult to apply in isolation from one another. Given this, a minor re-ordering of the criteria was warranted, so that Geo-evolution/ Geodiversity and Bioevolution/Biodiversity can be jointly analysed and evaluated. Similarly, criteria 5 (Natural Integrity) and 6 (Natural Processes) are closely related.

Assessment criteria for something as complex as natural heritage will benefit from subdivision into increasingly more specific sub-criteria. Sub-criteria are more likely to correspond to the form in which data are gathered. Indeed, sub-criteria can be designed to directly correspond to the form of the data. Thus, there should be an ongoing iteration between data specification and definition of sub-criteria that progressively refines both. A set of sub-criteria was developed for the new criteria by simple subdivision of each criterion to its component parts using the definition in Table 2.1 as a checklist. These sub-criteria are in Table 2.4.

2.9 CONCLUSIONS

By evaluating a number of existing natural heritage criteria currently in use, it proved possible to develop a set of criteria which covered the full spectrum of natural heritage as illustrated in Table 2.1 and to be sufficiently selective of natural heritage as to provide a sound basis for assessment of heritage in the Cape York Peninsula study area.

The five criteria developed from review of the World Heritage and National Estate criteria are substantially based on the World Heritage criteria which have stood the test of time. As such, they would be entirely appropriate to apply to the Cape York Peninsula study. The investigation of other natural heritage classifications lead directly to the development of an alternative set of criteria. The overlap between the revision-based criteria and the new criteria is substantial. However the new criteria are preferred as they are more comprehensive, explicitly address some of the more complex dimensions of biodiversity, and better lend themselves to the systematic development of subcriteria. If necessary, the new criteria can be readily correlated with the World Heritage criteria to the extent to which they overlap.

As noted in the introduction, the assessment of heritage significance on Cape York Peninsula is to be undertaken at four different geographical levels, namely, global, regional, continental and local. While the same criteria can and should be applied to all four levels, common sense adjustments may be made to match the particular geographical context. This should simplify the assessment process.

The recommended universal heritage significance assessment criteria should be regarded as the primary criteria and may be subdivided for ease of application, in a way similar to that adopted for application of the National Estate Criteria used by the Australian Heritage Commission.

The critical consideration in applying the recommended universal criteria is to have full regard for the particular geographical context being addressed, and recognise that this can completely change the level of significance for a given area or feature. The change in significance can be either positive or negative with change in geographical context; e.g. a value which is assessed as common at the local level may prove to be rare and hence very important at the global level; similarly, something valued for its rarity at the local level may be assessed as being common and hence of low value at the global level.

Table 2.1 A classification of natural heritage values

A. NATURAL HERITAGE

1.0 Biodiversity

- 1.1 *Genetic Diversity*
  - 1.1.1 *Plants*
    - 1.1.1.1 *Rare and Threatened Species*
    - 1.1.1.2 *Other species of special interest*
  - 1.1.2 *Animals*
    - 1.1.2.1 *Rare and Threatened Species*
    - 1.1.2.2 *Other species of special interest*
- 1.2 *Ecological Diversity*
  - 1.2.2 *Plants*
  - 1.2.3 *Plant communities*
  - 1.2.4 *Animals*
  - 1.2.4 *Animal communities and populations*

2.0 Geodiversity

- 2.1 *Geology*
- 2.2 *Geomorphology*
- 2.3 *Soils*
- 2.4 *Other natural phenomena*

3.0 Natural Processes

- 3.1 *Geological/Geophysical*
- 3.2 *Biological/Ecological*

4.0 Landscape and recreational
(Natural/quasi natural landscapes of contemporary interest)

- 4.1 *Wilderness*
- 4.2 *Scenic landscapes*
- 4.3 *Wild and scenic rivers*

5.0 Educational and scientific
(Natural features and places of contemporary interest for scientific and educational use)

- 5.1 *Reference catchments*
- 5.1.1 *Type localities*
- 5.1.2 *Long-term monitoring sites*
- 5.2 *Research/Education Sites*

Table 2.2 National Estate criteria and sub-criteria

NOTE 1: The sub-criteria have been developed by the Australian Heritage Commission of operational application of the legislated criteria. Only those sub-criteria relevant to natural heritage are presented.

(a) *its importance in the course, or pattern, of Australia's natural or cultural history*

A.1 Importance in evolution of Australian flora
A.1 Importance in evolution of Australian fauna
A.1 Importance in the evolution of Australian landscapes
A.2 Importance in maintaining existing processes or natural systems at the regional scale - landform processes.
A.2 Importance in maintaining existing processes or natural systems - biological and ecological processes.
A.3 Importance in exhibiting unusual richness or diversity of flora features.
A.3 Importance in exhibiting unusual richness or diversity of fauna features.
A.3 Importance in exhibiting unusual richness or diversity of landscape features.

(b) *its possession of uncommon, rare or endangered aspects of Australia's natural or cultural history*

B.1 Importance for rare, endangered or uncommon flora
B.1 Importance for rare, endangered or uncommon fauna
B.1 Importance for rare, endangered or uncommon natural landscapes or phenomena - geology/geomorphology.

(c) *its potential to yield information that will contribute to an understanding of Australia's natural or cultural history*

C.1 Importance for information contributing to wider understanding of Australian natural history, by virtue of its use as a research site, teaching site, type locality, reference or benchmark site.

(d) *its importance in demonstrating the principal characteristics of*
(i) a class of Australia's natural or cultural places; or
(ii) a class of Australia's natural or cultural environments;

D.1 Importance in demonstrating the principal characteristics of the range of landscapes, environments or ecosystems, the attributes of which identify them as characteristic of their class.

(e) *its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group*

E.1. Importance for a community for aesthetic characteristics held in high esteem or otherwise valued by the community.

Table 2.3 Natural heritage assessment criteria; primary criteria

1.0 GEO-EVOLUTION
Outstanding examples representing major stages of Earth's evolutionary history, including significant geological processes which have contributed to the development of landforms, or significant geomorphic or physiographic features.

2.0 GEODIVERSITY
The most important and significant lands for in situ conservation of geodiversity, including those containing rare or threatened features of outstanding (universal/regional/continental/local) value from the point of view of science or conservation.

3.0 BIO-EVOLUTION
Outstanding examples representing major stages of Earth's biological evolutionary history, including the record of life.

4.0 BIODIVERSITY
The most important and significant natural habitats for in situ conservation of biological diversity, including those containing rare or threatened species, communities or ecosystems of outstanding (universal/regional/continental/local) value from the point of view of science or conservation.

5.0 NATURAL INTEGRITY
Ecosystems and landscapes which exhibit outstanding ecological and geophysical integrity.

6.0 ON-GOING NATURAL PROCESSES
Geophysical, evolutionary, and ecological processes, including local and global-scaled life support systems fully functional.

7.0 CONTRIBUTION TO KNOWLEDGE
Examples of geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena, the study of which has, or is continuing to, contribute significantly to an understanding of natural history beyond that place.

8.0 AESTHETICS
Superlative natural phenomena or areas of exceptional natural beauty or aesthetic importance.

Table 2.4 Natural heritage assessment criteria; sub-criteria

1.0 GEO-EVOLUTION

- **1.1** Geological features - outstanding or representative
- **1.2** Geomorphological and landform features - outstanding or representative

2.0 GEODIVERSITY

- **2.1** Geological and geomorphological features or processes - outstanding or representative examples
- **2.2** Geological and geomorphological features or processes - rare or threatened

3.0 BIO-EVOLUTION

- **3.1** Palaeobotanical and palaeozoological (fossil records) - outstanding or representative
- **3.2** Plant and animal species or communities which are evidence of Earth's biological evolutionary history - outstanding or representative

4.0 BIO-DIVERSITY

- **4.1** Species, populations or ecosystems - representative examples
- **4.2** Species, populations or ecosystems - rare, threatened or endangered
- **4.3** Species, populations or ecosystems - endemic
- **4.4** Species, populations or ecosystems - other outstanding scientific or conservation value

5.0 NATURAL INTEGRITY

- **5.1** Terrestrial ecosystems - high degree of natural integrity
- **5.2** River corridor ecosystems - high degree of natural integrity
- **5.3** Wetland ecosystems - high degree of natural integrity
- **5.4** Coastal and marine ecosystems - high degree of natural integrity

6.0 ON-GOING NATURAL PROCESSES

- **6.1** Areas of sufficient size, natural integrity and other essential elements to allow or maintain significant on-going ecological, life support, and evolutionary processes
- **6.2** Areas of sufficient size, natural integrity and other essential elements to allow or maintain significant on-going geophysical evolutionary processes

7.0 CONTRIBUTION TO KNOWLEDGE

- **7.1** Geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena - significant contribution to understanding of natural history.
- **7.2** Geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes - significant contribution to direct educational value.

8.0 AESTHETICS

- **8.1** Natural phenomena - superlative
- **8.2** Natural beauty - exceptional

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3 EVALUATION OF CYPLUS REPORTS AND DATA

3.1 INTRODUCTION

A variety of reports were produced as part of the CYPLUS project. These aimed to provide, *inter alia*, a comprehensive analysis of the biophysical resources of the region. Here we review and evaluate the primary data underlying these reports for a number of inter-related reasons, including:

- To assess their utility for assessing natural heritage value using the universal criteria detailed in Chapter 2.
- These data were used to derive secondary indices and modeled variables such as the Biophysical Naturalness layer derived for Cape York Peninsula. The utility of these derived evaluations is a function of the validity of the underlying primary data.
- The adequacy of the primary data determines the extent to which locations and landscapes within the Cape York Peninsula can be ranked according to their relative natural heritage value. Thus, for example, the primary biological data may be adequate for evaluating the natural heritage value of Cape York Peninsula in *toto*, but inadequate for evaluating and ranking every landscape unit within Cape York Peninsula according to its relative natural heritage value.
- The comprehensive CYPLUS report on Areas of Conservation Significance on Cape York Peninsula (Abrahams *et al* 1995) is a valuable resource in that it does identify those areas that are known to be significant.

This evaluation is in two parts. We first examine each relevant CYPLUS report in terms of seven criteria. We then assess the geographical and environmental representativeness of the biological data in terms of a new micro-catchment based, environmental domain classification.

3.2 EVALUATION OF CYPLUS REPORTS

For the purposes of this preliminary report, a subset of CYPLUS reports are examined here, with a particular focus on those that provide primary field survey data. Following are the seven criteria used to assess the selected CYPLUS reports:

1. *Are the data and findings in the report based on a collation of existing data or was new field survey conducted?*

   The CYPLUS reports varied in terms of the extent they made use of existing field observation compared with undertaking new field survey.

2. *To what extent was the field data gathered using systematic survey methodologies?*

   Various field survey methods can be and were employed depending on the purpose of the study. Often though the data collected for a specific purpose using a particular method will have restricted application. Data collected on an entirely opportunistic basis, without regard for geographical and environmental representativeness, may not be able to be spatially extended beyond the limited area of sampling.

3. *To what extent were the data checked for errors or validated?*

   It is common for errors to be introduced during data base development, particularly in terms of geocoding (geographical position, elevation). This is particularly a concern when using existing field data such as herbarium and museum records where early collectors had poor base maps and accurate geocoding was not a priority.

4. *Was some attempt made to spatially extend or map the field data using (e.g. using satellite imagery, air-photo interpretation, or computer-based modelling)?*

   All field survey is based on observations from a network of site or field plots. These data represent samples of the total distribution of the phenomena of interest. The problem therefore always remains of how to spatially extend these point data to encompass the phenomenon's total distribution.

5. *What was the extent of the field sampling; in particular, (a) the number of sites sampled, and (b) were the data collected from a one-off survey, repeated site visits, or permanent monitoring plots?*

6. *What was the seasonal distribution of the field sampling, especially in terms of wet or dry season survey?*

   One-off surveys may give equivocal data regarding the extent to which the distribution and abundance of the target species have been adequately sampled. This is especially important for animals that are migratory, mobile, or have large home ranges. Most biological phenomena experience significant temporal variation, both seasonally and year-to-year, in response to, *inter alia*, changes in environmental conditions especially weather. The extent to which survey design captures temporal variability is therefore a critical consideration.

7. *Did any joint sampling occur with other CYPLUS survey teams?*

   At the landscape scale, the vegetation, soil, and many above and below ground fungi and invertebrates, are tightly coupled through various ecological processes. In turn these all provide the resource infrastructure for macro animals. Interpreting the distribution, abundance and character of any one of these elements is actually very difficult in the absence of observations of the other, interdependent elements.

NR17 ***Insect fauna Survey of CYP*****, Zborowski *et al*. (1995).**

1. Data sources	Used existing museum data, and employed new field sampling.
2. Systematic survey	The new survey focussed on target groups (abundant, rare, economic importance), and target areas (typical vegetation communities, dominant vegetation types).
3. Validation of data	New data appears to have been rigorously checked; extent of existing data checking is unspecified.
4. Spatial extension	Bioclim modelling of two species.
5. Extent of sampling	11 permanent trap sites, cleared once monthly over 2 years (half in first year, other half in second year); unspecified number of existing species location records.
6. Sample season	Wet and dry.
7. Joint sampling	None.

NR01 ***Vegetation Survey and Mapping of CYP*****, Neldner and Clarkson (1995).**

1. Data sources	Existing and new field survey.
2. Systematic survey	Significant attempt at CYP-wide systematic survey.
3. Validation of data	Extensive.
4. Spatial extension	Air-photo interpretation compiled at a scale of 1:250 000.
5. Extent of sampling	1473 field plots, 5700 vehicle observations, 2650 helicopter observations, 4000 herbarium specimens; one-off sampling.
6. Sample season	Mainly dry, some wet.
7. Joint sampling	300 sites integrated with soil survey.

NR02 ***Soil Survey and Agricultural Suitability of CYP*****, Biggs and Philip (1995).**

1. Data sources	Existing data and new field survey.
2. Systematic survey	Used free survey method, sites geographically biased due to access problems and time limitations.
3. Validation of data	Appears to have been carefully checked.
4. Spatial extension	Intent was to map at 1: 250 000 using air-photo interpretation; but scarce data only allowed 1: 900 000; some use of Landsat TM, gamma-ray spectrometric imagery, and modelled moisture supply.
5. Extent of sampling	905 sites over 19 weeks; about 750 existing soil data sites; one-off sampling.
6. Sample season	Dry season.
7. Joint sampling	300 sites integrated with vegetation survey.

NR03 ***Terrestrial Vertebrate Fauna of CYP*****, Winter and Lethbridge (1995).**

1. Data sources	Existing species records, plus new field survey.
2. Systematic survey	New systematic survey limited to the QDEH focal area; employed gradsect design.
3. Validation of data	All data appear to have been rigorously checked.
4. Spatial extension	None.
5. Extent of sampling	23 sampling localities; three primary survey sites per location; 23,000 existing species location data; one-off surveys.
6. Sample season	Wet and dry.
7. Joint sampling	None.

NR09 ***Wetland Definition and Fauna Assessment of CYP*****, Driscoll (1995).**

1. Data sources	Data from other CYPLUS projects (mainly NR03) or from past fauna surveys.
2. Validation of data	Minimal; very much an interpretive project; it did assess some wetland areas overestimated due to age of air photos used from NR01.

NR06 ***Marine Vegetation of CYP*****, Danaher (1995).**

1. Data sources	Some existing data of seagrass beds used; remote sensing (Landsat TM, air photos); new field surveys; employed helicopter observations
2. Systematic survey	Yes, covered most of the CYP coast ground-truthing remotely sensed data.
3. Validation of data	Images from Landsat TM validated with aerial photos and fieldwork for mangrove communities; aerial photos of seagrass ground truthed by dive and boat surveys.
4. Spatial extension	Landsat TM used to map entire distribution of mangrove and sea grass.
5. Extent of sampling	Unspecified number of helicopter landings were made along coastline to survey mangrove classes derived by Landsat TM analysis; assessment of seagrass beds made by transect dives out from coast, at about 4 km intervals-based landings and dive and boat surveys; one-off sampling.
6. Sample season	Field surveys: wet and dry; Landsat images: wet and dry.
7. Joint sampling	None.

NR18 ***Flora Data and Modelling of CYP*****, Cofinas *et al*. (1995).**

1. Data sources	Used existing point based data, and newer data from NR01.
2. Systematic survey	No new survey data.
3. Validation of data	For existing data, taxanomic checks with Qld Herbarium; checked species locations by removing terrestrial species located off-shore; but no test for remaining mainland sites; no check for duplicate data records; elevation checking unspecified.

NR19 ***Fauna Distribution Modelling for CYP*****, Glasco *et al*. (1995).**

1. Data sources	Used existing point based data, and newer data from NR03, NR10 and NR17.
2. Systematic survey	No new survey.
3. Validation of data	For existing data: location checks with mainland/offshore test, offshore records discarded; lats/longs checked manually against locality descriptions for many records (does not specify how many); no control over duplicate samples; elevation check unspecified.
4. Spatial extension	Data from NR11 used for modelling spatial distribution of 3 dung beetles, Golden-shouldered parrot, and several species of rock wallabies and possums, using BIOCLIM.

NR14 ***Coastal Environment Geoscience of CYP*****, Burne and Graham (1995).**

1. Data sources	Shoreline and offshore field surveys: seismic profiling, bottom sampling, inspection (offshore); remote sensing: Landsat TM, aerial photos.
2. Systematic survey	Undetermined; report does not describe sampling in any detail.
3. Validation of data	Cannot be determined from report.
4. Spatial extension	Cannot be determined from report.
5. Extent of sampling	Cannot be determined from report.
6. Sample season	Cannot be determined from report.
7. Joint sampling	Cannot be determined from report.

NR16 ***Groundwater Resources of CYP*****, Horn *et al*. (1995).**

1. Data sources	Existing data on 1025 registered bore holes; supplemented with new field survey; other data used included seismic information; Landsat images; data from other CYPLUS projects.
2. Systematic survey	Attempt to fill geographical gaps in existing data; sampled each tectonic unit; bores drilled in areas where no stratigraphic and hydrogeographic information was present.
3. Validation of data	Data appears to have been rigorously checked; geological interpretations considered to have broadscale accuracy.
4. Spatial extension	Correlation with existing knowledge and mapped data about extent of ground water resources.
5. Extent of sampling	12 bores drilled for program; some bores were monitored.
6. Sample season	Dry.
7. Joint sampling	None.

LUP ***Surface Water Resources of CYP*, Horn (1995).**

1. Data sources	Used hydrographic gauging station records.
2. Systematic survey	Field trip to two rivers to assess habitat/environmental flow requirements; surface water data considered inadequate.
3. Validation of data	Gauge station data thoroughly examined.
4. Spatial extension	Several basins unsampled.
5. Extent of sampling	17 gauging stations in operation (51 in data base).
6. Sample season	Wet and dry, over multiple years for stream gauge data; unspecified for field survey.
7. Joint sampling	None.

NR10 ***Freshwater fish and aquatic habitat survey of CYP,* Herbet *et al.* (1995).**

1. Data sources	Existing field data; new field survey.
2. Systematic survey	Priority given to unsampled river systems, given accessibility.
3. Validation of data	New data thoroughly checked and analysed; existing data poorly geocoded.
4. Spatial extension	Species associated with stream segment corresponding to survey sites where it was found.
5. Extent of sampling	177 sites; each site visited once.
6. Sample season	Dry.
7. Joint sampling	None.

LUP ***Land Degradation in CYP*, AGSO *et al*. (1995).**

1. Data sources	Existing data (e.g. for Universal Soil Loss Equation in part 2); used data from NR02 and NR12; some field data collected for parts 2 (for USLE) and 3 (EM for salinity).
2. Systematic survey	Unspecified.
3. Validation of data	Unspecified.
4. Spatial extension	Yes, spatial modelling of predicted water erosion hazard over CYP using USLE.
5. Extent of sampling	Appears to have been limited and one-off as sampling was not described in detail.
6. Sample season	Part 2 sampling in dry season; part 3 sampling season not stated.
7. Joint sampling	None.

LUP ***Land Tenure Systems and Issues of CYP*****, Hardy *et al*. (1995).**

1. Data sources	Existing data (predominantly part 1); field survey: questionnaire to interest groups (part 2).
2. Systematic survey	Unspecified.
3. Validation of data	Unspecified.
4. Spatial extension	-
5. Extent of sampling	Questionnaire went out to 6 interest groups; it was a one-off survey (a supplementary questionnaire was to be used but was not completed for the report).
6. Sample season	-
7. Joint sampling	None.

NR05 ***Geology and minerals of CYP*****, Bain (1995)**

1. Data sources	Existing data: used many original maps from 1960-1972 to produce a single integrated geological map of CYPLUS area.
2. Systematic survey	-
3. Validation of data	Unspecified.
4. Spatial extension	Compilation maps.
5. Extent of sampling	-
6. Sample season	-
7. Joint sampling	-

LUP ***Survey of Forest Resources of CYP*****, Wannan (1995).**

1. Data sources	Mostly existing data (previous reports and studies); data from NR01, and some from NR03 and NR10; community discussions; field study trip.
2. Systematic survey	-
3. Validation of data	Unspecified.
4. Spatial extension	-
5. Extent of sampling	Although there were no field surveys, a 4 day field trip was undertaken to look at some forest stands and a mill.
6. Sample season	Field trip occurred in the dry season.
7. Joint sampling	None.

LUP *Fire on CYP*, Crowley (1995).

1. Data sources	Existing data: information mostly from N.T. Top End; other data from temperate Australia and overseas tropical savannas research.
2. Systematic survey	-
3. Validation of data	None, general fire data used; report states that no aspect of fire is adequately documented for CYP, and that community/local knowledge is the best source of data but was not used in this report.
4. Spatial extension	-
5. Extent of sampling	-
6. Sample season	-
7. Joint sampling	-

NR11 *Environmental Regions of CYP*, Cofinas and Bolton (1995).

1. Data sources	Existing data; DEM, climate, terrain, and soil data to produce a GIS package CYP ERA. remote sensing data used.
2. Systematic survey	-
3. Validation of data	GIS model developed looked at by *experts*; maps produced give *generalised picture* of CYP environment; report states the regionalisations have not been comprehensively validated against independent data sets.
4. Spatial extension	Mapped environmental assessed adequacy of taxanomic groups/data sets/applied categories in region - shows if sampling is adequate for a group of taxa in a region; was applied to all point based flora data from NR18; CYP ERA used to report plant and animal diversity in Conservation and Natural Heritage Assessment project domains; 1/40th degree resolution; 10 domains
5. Extent of sampling	-
6. Sample season	-
7. Joint sampling	-

LUP *Animal and Weed Pests in CYP*, Mitchell and Hardwick (1995).

1. Data sources	Existing data, GIS data (*Pestinfo*); interviews with landholders; field surveys to validate existing data, upgrade incomplete or inaccurate data, fill gaps where data for an area is lacking.
2. Systematic survey	Unspecified; sampling did not appear to be very comprehensive.
3. Validation of data	Minimal validation of existing data through field survey.
4. Spatial extension	Unspecified.
5. Extent of sampling	A 14 day ground survey recorded the presence and relative population levels of weed and animal pests - traversed (walking or driving) creek lines and tracks (would have been one-off due to the short duration of the survey); 35 survey forms were distributed for the interviews.
6. Sample season	Unspecified.
7. Joint sampling	None.

3.3 DISCUSSION

The various CYPLUS natural resource inventory and assessment reports vary significantly in terms of the adequacy and quality and of the primary data. Some of the CYPLUS reports amassed all available data, which were supplemented by new field survey designed to fill critical gaps - within the constraints of the limited time and resources. Other reports were based entirely on pre-existing data or data generated by other CYPLUS-related surveys.

The *Vegetation Survey and Mapping of Cape York Peninsula* of Neldner and Clarkson (1995) is most likely the best regionally scaled vegetation map and data base ever produced in Australia. It is the most geographically and environmentally representative and comprehensive of all the reports. The total number of systematic observations is sufficiently large to ensure a high level of mapping reliability of much of the region. The primary observation data represents a unique scientific resource.

Neldner and Clarkson (1995) note that the historical collecting effort had been concentrated in areas of closed forest. Even with their own systematic survey of the extensive open-forests and woodlands vast areas of the drier western lowlands remain under collected.

The *Marine Vegetation of Cape York Peninsula* by Danaher (1995) is also commendable in terms of the geographically comprehensive nature of its coverage, and its commendable efforts for substantial field validation within what were obviously tight time lines and resources.

The *Freshwater Fish and Aquatic Habitat Survey Cape York Peninsula* of Herbert *et al.* (1995) is an outstanding report, reflecting a high degree of technical skill, ecological understanding, and systematic survey methods. However in assessing the adequacy of the available fish fauna data for Cape York Peninsula they correctly detailed significant limitations, including:

- Many fish distributions in Cape York Peninsula appear to be discontinuous; this makes the spatial extension (i.e. mapping the distribution of species based on limited field survey) problematic. Existing spatial modelling procedures are inappropriate. Thus, the Cape York Peninsula distribution of many species remains to be clarified

- No ecological studies of freshwater fish fauna have been undertaken in Cape York Peninsula. This requires longitudinal study of selected sites through complete seasonal cycles. Consequently, any predictions of possible effects on fish faunas and aquatic habitats are constrained since the fundamental factors that affect breeding, distribution, inter and intra specific interaction, etc. are not known

- Fish species abundances fluctuate greatly in both space and time, and the casual factors are poorly understood

- The important role of persistent surface water as refugia and as special habitats during the dry season has been largely overlooked

- Critical gaps remain in the geographical, environmental and temporal coverage of the existing and CYPLUS derived survey data. For example, survey data fail to sample the major temporal variations that occur in the distribution and abundance of fish fauna. Survey designs are needed that capture diurnal, seasonal, and year-to-year variation.

The CYPLUS Terrestrial Vertebrate Fauna Survey by Winter and Lethbridge (1995) is of a similarly high professional standard to that of the fish fauna survey. However similar limitations remain with the terrestrial vertebrate data: information about the CYP-wide distributions and abundance of these species is very limited; significant data gaps remain; and ecological studies have been few. The CYPLUS Invertebrate study of Zborowski *et al.* (1995) also echoes these findings.

The CYPLUS Surface and Groundwater reports are based on primary field data (stream gauges and bore hole locations), but both highlight the limited nature of these primary data sources. In particular, they note the paucity of stream gauges (n=17) and the lack of metered bore holes (n=8). Given the seasonal extremes in the rainfall regime, water resource data are critical to any understanding of the ecology of Cape York Peninsula, both during the waterlogged wet season and the essentially arid dry season. Key processes that need study are:

- Maintaining the integrity of groundwater recharge landscapes. These are critical to the long term maintenance of the region's groundwater resources

- Groundwater is critical for maintaining dry season baseflows in many rivers, and for maintaining hyporheic (i.e. sub-surface river channel) flows which in turn maintains riparian zones, billabongs and oxbow lakes during the long dry season

- Groundwater outflow areas (perennial springs) are important sources of base flows for certain rivers

- Spring-fed water holes may be important as refuges for biota and probably also constitute special dry season habitats.

An attempt has been made to map key recharge landscapes and associated refugia, but much more systematic survey will be necessary.

3.4 ENVIRONMENTAL AND GEOGRAPHICAL REPRESENTATIVENESS OF PRIMARY BIOLOGICAL FIELD DATA

The report on environmental regionalisation by Confinas and Bolton (1995) drew upon the environmental domain methodology documented in Mackey *et al.* (1988) and which has been significantly developed and applied in a diversity of settings (e.g. Mackey *et al.* 1989, Richards *et al.* 1990, Mackey *et al.* 1996), but most substantially by Nix and colleagues in recent work for the World Bank in Papua New Guinea (Nix *et al.* 2000). This approach aims at quantifying, at highest possible levels of spatial resolution, the distribution and availability of those primary environmental attributes that drive landscape physical processes and biological function. The spatial patterning of these primary environmental attributes closely tracks meso-scale climate, the substrate (regolith with soil), and topography. Environmental domains are objectively defined spatial units that are homogenous with respect to defined terrain, climate and substrate units at a prescribed limit of dissimilarity.

Confinas and Bolton (1995) presented environmental domain classifications for Cape York Peninsula, and discuss, with examples, how these can be used to assess the representativeness and adequacy of the biological survey data. This question is also of vital interest to this study in relation to the suitability of these data for assessing natural heritage significance. They identified only ten environmental domains across Cape York Peninsula, but we judged this to be an order of magnitude too small for capturing significant ecological gradients across this vast region. Also, the then available resolution of the gridded environmental data at 1/40th of a degree was inadequate for the definition and mapping of microcatchments and for more refined estimates of terrain attributes at that scale.

We support the use of environmental domains in assessing the representativeness of the biological survey data (indeed this approach is one we have been instrumental in developing and applying). Here we generated a classification where the spatial units of analysis were 25,000 micro catchments produced at 250m resolution using a new digital elevation model for Australia. These microcatchments were the basic spatial units that were classified into environmental domains. A combination of existing CYPLUS data and newly generated environmental data were used. Microcatchments have the advantage of generating domains with boundaries that are ecologically meaningful at the landscape scale. They are generally visible on the ground, and capture important hydroecological processes. Figure 3.1 shows the microcatchment boundaries delineated for Cape York Peninsula.

The results are mapped in Figure 3.2 (40 group classification) and Figure 3.3 (96 group classification). Table 3.1 presents the summary statistics for the 40 group classification. The colours in these figures represent the statistical similarity of the groups based on their location in a three dimensional ordination. Further insight into the inter-group relations is provided by the dendrogram given in Figure 3.4. These domain classifications are discussed more fully in Chapter 5 where they are used as an index of biodiversity. In this chapter we are mainly concerned with using them to assess the representativeness and adequacy of biological survey data.

3.4.1 DOMAIN INTERPRETATION

The higher level grouping of environmental domains provides useful insights. Because the southern boundary was extended to -16.5 degrees latitude (that is, beyond the CYPLUS limits) in order to allow freer expression of environmental domain boundaries, the analysis includes extensions of the Wet Tropics Bioregion in the south east and the Eiasleigh Uplands Bioregion further to the west. As mentioned earlier, there is scope for some adjustment of these bioregion boundaries, but none of course are absolute. All merely reflect steeper gradients in key environmental controls and associated biodiversity components.

Examination of the 40 group level of environmental domains (ED) (Figure 3.2) reveals 10 groups that separate from the remaining 30 groups at a high level. Eliminating one small offshore island (ED32) for which no biological data were available, the remaining nine groups are microcatchments with generally steeper slopes, moderate to high local relief, lower temperatures, significantly higher annual and driest quarter rainfall and are on very similar substrates (Table 3.1). All are confined to the extreme south-east, represent a northward extension of the Wet tropics bioregion and have no CYPLUS biological data associated with them. Accordingly, they receive no further attention. The remaining 30 groups then encompass the study region. Eliminating another small offshore island (ED40) from further analysis leaves 29 ED's that cover the CYPLUS survey region and that have matching biological data.

3.4.2 SAMPLING ADEQUACY OF FAUNA DATA

The vertebrate faunal data base was analysed with respect to the coverage of those EDs in the study region. The data base used represented field data gathered as the result of systematic survey. Many more field data were available, but were not adequately georeferenced and thus could not be used in the spatial analysis. Cumulative total species counts of all vertebrates (freshwater fish, frogs, reptiles, birds, mammals) for each environmental domain were plotted (Figures 3.5 and 3.6). Obviously environmental domains will differ in habitat provision for different vertebrate groups, but at the broadest level of classification all groups should have adequate habitat representation.

At the 40 group level of environmental domain classification vertebrate sampling was grossly uneven (Figure 3.5). Some 12 of the 29 EDs (41%) had no sample sites, another 6 EDs had less than 5 sample sites, whereas 2 EDs had more than 40 sample sites (EDs 14 and 16). Probably none of the EDs approached a true asymptote in species totals although a few of the better sampled EDs might appear to do so.

At the finer level of environmental domain classification, of the 96 EDs, only 84 intersect with the CYPLUS databases (Figure 3.6). Only 38 of these 84 EDs had sample sites and of these 20 EDs had 5 or fewer sample sites. Clearly, the distribution of sampling in environmental space is inadequate.

In the absence of environmentally representative and integrated sampling (that is, matching biophysical data are collected at the same place and time) it is unlikely that predictive modelling can fill the gaps.

Taken together the CYPLUS surveys and reports represent a credible Federal/State initiative that sought to accelerate the state of knowledge about the biophysical characteristics of Cape York Peninsula. Together with the well referenced, relevant published material, we conclude that they provide a substantial body of information that can underpin an assessment of the natural heritage significance of Cape York Peninsula. The state of knowledge is sufficient to allow a comparative analysis of its natural features at global, regional and continental scales. The next challenge lies in finding the contextual data needed to undertake these analyses.

We reemphasise that while the state of knowledge is sufficient for the broadscale it is not able to support the detailed ranking of individual parcels of land in terms of their relative natural heritage significance. At least from a biological perspective, the gaps in sampling, and the lack of detailed information about population dynamics and habitat requirements, constrain such an application. However, the microcatchment based environmental domain analyses provide the necessary framework for more systematic survey in the future.

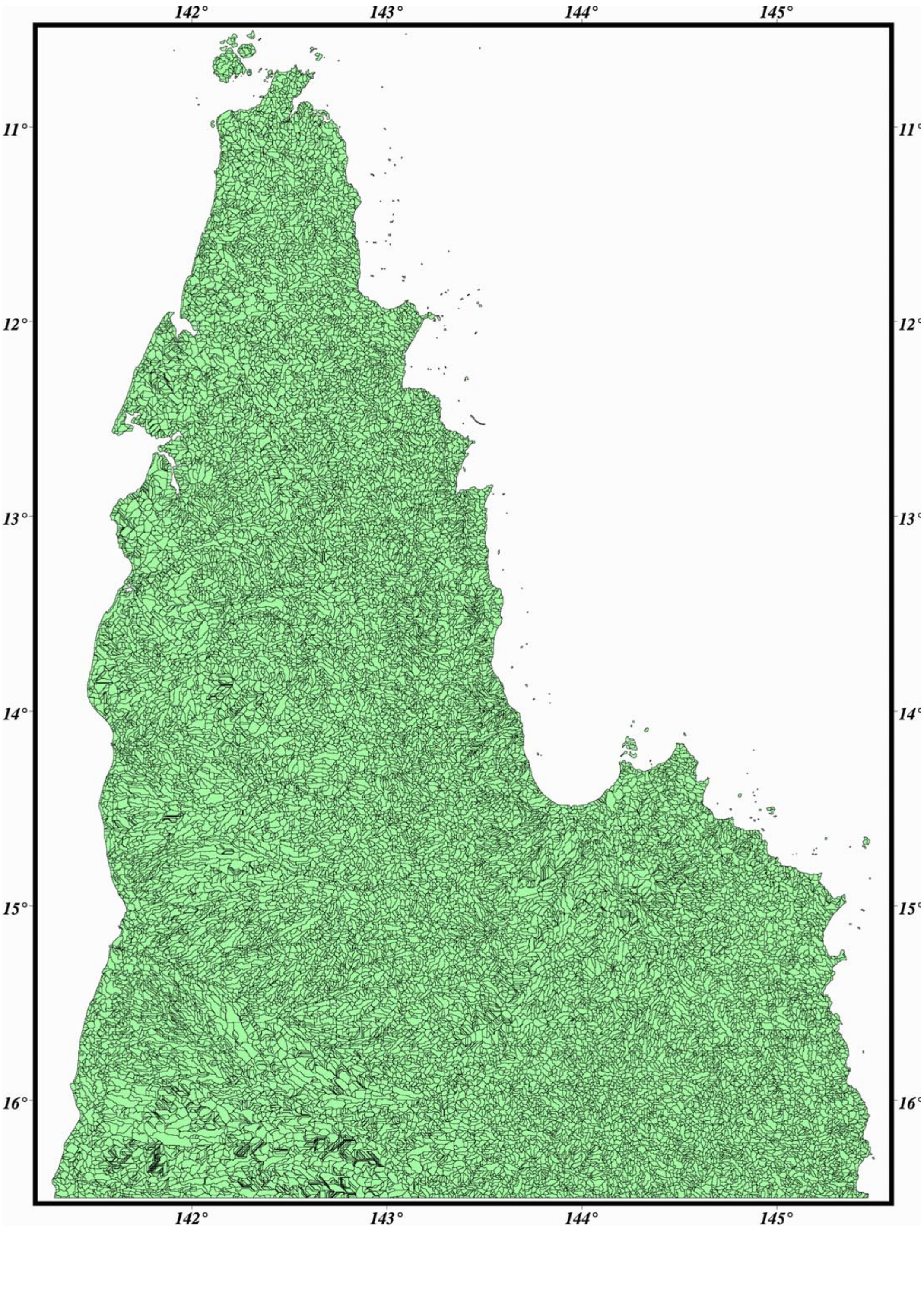


Figure 3.1 Microcatchment boundaries for Cape York Peninsula.
25,000 microcatchments were generated from a 250m resolution digital elevation model. Microcatchments delineate landscape units of hydroecological significance.

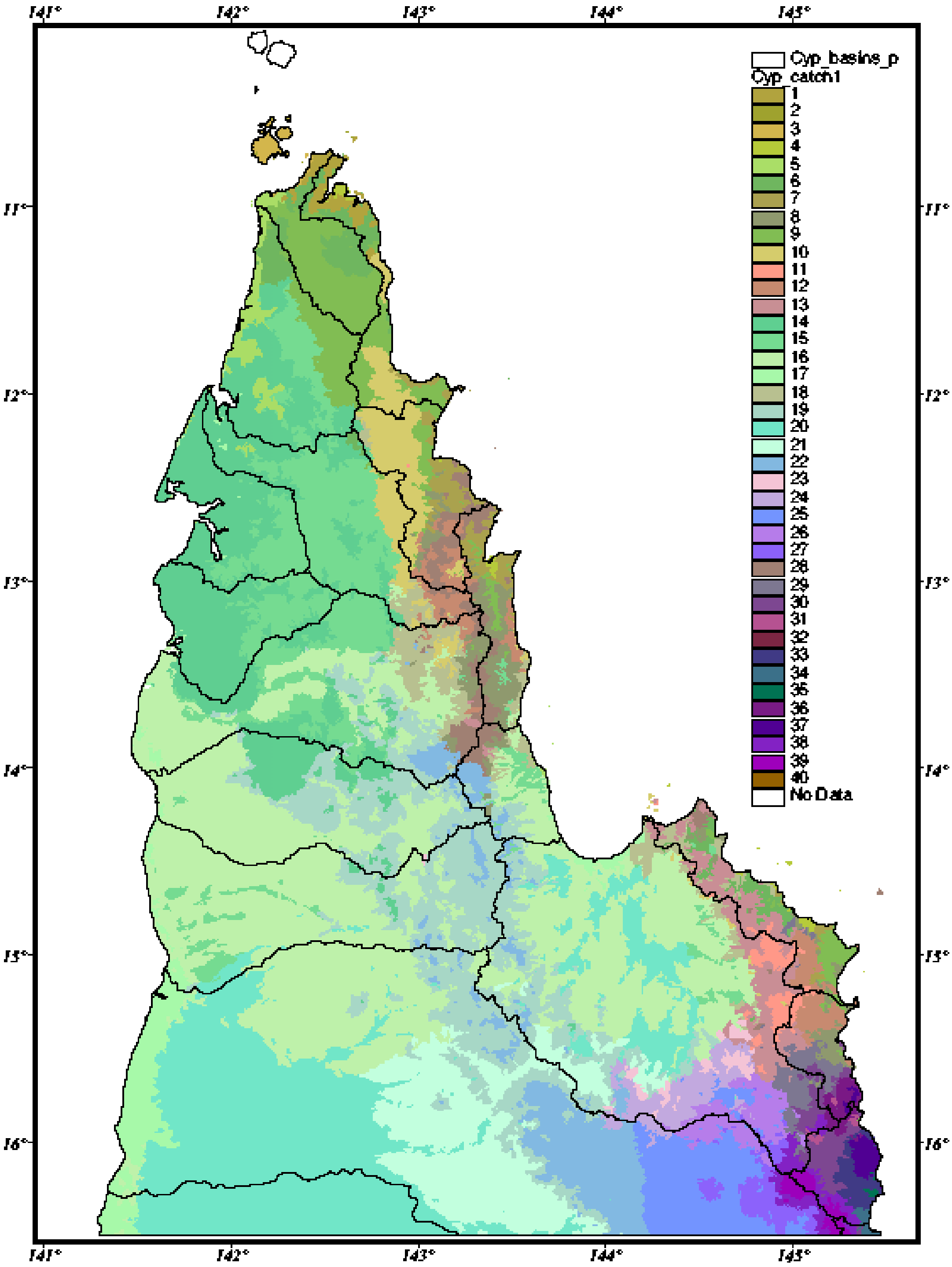


Figure 3.2 The 40 group Environmental Domain classificaton of Cape York Peninsula. Environmental Domains are objectively defined spatial units that are homogeneous with respect to terrain, climate and substrate at the micro-catchment scale. The domains are coloured to reflect their relative environmental similarity. Major catchment boundaries superimposed.

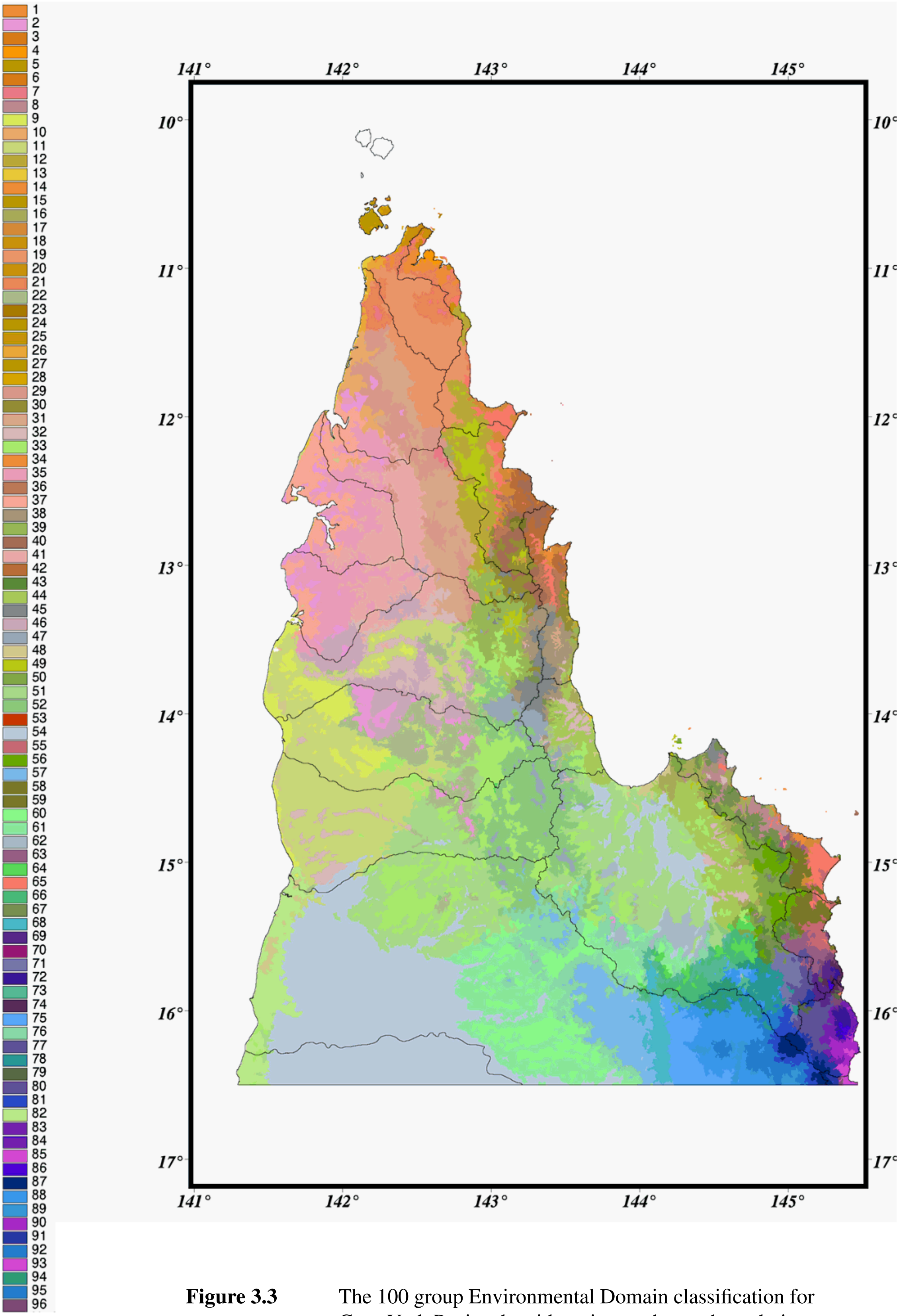


Figure 3.3 The 100 group Environmental Domain classification for Cape York Peninsula with major catchment boundaries superimposed.

Figure 3.4 Dendrogram showing relationships between microcatchment based environmental domains at the 40 group level.

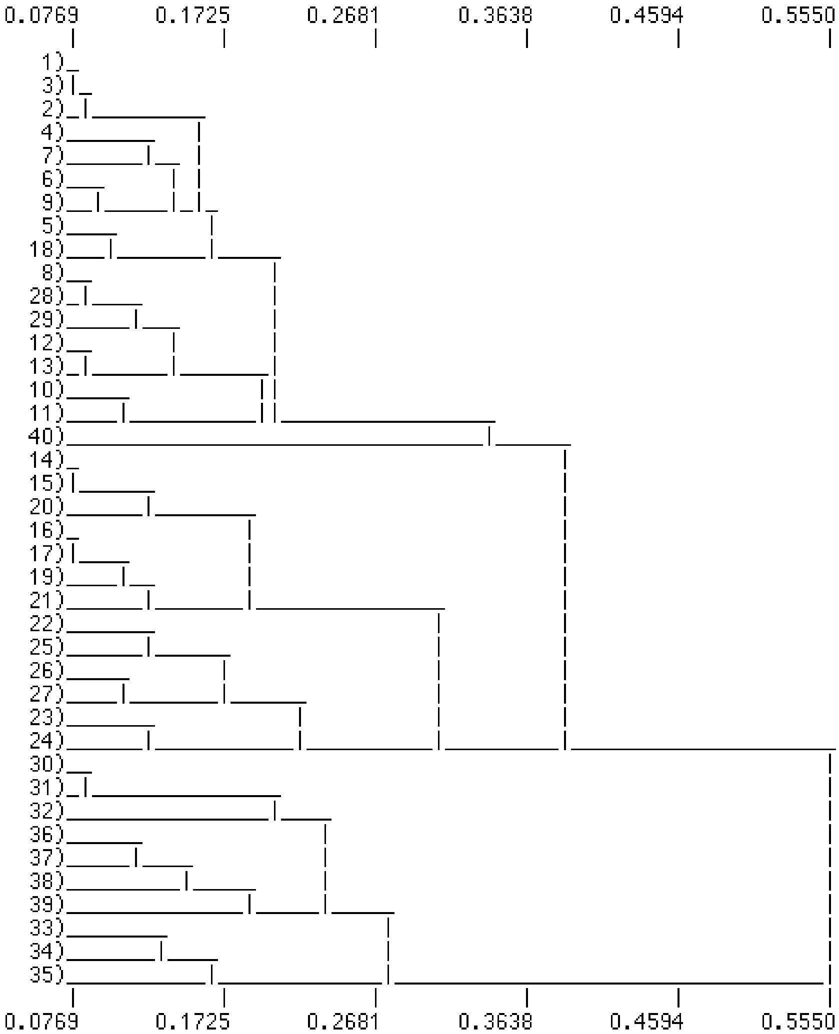


Table 3.1 Selected environmental attribute values for the 40 group Environmental Domain classification (only 38 groups fall within the defined CYPLUS area)

E.D. No.	AMT (°C)	MTCM (°C)	AMP (mm)	DQP (mm)	SLOPE (%) Mean	Max	Local Relief 1.25 km (m)	Nutrient Rating
1	25.8	19.9	1765	30	2.9	6.1	68	4.3
3	26.0	21.0	1631	2	3.5	8.4	100	4.8
2	26.0	21.0	1718	11	4.0	7.5	94	5.2
4	25.5	18.6	1580	29	0.25	0.6	8	5.5
7	24.9	16.9	1622	37	1.9	5.7	68	4.6
6	25.2	17.6	1491	12	1.2	3.4	44	3.3
9	25.0	17.3	1604	22	1.0	2.5	36	4.0
5	25.9	18.7	1541	0	0.26	0.7	9	4.9
18	24.6	16.1	1311	0	1.9	6.9	69	4.9
8	24.4	16.6	1526	29	3.0	10.5	110	4.1
28	23.8	15.7	1522	23	4.7	12.0	165	4.5
29	23.1	15.1	1490	45	3.3	10.0	117	3.5
12	23.9	16.4	1599	38	4.4	13.2	150	5.4
13	23.6	15.5	1382	25	5.0	15.7	191	4.9
10	24.7	16.4	1522	13	1.8	4.6	58	5.6
11	23.3	15.6	1496	37	5.7	12.2	161	6.0
14	25.7	16.8	1550	0	0.6	1.4	21	3.6
15	25.3	16.2	1445	0	0.4	1.1	16	4.0
20	25.2	14.1	1048	0	0.4	0.9	13	3.8
16	25.3	15.1	1259	0	0.4	1.2	15	5.5
17	25.8	14.9	1265	0	0	0.2	3	5.5
19	24.7	13.9	1143	0	1.0	2.8	35	4.9
21	24.8	13.1	997	0	0.6	1.3	19	5.6
22	24.0	13.3	1045	0	2.5	7.2	86	4.5
25	22.1	11.8	924	3	3.9	10.2	127	4.0
26	21.5	12.1	1145	19	5.7	14.2	176	4.8
27	20.7	11.0	1101	30	8.1	19.6	271	4.2
23	23.2	13.6	1110	4	4.5	10.7	132	6.0
24	23.0	13.1	1047	1	5.7	13.3	160	5.0
30	22.0	14.6	1922	88	6.5	15.9	221	4.0
31	22.6	14.7	1882	83	5.6	15.5	197	4.6
36	21.8	14.8	2210	123	11.7	25.3	393	4.1
37	20.3	14.0	2775	190	13.3	28.3	472	4.3
38	20.0	11.9	1763	97	12.2	26.3	424	4.3
39	18.2	9.8	2162	151	7.5	17.3	269	4.5
33	23.0	15.7	2767	164	6.3	16.0	207	4.0
34	23.9	16.1	2309	115	3.3	11.7	119	4.0
35	24.0	16.9	3159	195	1.5	3.4	64	4.0

Figure 3.5 Cumulative species counts for all vertebrates recorded from systematic field surveys tallied against environmental domains at the 40 group level (only 29 of these 40 EDs intersect with CYPUS databases, and only 17 had records present)

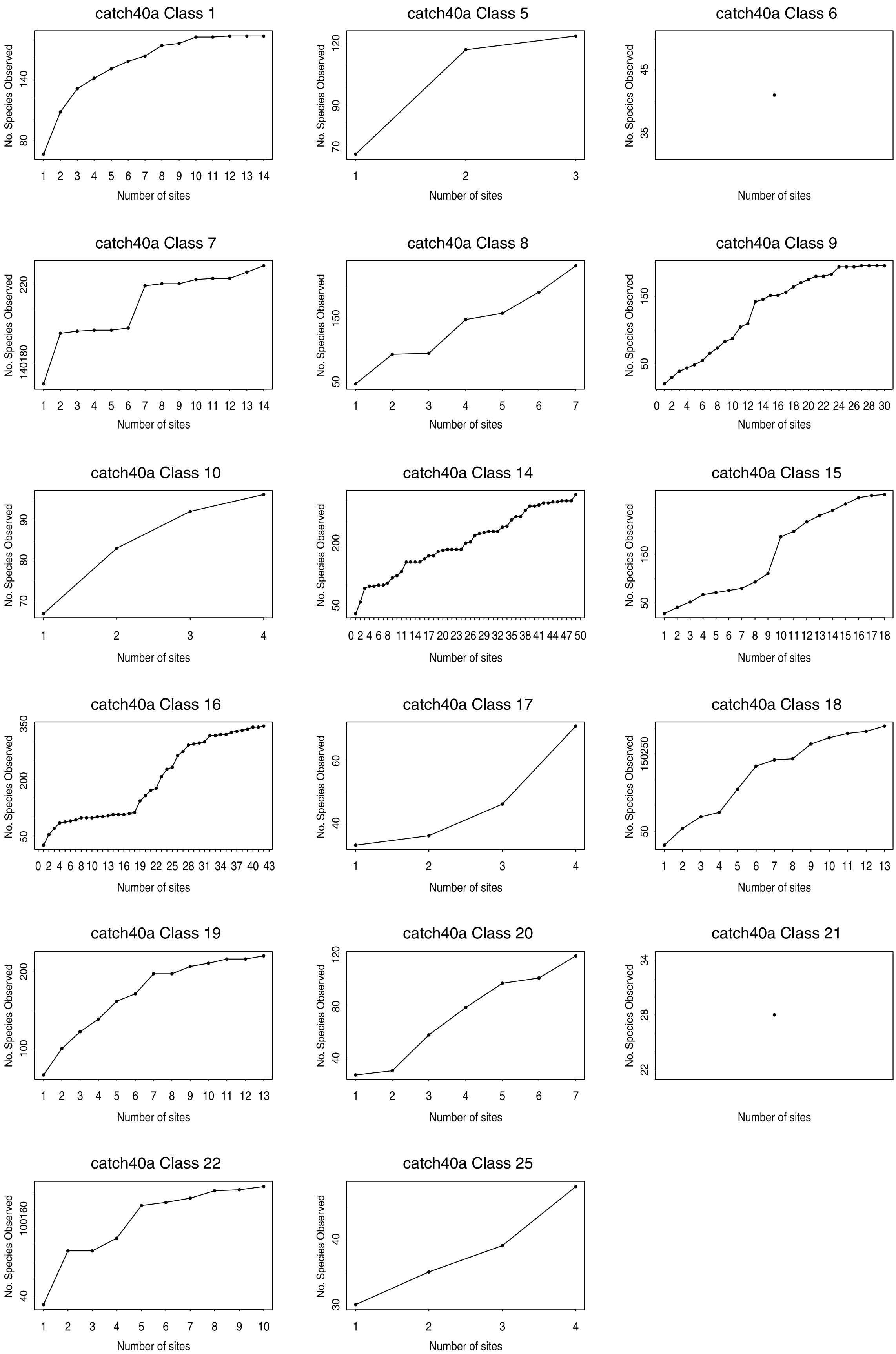


Figure 3.6 Cumulative species counts for all vertebrates recorded from systematic field surveys, tallied against environmental domains at the 96 group level (only 84 EDs intersect with CYPLUS databases, and only 38 had records present).

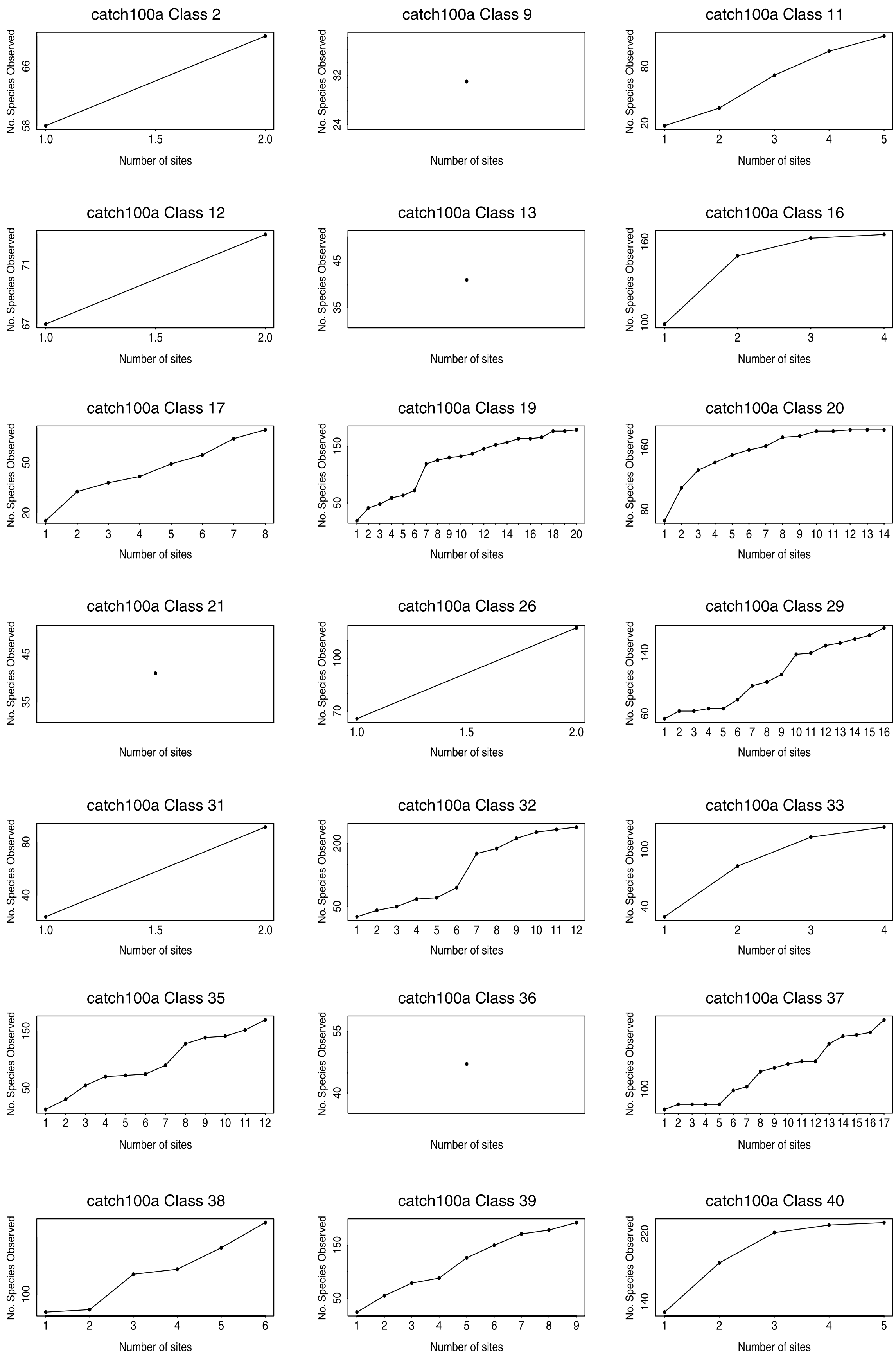
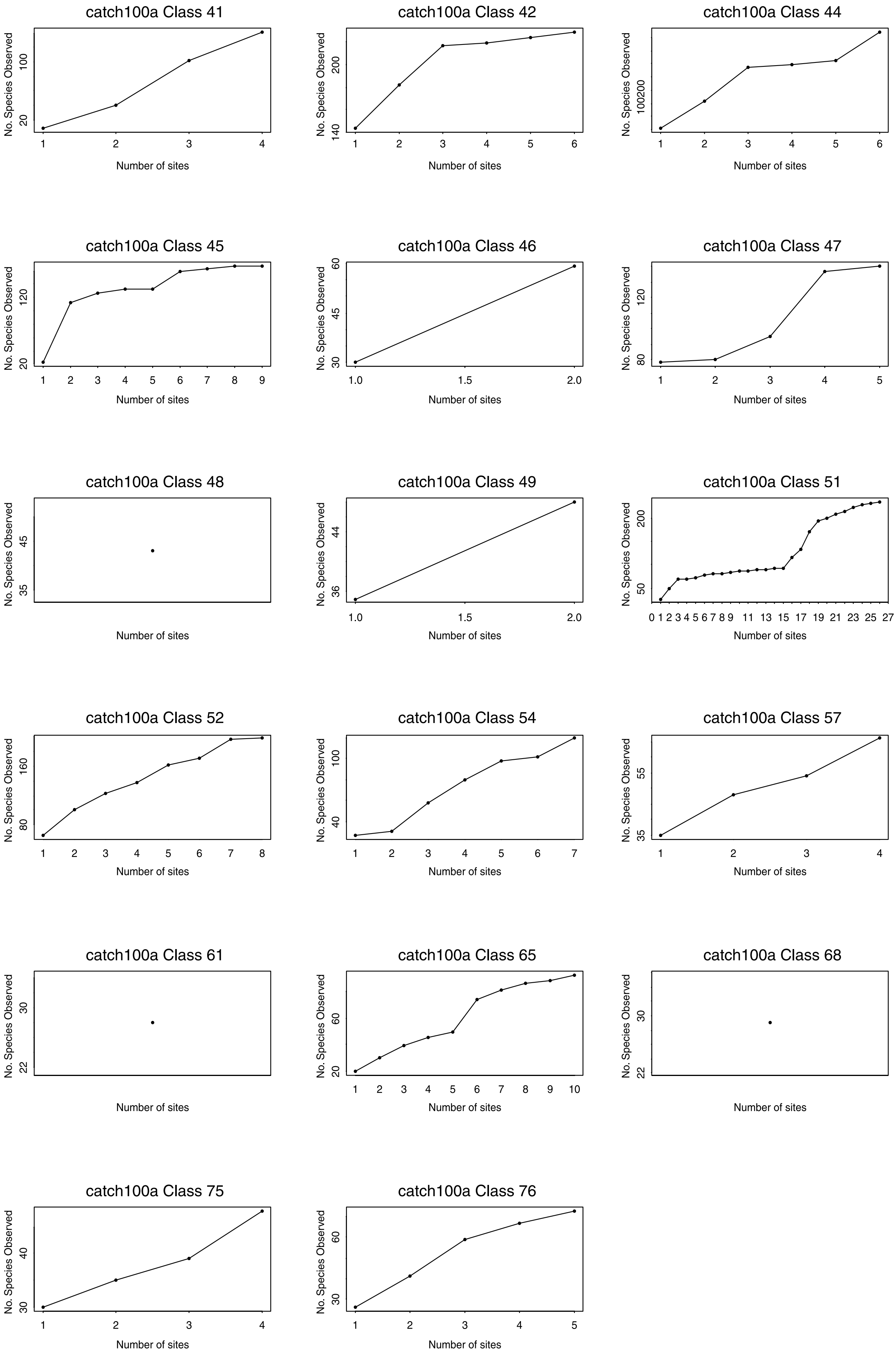


Figure 3.6 Continued



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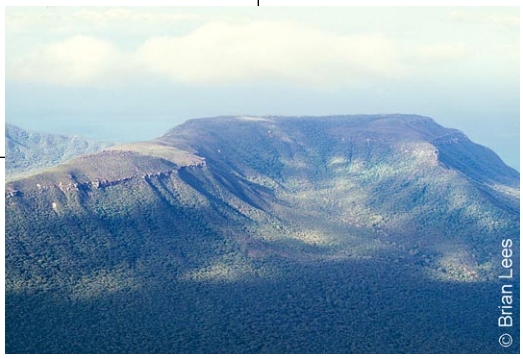
4 CRITERION 1 GEOEVOLUTION
CRITERION 2 GEODIVERSITY



CRITERION 1.0 GEO-EVOLUTION

Outstanding examples representing major stages of Earth's evolutionary history, including significant geological processes which have contributed to the development of landforms, or significant geomorphic or physiographic features.

Subcriteria:

1.1 Geological features – outstanding or representative.

1.2 Geomorphological and landform features – outstanding or representative.

CRITERION 2.0 GEODIVERSITY

The most important and significant lands for *in situ* conservation of geodiversity, including those containing rare or threatened features of outstanding (universal/regional/continental/local) value from the point of view of science or conservation.

Subcriteria:

2.1 Geological and geomorphological features or processes - outstanding or representative examples.

2.2 Geological and geomorphological features or processes - rare or threatened.

4.1 INTRODUCTION

The geological and geomorphological evolution Cape York Peninsula is comprehensively covered in the recent book, map and atlas of North Queensland Geology published jointly by the Australian Geological Survey Organisation and Geological Survey of Queensland (Bain and Draper 1997). Detailed accounts of specific regions of Cape York Peninsula are included and these are for the Coen Region (Blewett *et al.* 1997); Carpentaria lowlands and Gulf of Carpentaria Region (McConchie *et al.* 1997a); Quinkan Region (McConchie *et al.* 1997b); and the Regolith of Cape York Peninsula

(Pain *et al.* 1997). These products update the coverage that was provided by The Geology and Geophysics of Northeastern Australia by Henderson and Stephenson (1980). Both publications cover a larger area than Cape York Peninsula alone and provide necessary context. In addition, Mulvaney (1994) comprehensively assessed sites of geological and landform significance in the study region for the CYPLUS project. Drawing upon this material, we provide an account of the geoevolutionary history of the study region, and then examine documented features of geodiversity significance.

4.2 GEOEVOLUTION

Since 'Earth and life evolve together' it is important not to lose sight of the biological significance of Earth history and its converse. Cape York Peninsula holds the key to our understanding of events at the leading edge of the Australian plate. Events that produced the land and water environments that we now experience. These include events in the early history of the planet that laid down sediments in a shallow water environment (1500 m.y.) that were deformed and metamorphosed by later events, including extensive intrusion by granitic rocks (400 m.y.) and later (300-270 m.y.) in the north of Cape York Peninsula. Volcanic activity at this time was extensive in what is now the area surrounding Torres Strait. The oldest metamorphic, granitic and volcanic rocks form the backbone of Cape York Peninsula and offshore islands on the east coast and in Torres Strait. Everywhere these form the highest elevations and oldest exposed rocks in the study area.

The southern half of the island of New Guinea is a part of the Australian tectonic plate and as such, since the split of the Australian plate from the Antarctic core of Gondwana, has been an integral part of the continent of Australia. Collision of the leading edge of the northward moving Australian plate with the Pacific plate has resulted in uplift and the development of the central range of mountains in New Guinea. That process is on-going, with some mountains having now reached 4884 metres ASL in little more than 3 million years since the beginning of the accelerated uplift.

Australia and New Guinea have been alternately land-linked and separated by water on a number of occasions over millions of years. Cape York Peninsula provided the main land link, but a second land link between Arnhem Land and New Guinea formed at much lower sea levels (>-53m). Prior to the flooding of what is now Torres Strait between 6,000 and 8,000 years BP, New Guinea was integrally linked to mainland Australia. This made possible the movement of terrestrial plants and animals so that a potential biological 'bridge' existed between the continent and sub-continent.

It is important to understand the nature of this bridge; it was not a high mountain bridge, but a lowlands link that during full glacial times had much lower summer rainfall. This impact was ameliorated to some extent by lower potential evaporation. Throughout the Pleistocene, at times of lowest sea-level, a large freshwater to brackish lake formed, centred on the present day Gulf of Carpentaria (Nix and Kalma 1972, Torgersen *et al.* 1983, 1985, 1988, Jones and Torgerson 1988). This prehistoric lake (Lake Carpentaria) lapped the southern shores of present day New Guinea and Cape York Peninsula formed the eastern foreshore of the lake that existed until about 15-16,000 years ago. Not only did Cape York Peninsula provide a land link between New Guinea and north-east

Australia, but Lake Carpentaria provided a freshwater aquatic link and the eastern foreshore provided a marine littoral link.

Until the breach of the lower Wessell sill by rising sea level at around 15-16,000 B.P., the Wet Tropics region and New Guinea would have comprised an isthmus bounded by a freshwater/brackish lakeshore on the west, and a marine foreshore on the east. Both foreshores probably had their own littoral scrub or littoral rainforest communities. The last land bridge (last glacial) could therefore have only facilitated the movement and interchange of plants and animals adapted to the lowlands and the habitats extant on the isthmus. The littoral vegetation communities may have been conducive to movement of some of the lowland megatherm biota, but not the highland mesotherm biota of the Wet Tropics or New Guinea (Hope pers. comm.).

The opening of Torres Strait by rising sea levels (6-8,000 BP), and the on-going operation of climatic change on the habitats of Cape York Peninsula reinforce the barrier effect between New Guinea and the Wet Tropics. The study of Cape York in recent decades has provided much of the evidence of the ongoing evolution of this regional scale landscape.

Land connections with various parts of what is now the island of New Guinea have existed at various times throughout the Tertiary period, but events post mid-Miocene (about 15 million years) are of greatest significance for the evolution of biodiversity. Collision with the Pacific plate at that time, began the process of uplift and accretion of terranes in New Guinea. This provided cooler, moister mesotherm environments that favoured a rich assemblage of continental flora and fauna. Much of this formerly widespread biota was lost to Australia as it became cooler and drier in the south and much warmer and more seasonally wet/dry in the north. This extinction process accelerated with the next major global cooling event that began at around 3 m.y.b.p., peaked with formation of the northern hemisphere ice cap at 2.45 million years and then warmed towards 1.8 million years when the existing higher frequency glacial-interglacial cycles of approximately 100 000 years were initiated. The steady northward drift of the Australian plate through the Tertiary did compensate to some extent for global cooling (Nix 1982) but the cold, dry, glacial phases still had a major impact.

Coincident with the prolonged, major cooling event of the late Pliocene (3 – 2 m.y.b.p.), was the initiation of a new phase of uplift worldwide. From an existing, modest but not yet quantified elevation, the central cordillera of New Guinea began a new phase of rapid uplift that still continues, having reached a peak elevation of 4884 metres. These high ranges provide zones of near optimal microtherm and mesotherm habitat, while their accelerated erosion/sedimentation together with nutrient-rich volcanics, has produced highly favourable lowland megatherm habitat. Little wonder then, that these New Guinea environments support a rich biodiversity that compares with that of the far larger but ancient, eroded, nutrient-poor and climatically challenged continent of Australia. The long period of co-evolution and connection is evident in any comparison of the flora and fauna of Australia and New Guinea, but the present day disjunctions have masked this reality.

4.3 GEOMORPHOLOGY

Cape York Peninsula holds the key to connections between the ancient, stable shield of Australia and the much younger evolving land mass of New Guinea. The hilly and mountainous backbone of the Peninsula Ridge consists of Precambrian metamorphic rocks intruded by Palaeozoic igneous granitic rocks. These latter materials, very resistant to weathering, now form the highest elevations, rising to 824 metres in the McIlraith Range. Later Palaeozoic volcanics erupted and granites intruded at many points along the peninsula ridge that is exposed in the continental islands of Torres Strait.

Evidence of buried channels of major rivers flowing west into the Gulf of Carpentaria supports the hypothesis that their catchments were once much larger and extended much further east into a land mass that is no longer present. Probably this was coincident with the opening of the Coral Sea in the late Cretaceous and the submergence of the Queensland Plateau. Part at least of this missing land mass may comprise terranes that have accreted to south-eastern NG. That exotic terranes do occur in this region is not disputed, but their sources remain unclear.

The western slopes and plains are flat lying and continue below present sea-level into the Gulf of Carpentaria. Huge alluvial fans have developed further to the south on Cape York Peninsula, but these are less developed in the CYPLUS area itself. The landforms and highly weathered soils of much of the western slopes and plains are themselves ancient. These are of scientific interest because the notion that whole landscapes can persist for millions, even tens of millions of years, has been unimaginable to those trained in the young, post-glacial landscapes of the northern Hemisphere.

Possibly there is no match globally for evidence of very long-term stability of a tropical landscape. A recent, published claim (Nott and Horton 2000) suggests the Kimba Plateau, in the south of the study areas, provides evidence for the oldest known continental drainage divide in the world, at 180 m.y. Even were this to be disproved, geologists are in no doubt that Cape York Peninsula includes landscapes of very great age.

As discussed above, Cape York Peninsula forms the eastern catchment area of what was one of the largest lakes in the world (Lake Carpentaria). Now, under the present warm interglacial climate with its high sea-level, it is The Gulf of Carpentaria. The western Wessell sill which links Arnhem Land with New Guinea is a remarkable feature, presumably planed flat by wave action as sea levels rose and having less than 2 metres difference in elevation and at –53m. with current sea level. The eastern sill at Torres Strait now has deeply scoured channels between rocky islands, but critical depth may have been no more than –8m. For much of the past 2 - 3 million years, Australia and New Guinea formed one land mass, with Cape York Peninsula the key connector. A second connection in the west existed but only when sea levels were much lower. The Gulf alternated between brackish embayment, brackish lake, freshwater lake and open sea throughout the long series of Pleistocene glacial-interglacial cycles. Lake Carpentaria existed as recently as 15-16,000 years ago.

4.4 GEODIVERSITY

Drawing upon published material, we detail here just four significant geological features that highlight the geodiversity of Cape York Peninsula. Further survey and investigation will no doubt reveal additional candidates

4.4.1 EASTERN DUNEFIELDS

Sandy beaches and coastal dunes are a distinguishing feature of many sectors of the Eastern Australian coast, but extensive dunefields (now mostly vegetated) reach their maximum expression in Queensland. The great sandy island, Fraser Island, has been assessed as having World Heritage value and the onshore Caloola Sandmass is currently under consideration. Large national parks are in place in both areas but proximity to Brisbane has led to growing problems associated with human visitation. Offshore from Brisbane, enclosing Moreton Bay, are smaller but significant sand islands (Moreton, Stradbroke, Bribie). These southern, temperate, sand masses have been well researched from a whole variety of perspectives - geology, geomorphology, chronosequence, bio-geochemical cycling, hydrology, vegetation succession and unique flora and fauna. Important research on the dating of dunes in northern Australia has been conducted by various workers including (Lees *et al.* (1990), and Lees and Lu Lanchow (1992). Another large coastal sandmass and dunefield has developed near Byfield, just north of the Tropic of Capricorn. It contains some of the flora and fauna that was thought to be restricted to the dunefields further south, but has not had the same attention.

The fine, white, pure (>99%) silica sands of the east coast of Cape York Peninsula have been a magnet for mining. One mining operation is established on a small part of the Cape Bedford-Cape Flattery Dunefield north of Cooktown. While evident at many points along the more exposed eastern coastlines of Cape York Peninsula, the largest dunefields are in the extreme south-east (Cape Bedford-Cape Flattery) and in the far north (Shelburne Bay). The extraordinary landscapes of these two largest dunefields make a lasting impression on all who view them. Active, large, elongated parabolic dunes rise like snow-clad hills above vegetation and/or lake filled swales. Low ridges (<2m high) in repeated V-shapes form so-called Gegenwalle ground patterns within the dunefields, that are the best developed and largest in the world. Certainly the dune fields are one of the very few places in the coastal tropics where large, elongate, parabolic dunes are still active. Also, the occurrence of relictual Gondwanic conifers, *Araucasia cunninghamii*, in these tropical dunefields is indicative of deep time connections as well as unique hydrological conditions and lack of extensive wildfires. Remoteness and inaccessibility have not been conducive to in-depth research, but there can be little doubt that these tropical Cape York Peninsula dunefields rival the temperate Fraser Island/Caloola dunefields in every aspect – aesthetic, geomorphic, hydrological and ecological.

4.4.2 THE MITCHELL PALMER LIMESTONE BELT

Exposures of Siluvian-Devonian limestone extend north-south for about 100km and with a maximum width of 10km, from just south of the Mitchell River and Palmerville H.S. It is an extension of the Chillagoe Formation to the south, where many of the Karstic landscapes (towers, caves) have been reserved in National Parks. Geologists claim that the Mitchell Palmer limestone belt is a prime example of towers development and contains some of the best, richest and most diverse examples of surface solution features in Australia. Flutes (scalloped grooves), runnels (large channels), grikes (weathered slots), pans, rainpits, cups and wells are common. Vine thickets around the base of the towers form islands of closed-canopy habitat in the surrounding *Eucalyptus* dominated open-forest and woodlands. Considered (though as yet undocumented) expert opinion is that this, as yet, little explored karst region is significant at a national level and very possibly at the wider Austral/Pacific level.

4.4.3. BLACK MOUNTAIN AND CAPE GRENVILLE BOULDER LANDSCAPES

Huge piles of blackened boulders excite attention and, for the uninitiated, suggest a violent, volcanic origin. But these are the products of erosion and a boulder covering of very dark blue-green algae. Adding to the effect is an almost complete absence of vegetation, although a few Figs, Stinging Trees and patches of ferns occur. On Cape Melville there are emergent trees of the Gondwanic conifer, *Araucaria cunninghamii*, the Hoop Pine. These massive boulders are the largest and best examples in Australia and are Permian (225-280 m.y.) intrusions of numerous granitic plutons now exposed through erosion. Both occurrences are protected in small National Parks.

4.4.4 CHENIER PLAINS OF PRINCESS CHARLOTTE BAY

Much of the inner continental shelf bounding northern Australia has moved into a phase of sedimentation where many rivers are building significant deposits. Typical of these are extensive areas of poorly sorted material, which form tidal mud flats, with occasional shore parallel sandy, gravelly or shelly ridges which represent prior shorelines. These ridges are called cheniers and form as a result of changes in the depositional environment (Lees 1992). Processes leading to the formation of cheniers and chenier plains were reviewed by Augustinus (1989). Progradational shorelines where mud accretion is temporarily interrupted favour the development of these features. The most important feature of the environment in which chenier plains develop is a periodic variation in the local balance between fluvial and marine forces. There is a variety of factors which can be responsible for such local environmental changes, including switching in large deltas, increases in storm frequency, mortality of shellfish and climate change. The particular 12km section of chenier plain which borders the northeastern side of Princess Charlotte Bay towards Bathurst Head has been extensively studied by Chappel and Grinrod (1984). Chenier features can contribute to a better understanding of global and regional climates. For example, Lees and Clements (1987) identified across northern Australia a significant increase in chenier building between 2800 and 1600 b.p., hypothesising that this indicates a period of reduced fluvial discharge due to decreased wet season precipitation.

4.5 ASSESSMENT AGAINST CRITERIA 1 AND 2

As discussed above, notwithstanding the large extent of Cape York Peninsula, a full appreciation of the geological evolution of the Peninsula and its significance requires an understanding of the geological evolution of the adjacent sections of New Guinea and of the Gulf of Carpentaria. Torres Strait needs to be recognized for what it is, a recent flooding of an old isthmus, still represented by the Torres Strait Islands, and the adjacent section of New Guinea.

The beach barrier systems located on the Carpentaria coast of Cape York Peninsula appear to be especially significant as a very graphic record of the post-glacial progradation of the Carpentaria shoreline. The oldest chenier identified in this study dates from 120,000 BP (late Pleistocene). The presumption therefore is that the extensive chenier systems to the west of the Pleistocene ridge represent a continuous record of the progressive seaward accretion of the coastline. Nor has this study established if the beach barrier systems reflect changing sea levels. The composition of these very extensive barrier systems needs further clarification.

The dune fields of Shelburne Bay are clearly an outstanding landform of major significance. Although they may be geomorphologically analogous to the Cape Flattery dunefields, they are distinguished by their remoteness and the lack of mining impact. Both the eastern dunefields (Shelburne Bay and Cape Flattery) and the western beach barrier systems may be indicative of the contribution which the coastal landforms of Cape York Peninsula can make to an understanding of climate change and sea level changes post-Pleistocene.

Criterion 2, as the name suggests, is concerned with recognition of geological and geomorphological diversity, independent of its importance in illustrating Earth's evolution. The CYPLUS data set does contain an inventory of known geodiversity and identifies a number of geological features that warrant recognition at regional, continental and local scales, but more research and evaluations are recommended.

Some additional features on Cape York Peninsula which warrant further investigation into their significance for geodiversity include:

- The vast colluvial/alluvial outwash plains with their anastomising channels and ancient deltaic structures
- The Holocene beach barrier systems on the Carpentaria coast
- The Pleistocene shoreline chenier ridge inland from the Carpentaria coast
- The bauxite formations on the west coast, including stratigraphic cross-sections.
- The Quaternary landforms of Cape York Peninsula may well represent an important natural heritage resource.

In applying Criterion 2, obtaining the necessary contextual information at global and regional scales has proven to be difficult. For example, we were not able to undertake the necessary comparative geological analyses with PNG and other Austral/Pacific regions at similar scales and with matching descriptive material largely because the concept of geodiversity does not exist in the available geological literature. While our assessment is descriptive and indicative it is clear that there are elements of geodiversity on Cape York Peninsula that have national and wider regional significance and that, very possibly, have global significance.

In addition, we have been unable to obtain substantially systematic information on the Geodiversity of Cape York Peninsula. Thus the assessment presented here must be considered indicative rather than definitive.

4.6 CONCLUSION ON ASSESSMENT AGAINST CRITERIA 1 AND 2

The assessment of the geodiversity (Criterion 2) of Cape York Peninsula was necessarily constrained by the data available and so, with a few exceptions, must be considered as indicative. Those places which clearly qualify in terms of their contribution to geodiversity are the Eastern Dunefields, Shelburne Bay dunefields and the comparable Cape Flattery dunefields (though the latter have been impacted to some extent by mining), the Princess Charlotte Bay chenier system, the Mitchell Palmer Limestone Belt and the Black Mountain and Melville Range boulder landscapes. Doubtless other areas would qualify with further investigation and research.

The whole of Cape York, as part of the physical bridge between Australia and the of New Guinea represents an outstanding evolving geological landscape. Cape York Peninsula holds the key to connections between the ancient, stable shield of Australia and the much younger evolving land mass of New Guinea.
Cape York Peninsula contains a central spine of very old rocks (1,500 m.y. Pre-Cambrian) which graphically reveal geo-evolution including volcanic and granitic instrusion.

Not withstanding some of the major tectonic events taking place to the north and east of Cape York Peninsula, it appears to have been extraordinarily stable over the past few hundred million years. To the point where the stability and age of the landscape has attracted scientific attention with recent research suggesting for example that the Kimba Plateau may be the oldest known continental drainage divide in the world, at 180 m.y.

Cape York Peninsula contains extensive and potentially very important Quaternary landscape units which provide some of the most graphic evidence of recent geo-evolution. The eastern dunefields and the chenier systems are of global significance as evidence of geo-evolution under the influence of global climate change/sea level change.

Apart from the above cited localities which clearly qualify as being of global significance, our assessment of geoevolutionary and geodiversity values, although mostly indicative, strongly suggests that the greater part of Cape York Peninsula represents a region containing other geological and geomorphological features which will prove with further research to be of national, regional or global significance from a natural heritage viewpoint.

5 CRITERION 3 BIOEVOLUTION
CRITERION 4 BIODIVERSITY

CRITERION 3 BIOEVOLUTION

Outstanding examples representing major stages of Earth's biological evolutionary history, including the record of life

Subcriteria:

3.1 Palaeobotanical and palaeozoological (fossil records) - outstanding or representative

3.2 Plant and animal species or communities which are evidence of Earth's biological evolutionary history – outstanding or representative

CRITERION 4 BIODIVERSITY

The most important and significant natural habitats for *in situ* conservation of biological diversity, including those containing rare or threatened species, communities or ecosystems of outstanding (universal/regional/continental/local) value from the point of view of science or conservation

Subcriteria:

4.1 Species, populations or ecosystems - representative examples

4.2 Species, populations or ecosystems - rare, threatened or endangered

4.3 Species, populations or ecosystems - endemic

4.4 Species, populations or ecosystems - other outstanding scientific or conservation value

5.1 INTRODUCTION

In Chapter 2 we stressed that natural heritage assessment demands the target location be placed in a set of appropriate geographical contexts, and that a range of scales be considered. Here we place Cape York Peninsula in a global, regional, and continental context - as this is the first, critical step demanded by our methodology. Context is examined from various evolutionary, environmental, ecological and biological perspectives.

5.2 EVOLUTIONARY AND HISTORIC BIOGEOGRAPHY

The ecosystems with their component species, populations and genetic inheritance together comprise the biodiversity of Cape York Peninsula. The CYPLUS reports, taken together, provide a working outline of the dominant ecosystems; a reasonably complete listing of the higher plant and vertebrate animal species, but with very large gaps in knowledge of distribution and habitat requirements; and virtually no reference to studies at population and genetic level. However, on this latest point, a few reports include preliminary studies using molecular biological techniques and they identify plant and animal taxa that warrant further study. The value of these new techniques in building a far better understanding of evolutionary biogeography has been demonstrated by Moritz and colleagues further to the south in the World Heritage Area of the Wet Tropics (see discussion in Moritz 1994).

Biodiversity is a portmanteau word that is inclusive of all components of the living world – genes, species, populations, through to whole ecosystems. In assessing these living components of Cape York Peninsula we need to make some geographical distinctions. Strictly, Cape York Peninsula extends north from about 18^{o}S, at the southernmost point of the Gulf of Carpentaria. Taking this as a boundary widens the biogeographic context greatly to include large parts of the Gulf Lowlands, the Einasleigh Uplands and the Wet Tropics Bioregion as well as the more narrowly defined Cape York Peninsula Bioregion north of about 16^{o}S. This latter region, as defined in the Interim Biogeographic Regionalisation of Australia (IBRA) has been the entire focus of all the CYPLUS studies and reports and hence remains the principle focus of the present evaluation.

A close inspection of those maps depicting key bioclimatic controls (temperature, rainfall, substrate) generated in both the CYPLUS reports and the present study suggests that the IBRA defined Cape York Peninsula is distinctive, but with scope for redefinition of boundaries in the south. Thus, extensions of Wet Tropics components in the southeast, and of the Einasleigh Uplands in the south, if included, add greatly to species lists and confound numerical analyses. Also, the Gulf Lowlands are a very distinctive geomorphic region, but with significant gradients in rainfall and water regimes from the south to north. Assigning meaningful biological boundaries here is problematic.

The patterns of plant and animal distribution and the processes that have produced and that maintain them are central to the study of biogeography. At global scale there is a general concordance of agreement among biologists that six distinct biogeographic realms occur, though even at this level further aggregation has been considered e.g. The Palaearctic (North Africa, Europe and North Asia) combined with the Nearctic (North America) to form the Holarctic realm. However, the Neotropical (Central and South America) and Australian realms are always separated as highly distinctive components. The boundary between the Oriental realm (South and South-east Asia) and the Australian realm has fluctuated since Wallace (1869) first recognized sharp differences between Bali and Lombok. Modern treatment puts the key boundaries at the edge of the submerged Sunda and Sahul plates respectively, with the intervening islands of eastern Indonesia forming an overlap zone termed Wallacea.

It is now clear that the island of New Guinea comprises a mosaic of terranes, accreted to the platform at the leading edge of the Australian plate, but its biogeographic position remains a source of contention. Vertebrate affinities are clearly Australian, as also, are those of much of the upland flora, but the lowland flora and invertebrates appear to show stronger affinities with the adjacent Oriental realm (Gressitt 1982). Current environmental differences between northern Australia and New Guinea confound these arguments as well as the extent to which a palaeotropic flora and fauna has contributed to these lowland, tropical affinities. Whatever, Cape York Peninsula has been and remains the key connection to New Guinea, and Torres Strait has acted as both a bridge and a barrier (Walker 1972, Schodde and Calaby 1972).

Cape York Peninsula is the longest standing land connection between ancient Australia and the still emerging land mass of New Guinea. For much of the past 3 million years, and at times before then, Cape York Peninsula has been the dry land connection to New Guinea. Separation by the shallow seas of Torres Strait occurs only for relatively short periods of high sea-level during interglacials. Throughout each of the glacial-interglacial cycles there has been a waxing and waning sequence of colder-dryer; cooler-wetter; warmer-wetter; and warmer-drier climates. These provide ever-changing opportunities for differently adapted elements of the biodiversity pool in the wider region. Thus, while broadly and structurally defined ecosystems such as rainforest, open-forest, woodland, open-woodland, heath and grasslands persist through time (despite large changes in area and relative significance) their component species assemblages can exhibit great differences.

The present day high sea-level, warmer-drier climate sequence has isolated formerly connected ecosystems and their component biota on both sides of Torres Strait. Thus, rainforest, *Melaleuca* dominated savannas and heath ecosystems occurring on Cape York Peninsula have counterparts in the Western District of PNG (Webb and Tracey, 1972) and *Eucalyptus* dominated savannas much further to the east in the dry zone around Port Moresby have parallels on Cape York Peninsula. Quite apart from the separation imposed by Torres Strait, the climatic regimes, although broadly similar, are different enough to have produced a resorting of biotic components. While many species remain in common, others have been sifted out to be replaced by others from the surrounding pool of continental Australian or insular New Guinea species. Biodiversity is dynamic, continuously responding and adjusting to environmental challenges.

Cape York Peninsula is unique in Australia with respect to the strength of its biological affinities and connections with New Guinea. These are most developed in the north and east, while the western lowland sectors of Cape York Peninsula exhibit strong affinities with northern tropical Australia. Only the highest parts of the McIlwraith Range on Cape York Peninsula exhibit biological connections with the mesotherm uplands to the south and through them to south-eastern Australia. Cape York Peninsula holds an amalgam of the megadiverse Australian biota and the megadiverse New Guinea biota in a dynamic matrix that is of global significance.

Cape York Peninsula together with the Fly-Oriomo-Digoel lowlands in New Guinea to the north, has extensive areas of sedimentation that contain clues to the palaeobiogeography and evolution of both a common and a derived assemblage of flora and fauna. As yet, prospecting for key bioaccumulations has been very limited and indeed virtually non-existent over most of these areas. Off-shore cores, both in the Gulf of Carpentaria and from the Great Barrier Reef, have provided tantalising glimpses of the potential (de Dekker *et al.* 1988).

While the research of Peter Kershaw and associates (Kershaw 1998, Kershaw *et al,* 1998) has yielded useful insights into the environmental fluctuations and vegetation responses through the later Pleistocene on the elevated plateaux of the Wet Tropics region, it is limited in terms of what can be deduced about lowland, megatherm environments. Similarly, the research of Walker *et al.* (1972) and Hope and Golson (1995) in New Guinea has focused on higher elevation sites that limit inferences that can be drawn about the warmer lowlands. Indeed, one result of the excellent research carried out in these upland, mesotherm environments has been to set a high priority on finding equivalent lowland sites in both New Guinea and Cape York Peninsula. The Torres Strait islands (both continental and coral platform types) also warrant much closer attention.

Fossil locations throughout Cape York Peninsula are documented with representations from the Carboniferous (300-280 m.y.), Permian (280-255 m.y.), Lower Cretaceous (135-65 m.y.) eras. These hold important evidence for Australia's Gondwanic heritage of plant life. Potentially of critical importance to understanding of palaeo-climate and palaeo-ecology in the lowland, megatherm environments of northern Australia and New Guinea are the most northerly known Pleistocene fossil fauna sites in the Glen Garland Swamps on the relict land surface of the Coleman Plateau (Mulvaney 1994). Although not yet investigated, these 20 swamp depressions are likely to contain fossil pollen and sedimentary materials that can illuminate conditions around the last full glacial time (20,000-15,000 years).

The lack of research reflects the difficulties associated with remote and logistically challenged locations and in no way reduces the importance of finding sites on Cape York Peninsula and in surrounding seas that will clarify the evolutionary biogeography of lowland, tropical northern Australia and southern New Guinea. Currently, this whole region is a major lacuna in understanding of connections between the mesotherm environments of southern and eastern Australia and upland New Guinea.

Cape York Peninsula contains an array of contemporary biota that illustrate stages in biological evolution that extend back in time to before the break up of Gondwana and final separation of Australia from Antarctica. The austral conifers are a case in point. *Araucaria cunninghamii* is a mesotherm in its temperature response, but persists as relict populations on deep sands in dune fields and among massive boulders on rocky hillsides under high annual mean temperatures on Cape York Peninsula.

5.3 ENVIRONMENTAL, BIOLOGICAL AND ECOLOGICAL DIVERSITY

The preceding section provides an historic context, which in addition to its inherent interest and relevance to criterion 3, provides a basis from which to consider the application of criterion 4 to Cape York Peninsula. In considering criterion 4, a range of analyses were undertaken based on available CYPLUS data and reports, new data sets obtained from The Centre for Resource and Environmental Studies at The Australian National University (CRES/ANU), and additional published material. Unless otherwise stated, all spatial analyses reported below were undertaken using the Arcinfo GIS (ESRI 1996), together with environmental modelling software running at CRES/ANU, in particular ANUCLIM (Houlder *et al.* 1999) and PATN (Belbin 1987). The results provide a substantial body of background material to underpin application of these two criteria, but particularly criterion 4.

5.3.1 GLOBAL SCALE

At a global scale, the distribution of major vegetation formations is strongly correlated with climate. This is because temperature, water availability, and solar radiation control the fundamental processes of primary production (photosynthesis and biomass production) and decomposition, together with nutrient recycling). The major climatic gradients control vegetation structure (height, density, layering), physiognomy (leaf characteristics), and plant life and growth forms (Woodward 1987, Mackey 1993). Thus the amount, chemical composition (e.g. proportion of cellulose to lignin), and storage (above ground and below ground) of biomass in a landscape is climatically driven. These vegetation characteristics, in turn, provide the basic habitat infrastructure on which animals (micro- and macro-size) depend. It follows that significant differences in climate at a global scale correlate with significant biological and ecological characteristics (as used here, *ecology* refers to the interactions between plants, animals, microorganisms, fungi, and physical environmental conditions and processes).

Global-scaled analyses are fraught with difficulties that relate to the lack of systematic monitoring networks, the paucity of reliable data in many geographical regions, and the errors that arise when compiling fine-scaled features into globally-scaled coverages. For current purposes, no single data set was considered adequate. Rather, various global data sets were obtained that provide the basis for complementary perspectives. A range of analyses were undertaken with these data aimed at providing global context for Cape York Peninsula in terms of bioclimate and vegetation cover.

5.3.1.1 Gridded climate data analysis

A global data base of selected long term mean monthly climatic parameters was obtained from the Potsdam Climate Research Centre (http://www.pik-potsdam.de/). This data base contains gridded estimates of climate interpolated from a global climate station data set using the ANUCLIM software. The grid has a resolution of about 60km. The climatic parameters selected for analysis were:

- annual mean precipitation
- annual mean temperature
- driest quarter precipitation
- precipitation seasonality
- wettest six months precipitation.

These data were analysed using a simple rule-based model of core tropical savanna bioclimate developed by Nix (1983). The model comprises a set of rules that specify the range of climatic conditions that encompass core tropical savanna (see Table 5.1). Two key parameters could not be evaluated as they were unavailable in the Potsdam data base. These were that annual totals of solar radiation range between 6-8GJm^{2}yr^{-1}, and the mean minimum temperature of coldest month exceeds 13^{o}C and ranges upward to 18^{o}C.

Figure 5.1 maps the distribution of those cells whose climate matches the subset of five rules and highlights a number of critical features. First, the northern extremity of Cape York Peninsula is excluded because annual mean precipitation exceeds 1500mm. Similarly, the mid-eastern sector of Cape York Peninsula is excluded because driest quarter rainfall exceeds 50mm. On this basis then, at a global scale, Cape York Peninsula includes three significant bioclimates: the drier south western lowlands; the wetter region at the tip; and the wetter and slightly less seasonal rainfall areas of the mid-east (the latter two are discussed further below).

Second, the global distribution of core tropical savanna as defined and that is found in the south western lowlands of Cape York Peninsula, is not as geographically extensive as has been indicated in a number of vegetation maps. This is because the term savanna has been used to describe a very broad gradient of vegetation formations that range from grassland through to low woodland and woodland (as defined by AUSLIG 1990). Tropical savannas generally form a broad transition zone between closed tropical forest and open desertic steppes. The common characteristics being a continuous grass layer scattered with trees (see discussion in Bourliere and Hadley 1983). Gillison (1983), in a discussion of Australian woodland savannas, described vegetation formations defined by a diversity of ground cover (Acacioid shrubs, hummock grasses, tussock grasses) and scattered overstorey (mainly Eucalyptus species) plants across most of tropical Australia, within eight continentally defined bioclimatic provinces. The core tropical savanna defined by Figure 5.1 is more restrictive in that it excludes more xeric (annual mean rainfall <1000mm) and more mesic (annual mean rainfall >1500mm) environments.

5.3.1.2 Comparison with existing global classifications

Other lines of evidence suggest that the globally significant bioclimatic gradients identified in Cape York Peninsula have not been arbitrarily defined. Quantitative comparison (for example, by spatially overlaying within a GIS data base) of globally-scaled data sets must be undertaken with caution due to the potential errors arising from differences in spatial precision of source data, categories of classification and map scales. Providing we remain cognisant of these difficulties, useful and informative comparisons can be gleaned.

The BIOME classification of Prentice *et al.* (1992) maps biomes that are defined by a set of plant functional attributes that correlate with climatic thresholds. Their BIOME model maps tropical dry/savanna as a major global biome within a classification that recognises only 17 global biome types.

A digital map of estimated original (pre-human) and current global forest cover produced by the World Conservation Monitoring Centre (WCMC) (http://www.wcmc.org.uk/) provides another perspective. The global forest map of the WCMC is shown in Figure 5.2. Our predicted subset of core tropical savanna is encompassed by their tropical dry forest class. Note that this forest type has been extensively cleared in Asia, India, Latin America and Africa. Tropical Australia contains the largest remaining, relatively intact area in this (see further discussion in Chapter 6).

Hutchinson *et al.* (1992) produced a global bioclimatic classification by coupling a general plant growth model (GROWEST) to a global network of 4,159 climate stations. GROWEST transforms the dynamic, non-linear responses of plants to light, thermal and water regimes into three dimensionless indices on a linear scale from zero to unity. These separate environmental response indices are then combined into a single multi-factor growth index. A set of these derived bioclimatic indices that characterised each climate station was used to generate a numerical classification of 34 global bioclimatic regions which are nested within 10 bioclimatic meta-domains.

At this broadest global level, three of the 34 bioclimatic regions occur in Cape York Peninsula (Figure 5.3). One is restricted to the extreme south east and is really a minor northward extension of the Wet Tropics bioregion. Region I is characterised by a markedly seasonal moisture regime with a significant wet season and a significant dry season. Group I1 extends over northern Australia, the east coast of Africa, Madagascar, India, Burma, Thailand, Venezuela and eastern Brazil, as well as the Sahelian zone that makes the transition between tropical rainforest and desert in west and central Africa. Group J are hot, wet climates characterised by non-seasonal temperature regimes and moisture regimes which are either uniformly wet or have at most a short dry season. J1 occurs at the northern and southern limits of the equatorial rain forests of Africa and South America, as well as in Bangladesh, Vietnam, Kampuchea, and some coastal locations in Central and South America and north-east Australia.

The global analyses presented above all characterise Cape York Peninsula as having three globally significant bioclimates. The core tropical savanna biome represented in Cape York Peninsula is a subset of the more broadly defined general vegetation class of savanna/tropical dry forest of Prentice *et al.* (1992).

5.3.1.3 Other elements of biodiversity

The CYPLUS report of Abraham *et al.* (1995) summarised and highlighted the global significance of selected elements of Biodiversity found in Cape York Peninsula. Their analysis suggests that the following characteristics are of particular global significance:

- The closed forests, wetlands, seagrass, seabird breeding, roosting, and feeding locations, and orchids.
- The mangrove ecosystems which are amongst the worlds most species rich
- One of the world’s largest number of recorded orchid species.

5.3.2 REGIONAL CONTEXT

The Australian (also termed Oceanian) Biogeographic Realm includes Australia, New Guinea and outlying Pacific Islands including New Zealand. The relationships of biodiversity within this realm were authoritatively and extensively reviewed by Keast (1996). The strongest connections within the realm are those between Cape York Peninsula and New Guinea to the north, Cape York Peninsula and the Wet Tropics bioregion to the south, and bioregions to the west across tropical northern Australia.

5.3.2.1 Environmental gradients

Digital climate, terrain and geological data have been developed by CRES/ANU for Papua New Guinea (PNG) and Cape York Peninsula at commensurate spatial resolutions. These provide a basis for comparison of overarching environmental controls on biological and ecological phenomena.

Elevation data highlight both similarities and differences between Cape York Peninsula and Papua New Guinea (Figure 5.4). An archipelago of higher, but modest, elevation extends north from the Einasleigh Uplands and mountains of the Wet Tropics up through Cape York Peninsula and the continental islands of Torres Strait to disappear in the extensive lowlands of the Western province, PNG and re-emerge in the central cordillera of PNG.

Temperatures are very much influenced by elevation with modern lapse rates approximating –6.6°C/1000m. Annual mean temperatures (Figure 5.10) reflect the archipelago of cooler uplands described above. A significant east-west divide is also evident in Cape York Peninsula. Warmest month mean maximum temperatures (Figure 5.11) reinforce this, with the far northern tip and east coast sectors of Cape York Peninsula being cooler than the western lowland sectors. Biologically, the coldest month mean minimum temperature is very important in differentiating cooler and warmer adapted vegetation and associated biota (Figure 5.9). Here the differences between PNG and Cape York Peninsula are striking. Only the Torres Strait islands have coldest month mean minimum temperatures (>20°C) that match all of lowland PNG, while for Cape York Peninsula it is necessary to move well upslope in the central cordillera of PNG to find matching values. This is due, principally, to the influence of colder, continental, air masses influencing winter minima in northern Australia.

The water regime is a function of rainfall seasonality and amount, potential evaporation, soil water storage and rooting depth of perennial/annual vegetation. Thus while indicative, annual mean precipitation (Figure 5.8) is a crude and imperfect indicator of water regimes. Using this measure alone, large areas of Cape York Peninsula with annual mean precipitation >1250mm are matched across Torres Strait and even with some areas >1000mm<1250mm. But driest quarter precipitation (that is, the cumulative precipitation of the driest consecutive three months) (Figure 5.6) tells another story. All of Cape York Peninsula, with exception of the south-eastern strip, is drier at this critical time than anywhere across Torres Strait. Only further south in the wettest part of the Wet Tropics Bioregion do we find matches. However, coldest quarter precipitation (that is, winter season) illustrates another ameliorating factor for mid-eastern and tip of Cape York Peninsula and the Wet Tropics Bioregion to the south (Figure 5.5 shows this parameter for Cape York Peninsula only). This rain is significant in sustaining the east-coast and tip of Peninsula rainforests, by recharging soil profiles to carry this vegetation through the succeeding dry months. Another measure, precipitation seasonality (percentage coefficient of variation of monthly mean rainfall) simply emphasises the sharp demarcation between all of Cape York Peninsula and all but some tiny enclaves in PNG (Figure 5.7).

5.3.2.2 Discussion

The dominant influence on the precipitation regime in Cape York Peninsula is the seasonal movement of the Inter Tropical Convergence Zone (ITCZ). This is discussed in detail by Sturman and Tapper (1996). In mid-summer the ITCZ shifts south of the equator, resulting in north-westerly airflow over the region as the north-east trade winds recurve as part of the monsoonal circulation over northern Australia. In winter the ITCZ shifts north of the equator bringing significant changes to the pattern of precipitation. The south-easterly trade wind flows dominate, bringing moist and warm air to the eastern Australian coastline, including the east coast of far north Queensland and Cape York Peninsula. Thus, tropical maritime air masses, which originate over the tropical western Pacific and maritime continent area, affect far North Queensland for much of the year, bringing precipitation to the northern east coast even during the winter months.

The coastal McIlwraith-Iron Ranges in eastern Cape York Peninsula are evident in Figure 5.4. Given the presence of significant elevations, and the warm and moist air brought into contact with this part of the coast by the easterly trade winds, higher rainfall than estimated is likely. The presence of closed forest on these ranges (see discussion below) is evidence of persistence of rainfall throughout the year. The absence of rainfall records at higher elevations in this eastern sub-region of Cape York Peninsula (with no weather stations above 50 metres) limits the accuracy of interpolated values.

Together, Figures 5.5-5.11 clarify the critical bioclimatic position that Cape York Peninsula occupies in the broader region. The western subregion of Cape York Peninsula has strong affinities with the lower rainfall lowland megatherm environments to the north in PNG, while the tip and eastern regions have affinities with higher rainfall megatherm environments in PNG. Only very restricted summit areas (>500m) of the McIlwraith Range retain some affinity with mesotherm environments further south in the mountains of the Wet Tropics.

While there are strong climatic affinities, Cape York Peninsula is bioclimatically distinct from PNG as well as from the adjacent Wet Tropics region.

5.3.2.3 Elements of biodiversity

Abrahams *et al.* (1995) identified elements of biodiversity that are shared between Cape York Peninsula and New Guinea. Their analysis has been complemented here with a tabulation of published data (Frith and Frith 1995). Tables 5.2-5.11 show the number of selected invertebrate and vertebrate fauna by genus (G) and species (S) that are restricted to Cape York Peninsula (CY), or that co-occur across tropical Australia (TRA), more widely in Australia (A), and in New Guinea (NG). Those endemic to Cape York Peninsula are shown in brackets.

What is obvious from the tabled data is that although Cape York Peninsula exhibits very strong biological connections with New Guinea (by far the strongest of any Australian region) a high percentage of all taxa recorded there also occur in other bioregions of

Australia. This needs careful interpretation, since for very many species Cape York Peninsula provides the most important remaining, relatively undisturbed habitat. Most extensions of range beyond Cape York Peninsula in Australia are of:

- Savanna species that range across monsoonal northern Australia
- Rainforest species that occur in the Wet Tropics to the south
- Species with seasonal movements to breed in, overwinter in or transit Cape York Peninsula
- Very wide-ranging marine birds, Palaearctic waders, aerial feeders.

Notwithstanding these wider connections, Cape York Peninsula does have significant percentages of species in the tabled groups whose distribution within Australia is restricted to its boundaries (i.e. are endemic). Within the butterflies this is 21%; non-passerine land birds 5%; passerine land birds 14%; volant mammals 16%; freshwater fish 13%; frogs 23%; reptiles 25%; and non-volant mammals 20%. These are high values for any Australian bioregion. To add another perspective, a significant proportion of these species whose distribution in Australia is restricted to Cape York Peninsula are bidomicilic, that is, they also occur across Torres Strait in New Guinea (Tyler 1972).

Given the present day differences in bioclimate between Cape York Peninsula and those areas that are most similar in Papua New Guinea (Western Province; Port Moresby Province) and the very different bioclimatic context within which these regions are emplaced, the percentage of bidomicilic species is, perhaps, surprising. However, there is a general relationship between the percentage of taxa that are bidomicilic and the known mobility and dispersal ability of the broad taxonomic group:

GROUP	PERCENT BIDOMICILIC
Marine birds	100
Palaearctic waders	100
Wetland birds	89
Butterflies	78
Land birds (non-passerine)	77
Land birds (passerine)	72
Volant mammals (bats)	68
Freshwater fish	60
Frogs	45
Reptiles	38
Non-volant mammals	34

The surrounding seas and shorelines provide continuous habitat choices for marine birds and Palaearctic waders, so that it is not surprising that they are 100% bidomicilic. Indeed, more than 80% of the marine birds and Palaearctic waders recorded in Cape York Peninsula occur widely throughout Australia. This should not be taken to indicate that Cape York Peninsula is of lesser value for these groups. In fact, offshore coral cays and islands are the most important known breeding grounds for many tropical marine bird species and the extensive wetlands provide important breeding and dry-season foraging grounds for a large assemblage of wetland species. The seasonal cycles of filling and drying are responsible for complex movements of wetland bird species from regions both to the south and to the north of Cape York Peninsula.

The only invertebrate group for which we have a reasonably complete inventory and knowledge of distribution is the butterflies, although even here more work is needed in Cape York Peninsula and northern Australia generally. Cape York Peninsula is 'butterfly heaven' for the ardent Lepidopterist! About 60% of all Australian species have been recorded there. Of the 234 species listed (Table 5.2), 183 species are bidomicilic, that is, 78% of Cape York Peninsula butterflies also occur in New Guinea. However, the species list includes a significant number that, so far, have been recorded only in Torres Strait islands and not the mainland. Although butterfly species are capable of long-distance dispersal (both purposive and accidental) it is likely that the co-occurrence of host food plants on both sides of Torres Strait, together with very long periods of co-evolution are more important in determining the high percentage of species that are bidomicilic.

The non-passerine land birds are of ancient lineages that long predate the glacial-interglacial cycles of sea-level rise and fall during the Pliocene-Pleistocene. This accounts for the presence of the flightless Cassowary (*Casuarius casuarius*) on both sides of Torres Strait. Many others are large birds (Megapodes, Hawks, Eagles, Bustards, Pigeons, Cockatoos, Owls) with excellent powers of flight, while others again are long distance migrants (Pratincoles, Cuckoos, Nightjars, Swifts, Kingfishers, Bee-eaters and Rollers). Once again though the fact that 77% are bidomicilic owes more to co-occurrence of suitable habitat on both sides of Torres Strait and the relative recent separation by sea-level rise (about 8,000 years b.p.) than to any putative powers of dispersal. The passerine (perching) birds recorded in Cape York Peninsula are 72% bidomicilic. We now know that most species in Australia and New Guinea are derived from an extensive radiation that followed the final break-up of East Gondwana when Australia separated from Antarctica around 55 million years b.p. As discussed in chapter 4, the construction of New Guinea began around 15 million years ago with successive accretion of terranes onto the leading edge of the Australian plate, plus uplift which gained pace around 3 million years b.p. and continues today. The creation of near optimal mesotherm and microtherm habitat in these uplands led to speciation in Australian sourced passerine genera, now essentially isolated from the source areas to the south. This accounts for the close relationship between the endemic bird species in the uplands of the Wet Tropics and the highlands of New Guinea.

For the lowland megatherm fauna however it is a different story, with very recent (<8,000 years) and repeated contacts and co-occurrence of habitats extending back 2-3 million years. Thus 72% of the passerine land birds on Cape York Peninsula are bidomicilic. Contributing to this high percentage are a significant number of species that breed in Cape York Peninsula and elsewhere in northern and eastern Australia, but overwinter in New Guinea (Pitta, some Monarchs and Flycatchers, a Bird of Paradise - the Manucode and the Metallic Starling).

The volant (flying) mammals include fruit bats (flying foxes) and microbats that are 68% bidomocilic. Both of these have the capacity for long-distance dispersal and migration and this may account for some, at least, of the relatively high figure. Again, however, long-standing connections and co-occurrence of suitable habitat on both sides of Cape York Peninsula must be significant.

The freshwater fish species are, with a single exception, derived from marine ancestors, but this does not explain the fact that 60% of the Cape York Peninsula species are bidomicilic. The Jardine River, near the tip of Cape York Peninsula, has a freshwater fish species list that is 63% bidomicilic (Allen and Hoese 1980). Almost certainly this is due to a common and relatively recent inheritance from the Pliocene-Pleistocene Lake Carpentaria. New Guinea's largest river, the Fly River, flowed into Lake Carpentaria until it was diverted to the east by the Oriomo uplift, perhaps less than 40,000 years b.p. (Blake and Ollier 1971). While this argument may hold for the rich freshwater fauna of the westward flowing rivers of Cape York Peninsula, what of the eastern rivers? Here the affinities are with east coast fluvifaunulae although a few west coast species have managed to cross the drainage divide. During high runoff periods in the wet season, a freshwater 'esplanade' can provide temporary coastal connections between catchments allowing access by adult fish as well as by larvae and fingerlings. Stream captures of western tributaries by east coastal rivers may account for some of these transfers, but sheet flow across very gently sloping interfluves during cyclonic downpours is another alternative explanation.

Groups that have scant facility for traversing long distance water gaps drop to less that 50% of species that are bidomicilic. The frogs at 45%, the reptiles at 34%, and the non-volant mammals at 34% are significantly less bidomicilic than the previous groups described. Even so, these are significant by comparison with other Australian bioregions and once again they reflect the long history of repeated connections and separations of Cape York Peninsula and New Guinea.

A cautionary note is added with respect to the tabled data in that a number of New Guinea taxa have been recorded only on Torres Strait islands and not on the mainland of Cape York Peninsula. Although legally part of Queensland and thus included in the CYPLUS region, the far northern islands of Saibai, Boigu and Dauan are very close to and biologically part of New Guinea. For migratory animals (birds, bats) the Torres Strait islands provide useful stopover points and a refuge during inclement weather. Many migrant bird species appear to overfly Torres Strait directly and only occasionally are forced down on the islands (Draffan *et al.* 1983, Garnett 1991). Some of the islands with relatively high human population densities have suffered substantial habitat destruction.

Further, and more systematic, surveys, both in Cape York Peninsula and across Torres Strait in New Guinea, are likely to add to the list of bidomicilic taxa, but it is unlikely that they will change the broad outline presented above. What is more likely to alter it is the application of molecular biology in taxonomy and the refinement of more traditional morphometric approaches using cladistic analysis. A portent of potential change can be seen in the recent revision of Australian passerine bird taxa (Schodde and Mason 1999). Using more traditional approaches and drawing upon a much larger specimen base than earlier workers, they identify ultrataxa as the end members of populations of evolving species and argue for their recognition in conservation strategy and planning. These so-called ultrataxa or subspecies have indeed received formal recognition in the latest Action Plan for Australian Birds (Garnett and Crowley 2000).

At the sub-species or the ultrataxon level, among passerine birds, there is a greater degree of differentiation between those in Cape York Peninsula, New Guinea and northern and eastern Australia. Thus, the species *Meliphaga lewinii*, the Lewin Honeyeater, has an extensive distribution down the entire east coast of Australia. The isolated population in Cape York Peninsula, recorded only above 500m elevation on the McIlwraith Range is the ultrataxon *Meliphaga lewinii amphochlora*. Of the 113 passerine bird species recorded for Cape York Peninsula, more than 40% have been named ultrataxa that are either confined to this area or are largely confined to it but with southern extensions. Even within Cape York Peninsula there is recognisable differentiation, with *Sericornis magnirostris*, the Large-billed Scrubwren, having one population in the rainforest at the tip (Lockerbie Scrubs) *S.m.minimus* and another in the McIlwraith Range rainforests, *S.m.dubius*.

The significance of the Cape York Peninsula-New Guinea interconnections has been noted. A major review of the biogeography and evolution of the fauna of Cape York Peninsula was that of Kikkawa *et al.* (1981). These authors emphasise the discontinuities between the fauna of closed canopy and open canopy vegetation on Cape York Peninsula and New Guinea. They also show that there is a significant disjunction at the base of Cape York Peninsula, giving some rationale for the IBRA boundary.

As is generally found in the literature, the explicit role of the thermal environment is either ignored or acknowledged in passing. The match of habitats and associated fauna in Cape York Peninsula and NG is found in their shared thermal regime where megatherm plant response dominates. Then, further differentiation relates to water regimes and seasonality.

The so-called Wet Tropics, in contrast, are dominated by mesotherm plant response except for a very narrow coastal strip close to sea-level where much of the vegetation has been destroyed. The much larger suite of endemic vertebrate taxa in this region is due to the extensive uplands with lower temperatures that favour mesotherm response. All the endemic vertebrate taxa have closely related taxa in the appropriate thermal zone in New Guinea (>900m). In the present warm, wet interval only the highest points on Cape York Peninsula have thermal environments that are marginally mesotherm. Thus, the limited area available supports only one bird species (Lewin Honeyeater), frog species and reptile species. Smaller organisms such as invertebrates and lower plants are more diverse.

Unquestionably, Cape York Peninsula has a rich and diverse assemblage of flora and fauna with significant components that are unique in Australia. Much remains to be learned, but the broad outlines of the biodiversity heritage are clear, at least for the dominant higher plants and animals. At the level of vegetation assemblages, Cape York Peninsula and PNG exhibit floristic similarities and a selected set of these for closed forest, heath and mangrove, have been analysed by Webb and Tracey (1972). Living evidence of long-standing connection with New Guinea is strongest in Cape York Peninsula, becoming attenuated in Arnhem Land and much more so in the Kimberley of north Western Australia. While the Wet Tropics World Heritage Area to the south preserves more of the mesotherm (temperate) biological inheritance, Cape York Peninsula preserves much more of the megatherm (tropical lowland) biological inheritance that is shared with New Guinea. Both regions are of equal importance and have international significance from a biodiversity perspective, but only the Wet Tropics Bioregion is protected under the World Heritage Convention.

5.3.3 CONTINENTAL CONTEXT

5.3.3.1 Environmental gradients

At a continental scale, Cape York Peninsula, together with the 'Top End' of the Northern Territory (including the Arhnem Land Region) and the Kimberley region of Western Australia, are environmentally distinguished by the combination of a small set of key bioclimatic variables, as exemplified by Figure 5.12 (annual mean precipitation) and Figure 5.13 (coldest month minimum temperature). Other potentially biologically significant climatic variables include the average number of days on which thunder storms are observed over a given locality. Cape York Peninsula averages 30 days, Arnhem Land 60 days and the Darwin region over 70 days per year (Sturman and Tapper 1996). Thunderstorms generate lightning which is a significant source of incendiaries generating fires, particularly in the late dry season.

Figure 5.14 is a continental scaled geological map of Australia. This shows the dominance of Palaeozoic basement across the Top End from Arnhem Land and through to the Kimberley Region. This is distinct from the younger Proterozoic and Mesozoic material that underlies much of Cape York Peninsula. This difference in bedrock age and exposure has produced differing patterns of weathering, erosion, and landscape formation. These differences between Cape York Peninsula and Arnhem Land/Kimberley Region in landscape evolution are further reinforced by Figure 5.15, which shows elevation and the upland massifs predominant in the latter two regions.

5.3.3.2 Elements of biodiversity

At a continental scale, Cape York Peninsula, Arnhem Land, and the Kimberley Region do share affinities in terms of vegetation characteristics and in particular, *Eucalyptus* and *Mellaleuca* dominated woodlands, but important structural and floristic differences are evident.

Dr John Neldner and colleagues at the Queensland Herbarium have mapped the entire vegetation of tropical Australia at a scale of 1: 1,000,000. For the first time this provides the capacity to systematically compare the vegetation of Cape York Peninsula with the Arnhem Land and Kimberley regions. Table 5.12 lists those vegetation types that are unique to Cape York Peninsula (Neldner, pers.comm., unpublished data), and these are mapped in Figure 5.16.

Of the 39 unique vegetation types most have been distinguished on a floristic rather than a structural basis. For example:

- Vegetation map unit 17 is an association of *Asteromyrtus lysicephala, Jacksonia thesiodes, Choriceras tricorne, Neofabrica myrtifolia*, and emergent *Melaleuca stenostachya* (Heaths over sandstone plateau)
- Vegetation map unit 176 is an association of *Neofabricia myrtifolia, Jacksonia thesioidies, Thryptomene oligandra, Leucopogon spp*. (Quaternary dunefields)
- Vegetation map unit 184 is an association of Sorghum spp., *Themeda arguens*
- Vegetation map unit 102 is an association of *Eucalyptus tetradonta, E. nesophila, Asteromyrtus brassii*, and heath understory (Sandplains over sandstone).

Of particular interest are vegetation map units 1 and 2 which are structurally distinguished. The former is an association of *Eucalyptus tetrodonta, E. hylandii* var.

campestris , Erythrophleum chlorostachys. The latter is an association of *Eucalyptus tetrodonta, E. nesophilia, Erythrophleum chlorostachys* (Bauxite plateua, northern Cape York Peninsula). These associations are at the southern and northern ends respectively of the deeply weathered Aurukun land surface and in both cases trees can exceed 30m in height. These vegetation types cover 7.3% of the total area of Cape York Peninsula. This exceptional structural development most likely reflects the ability of deeply rooted trees to access ground water resources during the dry season (Neldner, pers. comm.). Intriguingly, the nearest ecological analogue is possibly Jarrah (*Eucalyptus marginata*) forest also growing on lateritic substrate in south-west Western Australia, where access to groundwater sustains tall canopies during the summer dry period.

This comparison of major vegetation types at a scale of 1: 1,000,000 excludes significant components of plant biodiversity that only occur and are mappable at finer scales. Furthermore, this analysis has not identified those vegetation map units which are dominant elements on Cape York Peninsula but are only minor elements elsewhere across tropical Australia

Unfortunately a complete taxonomic comparison between Cape York Peninsula and other localities could not be undertaken. Such an analysis is possible as the data exist in various herbaria (Brisbane, Darwin, Perth, and National Herbarium, Canberra). To date, only partial analyses have been undertaken. For example, Clarkson and Kenneally (1988) compared the floras of Cape York Peninsula and the Kimberley Region based on checklists held in the state herbaria of Queensland and Western Australia. Cape York Peninsula was found to contain a total of 2,412 vascular plant species compared with 1,592 in the Kimberley Region. Interestingly, Cape York Peninsula was richer by a factor of 1.5 at the species level, 1.7 at the generic level, and 1.4 at the family level. For ferns and fern allies, Cape York Peninsula was found to be 3.4 times greater. When families are ranked by the number of genera present, *Poaceae* and *Fabaceae* are the two most dominant in Cape York Peninsula and the Kimberley Region. However *Orchidaceae, Sapindaceae* and *Proteaceae* are in the top 10 list for Cape York Peninsula. These families are replaced by *Scrophulariaceae, Chenopodiaceae* and *Asclepiadaceae* in the Kimberley Region. Other important differences noted between the two provinces included: the number of *Acacia* species in the Kimberley Region is twice that of Cape York Peninsula; only three families of vascular plants found in the Kimberley Region are not found in Cape York Peninsula, whereas 65 families occurring in Cape York Peninsula do not extend into the Kimberley Region.

Geographical variation in endemic Australian seed plant species has been analysed by Crisp *et al.* (in press). All available vascular plant species location data were analysed on a 1^o x 1^o grid for the Australian continent. This data base had been compiled by Environment Australia based on a collaborative project with state herbaria. Endemism was calculated using the following measure:

- For each cell where a given species was present, an index was calculated as the ratio of 1/n where n = the total number of cells in Australia where that species is found; eg. for each cell where *E. camaldulensus* was found, the index was 1:375
- For each cell, the ratio calculated above was summed for all species present in that cell
- Finally, a weighted endemism index was calculated by dividing the above value by the total number of species in the cell.

The two regions with the highest weighted endemism index were the Wet Tropics Region and Cape York Peninsula. The total number of species records in the Environment Australia data base was 8,320, compared with a known Australian total of 17,000. The absence of data from the Western Australia herbarium may have biased this result. Note that the vegetation survey undertaken for Cape York Peninsula by Neldner and Clarkson (1995) found 3,338 species.

A further analysis illustrates the relative extent of endemism amongst seed plants in Cape York Peninsula. We identified 1^{o} x 1^{o} degree cells that delineate Cape York Peninsula (CY), Arnhem Land (AL), the Kimberley Region (KR), and the Wet Tropics of Queensland (WT), and listed the number of plant species that occurred within each region, and the extent of species overlap between regions. The results are given in Table 5.13.

These analyses are limited in that a total seed plant species list was not available, but they indicate that Cape York Peninsula contains a significant number of species that are not shared with other tropical regions in Australia, as well as a large number of species that are shared with one or more other tropical regions in Australia.

Other literature, summarised in the CYPLUS report by Abraham *et al.* (1995), provide additional perspectives on elements of Biodiversity contained by Cape York Peninsula relative to other Australian regions, including:

- Orchids - the 62 genera recorded in Cape York Peninsula exhibit a much greater diversity than the 'Top End' of the Northern Territory or the Kimberley Region
- Freshwater fish - species diversity is very high for Australian fluvifauna, e.g. the Wenlock River is argued to contain the richest known freshwater fish fauna in Australia, with the Jardine River not far behind it
- Invertebrates – despite the lack of comprehensive data and the inherently high levels of speciation in many invertebrate groups (which makes definitive assessment difficult), the available data generate interesting statistics, e.g. 65 species of drosophilid flies have been found in the Iron Range compared with a national total of 279; 106 species of ants have been found in a 7 kilometre strip of the Iron Range, 80% of which are found in New Guinea; Cape York Peninsula contains 57% of known Australian butterfly species.

The Abraham *et al.* (1995) report noted the following information about species endemic to Cape York Peninsula (i.e. those not found in other parts of Australia, New Guinea, or elsewhere in the world):

- Plants; 264 plant species and three genera are endemic to Cape York Peninsula; these are focussed in McIlwraith-Iron Ranges, gallery forests and vine thickets
- Terrestrial vertebrates; the total number of endemics so far known is 40. This includes two rock wallaby, bird, skink, frog, gecko, *Melomys*, monitor and *Antechinus* species [Table 5.14]
- Continentally significant animal habitats include: sand dune areas; heath; closed forest (Cape York Peninsula has 20% of Australia's closed forest cover) and gallery forest; islands; cliffs; boulder mountains; mangrove; seagrass.

5.3.4 LOCAL SCALE

Some of the issues concerning the within-region extent and variability of the environmental, ecological, and biological characteristics of Cape York Peninsula, were discussed in Chapter 3. Only a few of the data sets of Cape York Peninsula were considered sufficiently geographically comprehensive and ecologically adequate on which to base Cape-wide context analyses.

Two sets of new analyses were undertaken to investigate elements of the environmental, ecological and biological characteristics of Cape York Peninsula:

- Vegetation classifications based on the CYPLUS mapped vegetation data
- Environmental Domain classifications.

5.3.4.1 Vegetation Analyses

Neldner and Clarkson (1995) detail the results of their major vegetation survey of Cape York Peninsula. They identified 21 structural formations, 201 vegetation units, plus an additional six units for disturbed vegetation. These were agglomerated into 30 broad vegetation groups. Messmate (*Eucalyptus tetrodonta*) dominated woodlands and tall woodlands are the most extensive occupying 7.3% of the study area. *E. hylandii* and/or *E. tetrodonta* woodlands occurring sandstone, metamorphic and ironstone ranges occupy 7.3% of The Cape. Other extensive broad vegetation groups dominated by *Eucalyptus* species are the bloodwoods (*E. clarksoniana, E. novoguinensis* and *E.polycarpa*, covering 5.7%; the boxes (*E. chlorophylla, E.microtheca* and *E. acroleuca*) covering 5.0%; and ironbark (*E.cullenii* and *E. crebra*) covering 3.1%. Another extensive vegetation group is low open-woodlands, low woodlands and tall shrublands dominated by *Melaleuca* spp. (14.2%). Grasslands (6.1%), rainforests (5.6%), and heathlands (3.3%) are other important groups. The results of field collection together with herbarium records yielded a total of 3,338 species. Of these, 397 taxa are recognized as rare or threatened by the Queensland Herbarium. This represents 10.7% of the total flora.

The primary vegetation map units (*n*=201) can be regrouped to highlight several important characteristics of the ecology of Cape York Peninsula. Even at this scale of mapping it is apparent that Cape York Peninsula comprises a complex matrix of interdigitated vegetation associations. Compare the distribution of *Eucalyptus*-dominated vegetation (Figure 5.17) with that of non-*Eucalyptus* dominated vegetation (Figure 5.18). Subcatchment units may be dominated by *Eucalyptus* for example, but the broad landscape is occupied by a complex matrix of vegetation that includes closed gallery forests, grasslands, *Melaleuca*-dominated woodlands and, less commonly, heathlands.

Much of Cape York Peninsula experiences a long, dry season. This has profound biological implications, in that permanent or semi-permanent surface water becomes critical for the persistence of important elements of the flora and fauna. Thus, locations that contain permanent flowing streams, groundwater discharge areas (springs), and other forms of water holes, support vegetation that is differentiated from the surrounding landscape matrix and that constitutes important dry season habitat resources and refugia. The distribution of these 'wet' vegetation types is shown in Figure 5.19.

The wide variety of structural vegetation and its admixture; such as the network of gallery forests and the scattered vine thickets that occur throughout vast expanses of *Eucalyptus* and *Melaleuca* woodland; littoral thickets on mainland beaches and offshore islands; sandplain heath; mangroves and a range of other vegetation types, facilitates migration and seasonal movements of a number of bird and bat species. Cape York Peninsula is a vital component of the Eastern Australian Bird Migration System (Nix 1976) for species in transit to and from New Guinea; species that overwinter and other species that arrive from New Guinea to breed in Cape York Peninsula, as well as wetland species that have seasonal movements within the larger framework of north-eastern Australia and New Guinea (Blakers *et al.* 1984, Kikkawa 1976).

5.3.4.2 Environmental Domain Analysis

Probably no country or region on the planet has anything approaching a truly comprehensive audit of biodiversity. Typically, museum and herbarium collections, assembled over decades, collectively provide a list of species occurrence and even some indications of distribution. Always the collections are biased towards the higher plants and animals, although some invertebrate groups such as butterflies and beetles do get attention. Only in more recent times have the functionally important microfauna and microflora received the attention they deserve. Cape York Peninsula is typical in that much of our knowledge of biodiversity is based on specimens taken on ad-hoc collecting expeditions. However, the CYPLUS project did provide the opportunity and limited resources for more systematic surveys of biodiversity. As discussed in Chapter 3, the most complete coverage of Cape York Peninsula is that provided by the vegetation survey of Neldner and Clarkson (1995). Indeed, this may be the best vegetation mapping and description of a large region yet produced in Australia.

A singular problem of sampling biodiversity in Cape York Peninsula is that access to sites becomes difficult, if not impossible, at the time of peak biological activity in the wet season. Apart from the immediate vicinity of settlements or sites accessible from the coast, up navigable waterways, and from all-weather airstrips, the greater part of Cape York Peninsula is inaccessible during the wet season. Inevitably then we have a clearer picture of biodiversity in those areas with best dry and wet season access.

Newer technologies (such as remote-sensing and Geographical Information Systems) offer prospects of total coverage at high levels of spatial resolution. Although biodiversity as such cannot be determined directly, a combination of these new technologies with systematic ground sampling and predictive modelling can provide a more quantitative assessment of biological resources and component biodiversity. This was the approach used by Neldner and Clarkson (1995) in their vegetation survey of Cape York Peninsula. It was used by some others in the CYPLUS reports, but to lesser effect because of the lack of systematic ground sampling and matching environmental data.

A complementary approach is the environmental domain analysis reported in Chapter 3 that was used to assess the representativeness of the fauna survey sites. Environmental domain analysis is based on the premise that primary plant productivity ultimately depends on light energy from the sun, favourable temperature, water and nutrient regimes. Taking these four physical environmental regimes (light, temperature, water, nutrients) it is now possible to characterise geographical areas in terms of these principal drivers of biomass productivity, at high levels of spatial resolution and with total coverage. Numerical taxonomic methods are used to generate classifications based on the multidimensional environmental distance between component units. The resultant entities have been termed environmental domains. This quantitative subdivision of environmental space is then translated back into geographical space by coupling the environmental domain specifications to gridded primary environmental attributes. Thus, this procedure is abiotic, i.e. it does not include biological data. The assumption is that these abiotic environmental domains (ED's) provide a quantitative framework for assessment of natural environments and their associated biodiversity.

While similar procedures can and have been applied using biological data and also mixed abiotic/biotic data, serious problems arise. As mentioned earlier, biological survey data never have total coverage, are invariably biased toward higher plants and animals (and in particular the more charismatic megaflora and megafauna), and make the untested assumption that a selected subset of the biota can act as indicators for the rest.

This latter assumption is grounded in theory that postulates plant and animal communities as higher order entities that persist through time and space (Clements 1916). The opposing theory is that every organism has unique requirements and acts independently (except for parasites and symbionts) to become a member of an ever changing array of taxonomic assemblages through time and space (Gleason 1939). The first supports the notion of indicator species, the second does not.

The spatial objects in the environmental domain classification presented in chapter 3 were microcatchments rather than grid cells. Why? A practical reason was that the matrix of *grid cells x primary attribute data* exceeded the processing capacity of available hardware and software. Although a supercomputer solution had been developed in earlier applications this was deemed inappropriate here because of concerns about data quality and consequent assumptions about the level of spatial resolution.

However, microcatchments also offer a number of advantages. Using digital terrain analysis software (that includes sophisticated algorithms for capturing surface hydrological flows) developed by Michael Hutchinson of The ANU, it was possible to map catchments at a range of scales (commensurate with the level of spatial resolution of primary elevation data). The catchment units delineated in this process are then fully described in terms of primary attribute data by estimating the proportion of area occupied by discrete attributes such as geology and by selected statistical descriptions of continuous attributes such as climate and terrain (e.g. maximum and minimum values, quantiles). Subsequent to the classification process, the classified catchment units can be intersected with attributes for which there is complete digital coverage, in particular, vegetation and land use disturbance.

Even in very level, low-lying terrain on Cape York Peninsula, the hydroecological impacts of the monsoonal wet/dry seasons are so evident in terms of surface wetness/dryness and vegetation responses, that most of the delineated microcatchment boundaries can be detected in the field. Last, but by no means least, the catchment is a natural unit entraining key processes that drive landscape evolution and biological responses.

Of course, every microcatchment will include upslope, downslope and drainage components, each of which can be expected to have different hydroecological environments and thus, differing vegetation elements. However, at microcatchment scale, we could expect vegetation structural expression to be limited to dominant and subdominant types with minor expressions of other types due to riparian zones, rock outcrops, localised water features and so on. We tested this hypothesis by overlaying the mapped vegetation units of Neldner and Clarkson (1995) on environmental domains (ED) at the 96 group level and also at the 40 group level. Because the environmental domain analysis extended to 16^{o} 30' S (and thus beyond the southern limit of the vegetation mapping and also included some offshore islands with no vegetation data) some 12 EDs of the 96 ED group and 4 EDs at the 40 group level had no data for comparison. Thus we are left with 84 groups (96-12) and 36 groups (40-4) available for comparative analysis. Detailed results for these are in Tables 5.15 and 5.16.

At the 84 group level there is overwhelming support for the hypothesis that environmental domains, based on abiotic data alone, are correlated with vegetation structure, which in turn plays a major role in determining habitat for the flora and fauna components. In all but a few cases the dominant structural type exceeds 50% of ED area and dominant plus subdominant type exceeds 70% of the ED area. In addition, each of the vegetation structural types is best represented in a defined set of ED's. Thus, Tall Woodland in ED 2 (75.5%) ED 37 (55.5) ED 35 (50.3) ED 46 (43.9); Closed Forest in ED 4 (100) ED 86 (100) ED 72 (80) ED 74 (70); Open Forest in ED 83 (66.7) ED 79 (50) ED 80 (50); Low Closed Forest ED 34 (36.4); Low Open Forest ED 14 (21.1) ED 21 (19.1); Low Woodland ED 25 (50) ED 18 (33.5); Low Open Woodland ED 54 (38.3) ED 51 (27.4) ED 62 (24.1) ED 44 (23.4); Open Heath ED 65 (47.8) ED 19 (34.9) ED 17 (32.2) ED 12 (25.2); Tussock grassland ED 48 (40.8) ED 82 (52.3); Sparse Herbland ED 48 (36.7) ED 82 (19.2) ED 34 (18.2) ED 13 (18.2). The dominating structural type is Woodland, with some representation in all but a few ED's. Those ED's with more than 70% Woodland are ED 6, 24, 27, 33, 39, 41, 43, 47, 49, 50, 52, 56, 57, 63, 64, 66, 68, 71, 73, 75, 78, 81, 92, 94.

At the higher level of grouping, of which 36 groups have matching vegetation structural data, there is, as expected, a greater degree of heterogeneity of vegetation structure in each of the ED's. However, even at this level of agglomeration of microcatchments, based on their abiotic attributes, there remains a high level of correlation with mapped vegetation structural types. Despite a greater spread within ED's, dominant structural types in most cases exceed 50% and plus a subdominant, exceed 70% of ED area. Again, each of the mapped vegetation structural types is best represented within an even more restricted set of ED's. Thus Tall Woodland in ED 14 (45.3%) ED 6 (20.4); Closed Forest in ED 37 (85.7) ED 36 (62.9) ED 4 (58.8) ED 28 (44.2); Open Forest in ED 33 (66.7) ED 31 (50) ED 36 (37.5) ED 30 (38.3); Low Closed Forest ED 4 (23.5); Low Open Forest ED 6 (14.1); Low Woodland ED 3 (22.7); Low Open Woodland in ED 20 (37.0) ED 15 (19.8) ED 23 (17.1) ED 21 (14.8); Open Heath in ED 9 (38.1) ED 10 (23.5) ED 7 (19.4) ED 5 (15.9); Tussock Grassland ED 17 (49.7) ED 20 (15.8); Sparse Herbland ED 17 (23.6). The dominating structural vegetation of Woodland occurs in all but one of the 36 ED's with matching data and those with more than 70% representation are ED 2 (100) ED 27 (100) ED 29 (86.4) ED 22 (85.8) ED 24 (85.6) ED 26 (85.3) ED 11 (84.1) ED 23 (82.9) ED 19 (79.7) ED 25 (73.2) ED 13 (78.1).

A number of structural vegetation types such as Closed Sedgeland; Tall Shrubland; Tall Open Shrubland; Dwarf Open Heath; Closed Tussock Grassland; Closed Scrub Grassland; Open Scrub Grassland and Closed Herbland have limited expression, rarely exceeding 10%, but mostly less than 5% of the limited numbers of ED's in which they occur. While of a lesser significance on an areal basis they do contribute to vegetation and habitat diversity within the broader matrix and deserve closer attention.

We are confident that both sets of environmental domains provide a spatially distributed, ecologically sensible landscape-based classification of Cape York Peninsula. It provides a perspective of the landscape controls on biodiversity that usually remain un-investigated. The maps of the domains shown in Figures 3.2 and 3.3 also show the boundaries of the major watersheds. Together with the correlated vegetation structure, the environmental domains and watershed boundaries provide a window into the ecological complexity of Cape York Peninsula that promotes an integrated landscape perspective.

As discussed above, each of the environmental domains tends to be dominated by one mapped vegetation type with another subdominant. But within the broader vegetation matrix of each domain there are minor, but important other vegetation types that occur on inclusions of different substrate or in sheltered site, more exposed sites, or sites where there is a more regular supply of surface/near surface water. This landscape matrix can be thought of as sewn together with threads of riparian vegetation. These riparian threads link east coast to west coast and provide specialised habitat for a large assemblage of essentially closed forest taxa.

5.4 CONCLUSION ON ASSESSMENT AGAINST CRITERIA 3 AND 4

The global analyses presented above all characterise Cape York Peninsula as having three globally significant bioclimates. This is the first indicator that the biota of Cape York Peninsula may be globally significant. While there are strong climatic affinities, Cape York Peninsula is bioclimatically distinct from PNG as well as from the adjacent Wet Tropics region. These are also significant by comparison with other Australian bioregions. Cape York Peninsula has been and remains the key connection to New Guinea, and Torres Strait has acted as both a biological bridge and a barrier (Walker 1972, Schodde and Calaby 1972). Cape York Peninsula is unique in Australia with respect to the strength of its biological affinities and connections with New Guinea.

Unquestionably, Cape York Peninsula has a rich and diverse assemblage of flora and fauna with significant components that are unique in Australia. Much remains to be learned, but the broad outlines of the biodiversity heritage are clear, at least for the dominant higher plants and animals. It is an environmentally diverse area, with distinctive hydroecological features. As an indication of the importance of Cape York Peninsula for endemics, 264 plant species and three genera are endemic to CYP; these are focussed in McIlwraith-Iron Ranges, gallery forests and vine thickets. Further, of the terrestrial vertebrates the total number of endemics so far known is 40. This includes two rock wallaby, bird, skink, frog, gecko, *Melomys*, monitor and *Antechinus* species. Cape York Peninsula contains 39 vegetation types unique to tropical Australia.

While the Wet Tropics World Heritage Area to the south preserves more of the meso-therm (temperate) biological inheritance, Cape York Peninsula preserves much more of the megatherm (tropical) biological inheritance that is shared with New Guinea. Both regions are of equal importance and have international significance from a biodiversity perspective.

In conclusion, Cape York Peninsula is of national, regional and global significance both as an area of outstanding biodiversity, and as a largely intact land and biological bridge retaining valuable evidence of the bio-evolution and on-going ‘fragmentation’ of the biomes of the Australian Wet Tropics region and the island of New Guinea.

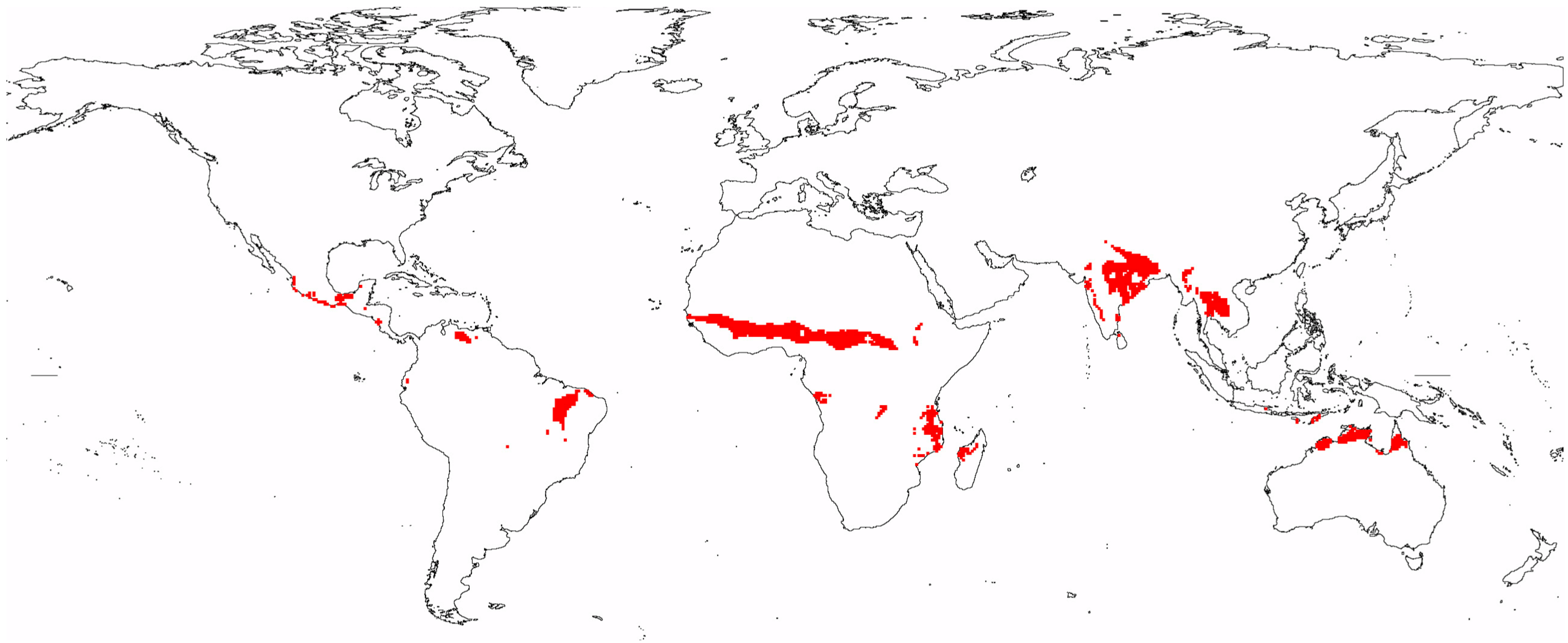


Figure 5.1 The predicted distribution of core tropical savanna with an analogous bioclimate to that found in Cape York Peninsula, based on a model by Nix (1983) coupled to a global GIS climate data base.

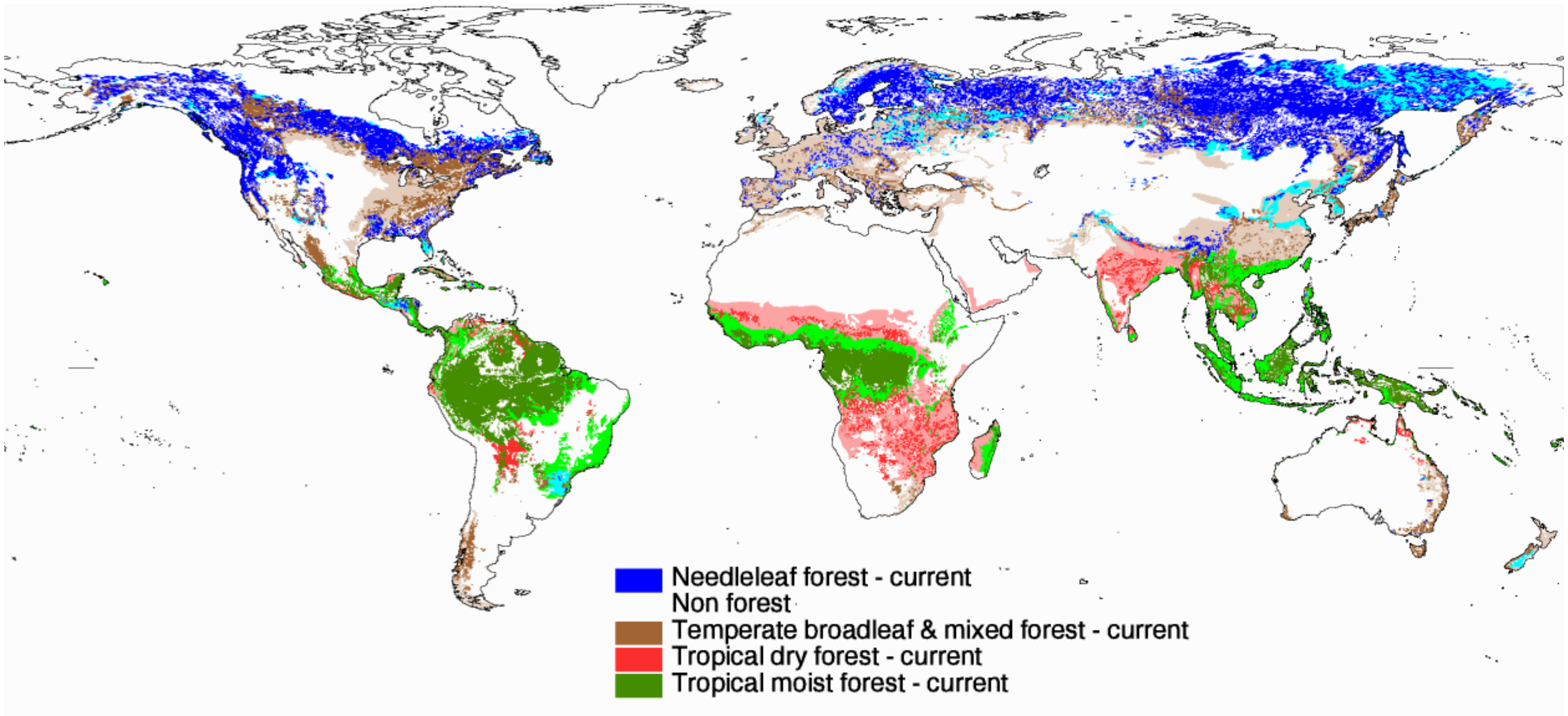


Figure 5.2 The current and original distibution of major forest ecosystem types.
The lighter shade of colour indicates original distribution.
Source: World Conservation Monitoring Centre.

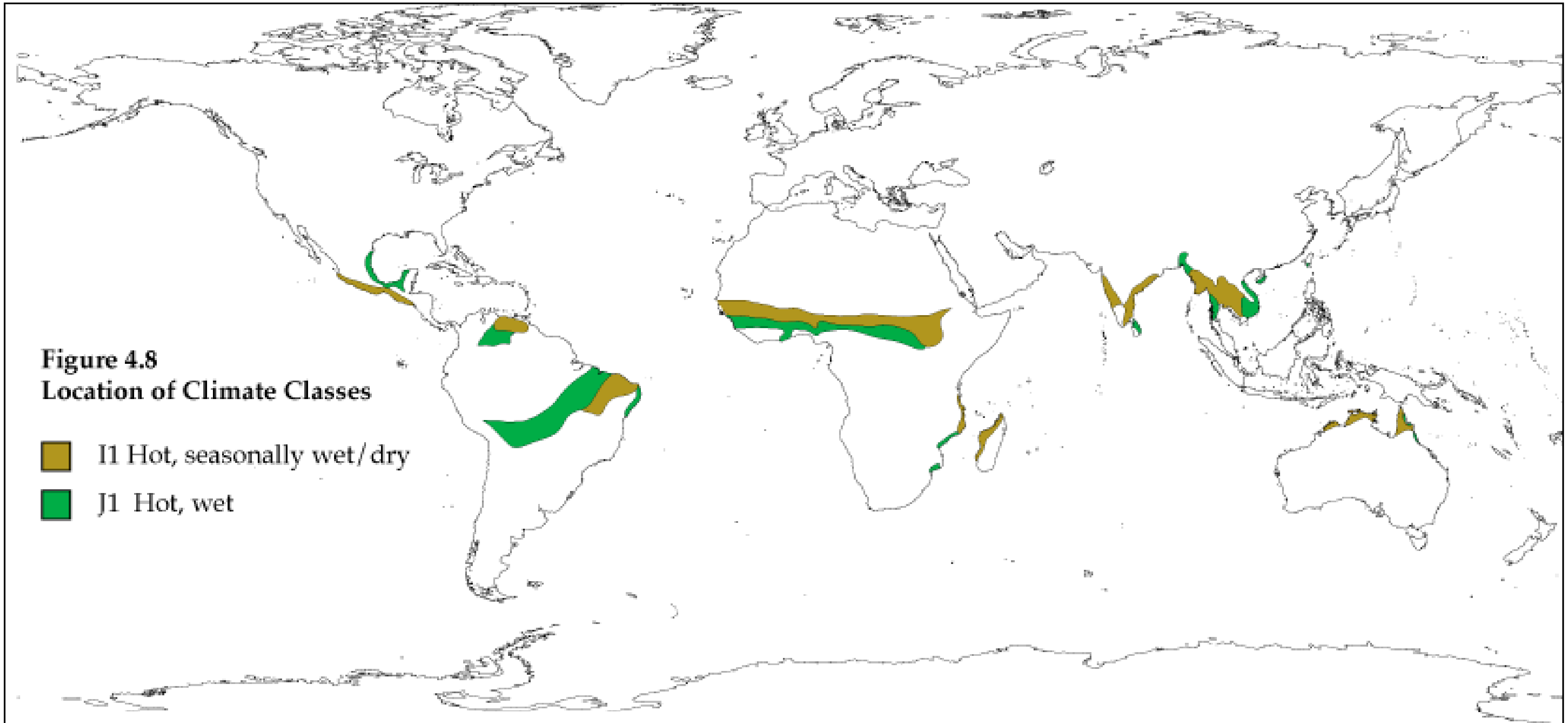


Figure 5.3 Global distribution of bioclimatic regions found in Cape York Peninsula, as calculated by Hutchinson *et al* (1992).

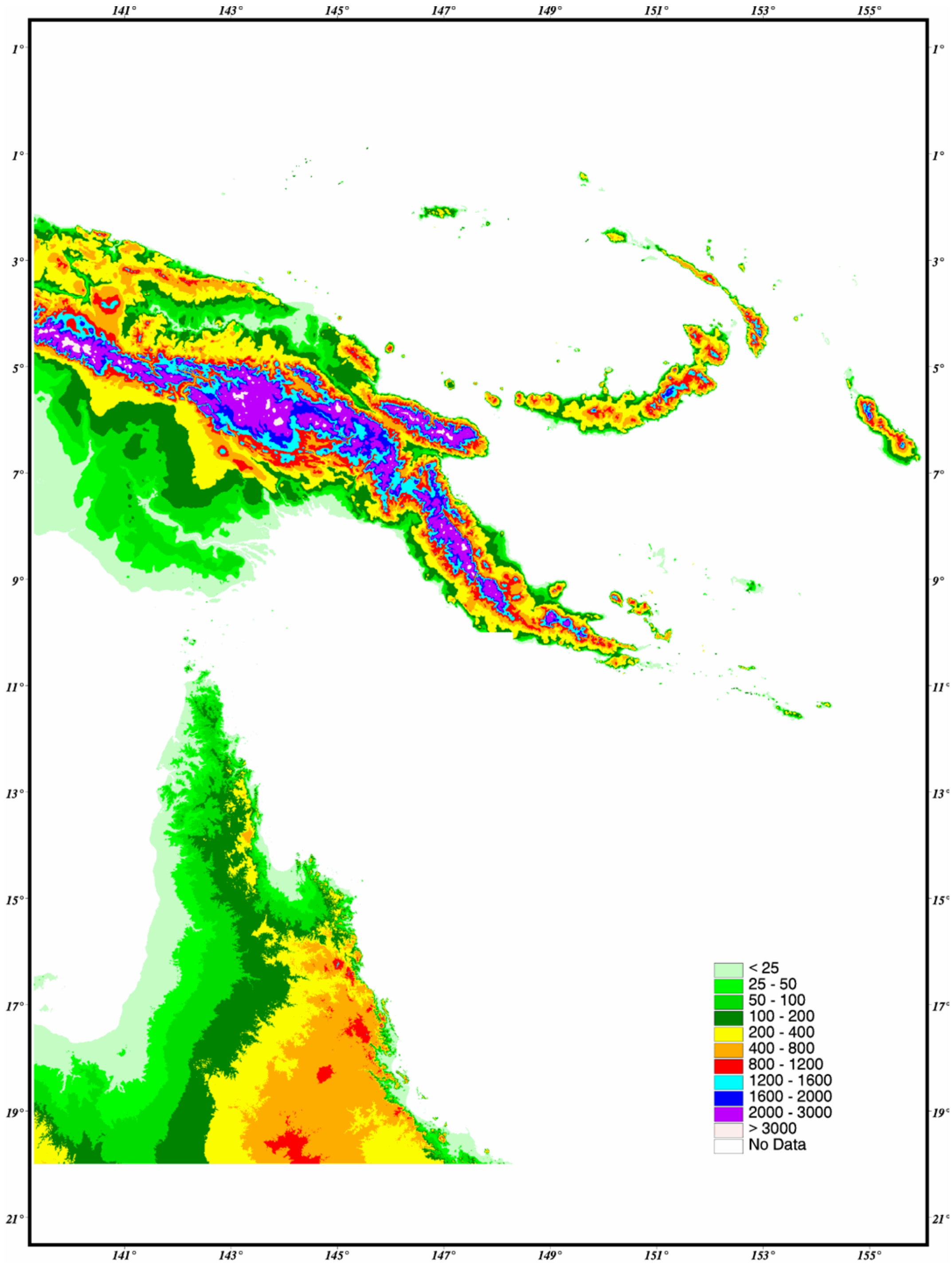


Figure 5.4 Digital Elevation Model (m) for PNG and Cape York Peninsula. Source: Regional GIS data base produced by CRES/ANU.

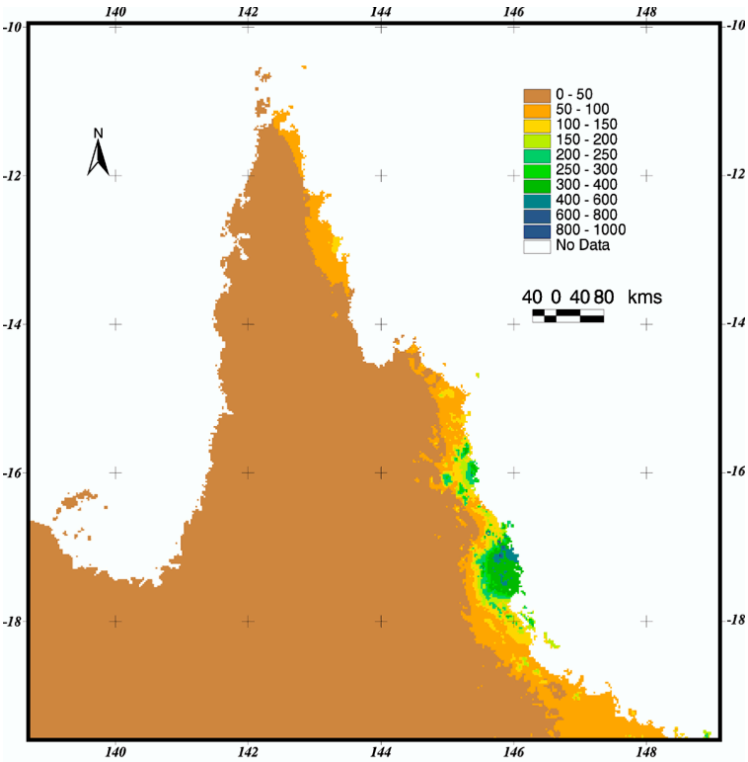


Figure 5.5 Precipitation of the Coldest Quarter (mm) for Cape York Peninsula.
Source: Regional GIS data base produced by CRES/ANU.

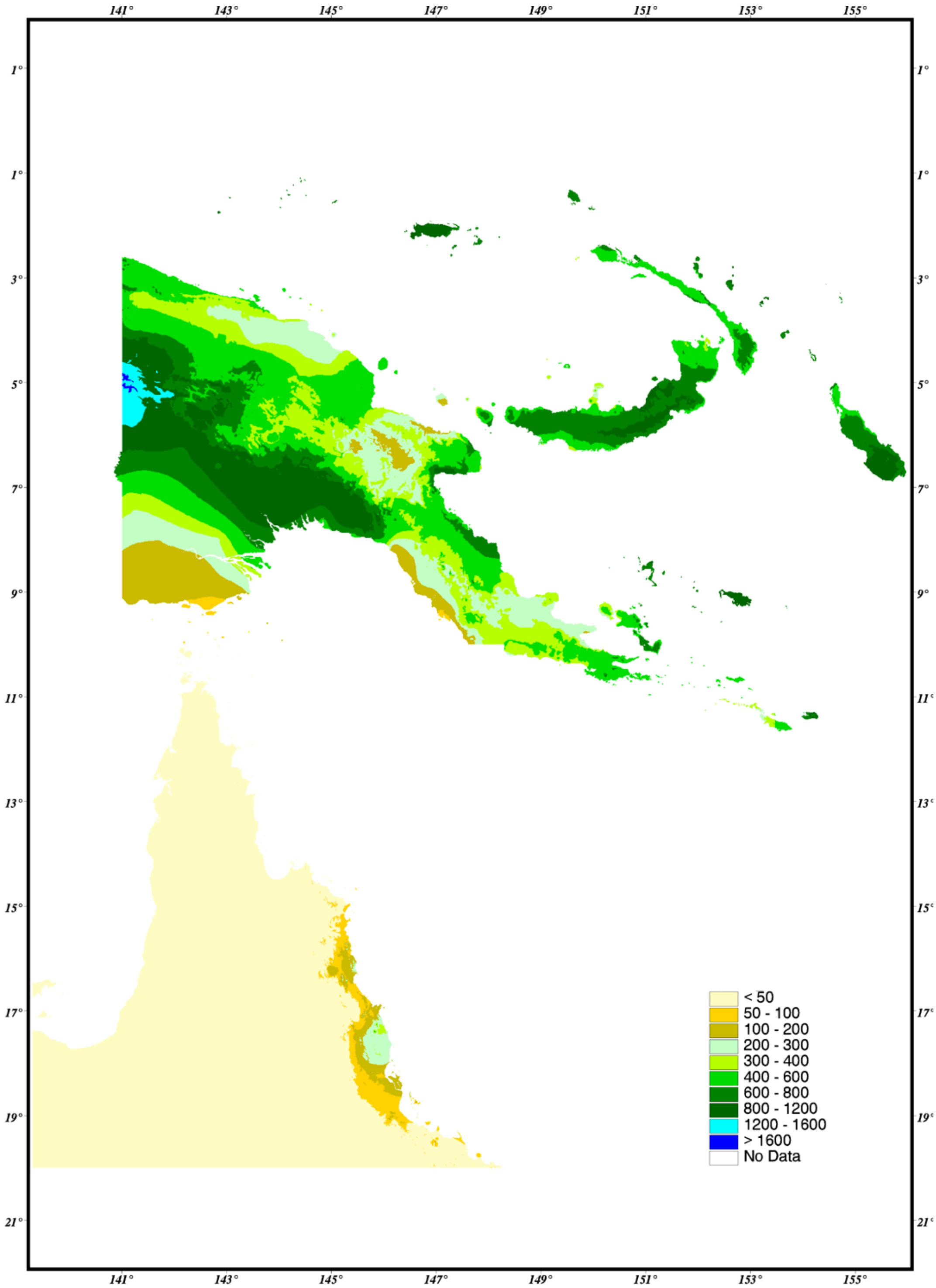


Figure 5.6 Precipitation of the Driest Quarter (mm) for PNG and Cape York Peninsula. Source: Regional GIS data base produced by CRES/ANU.

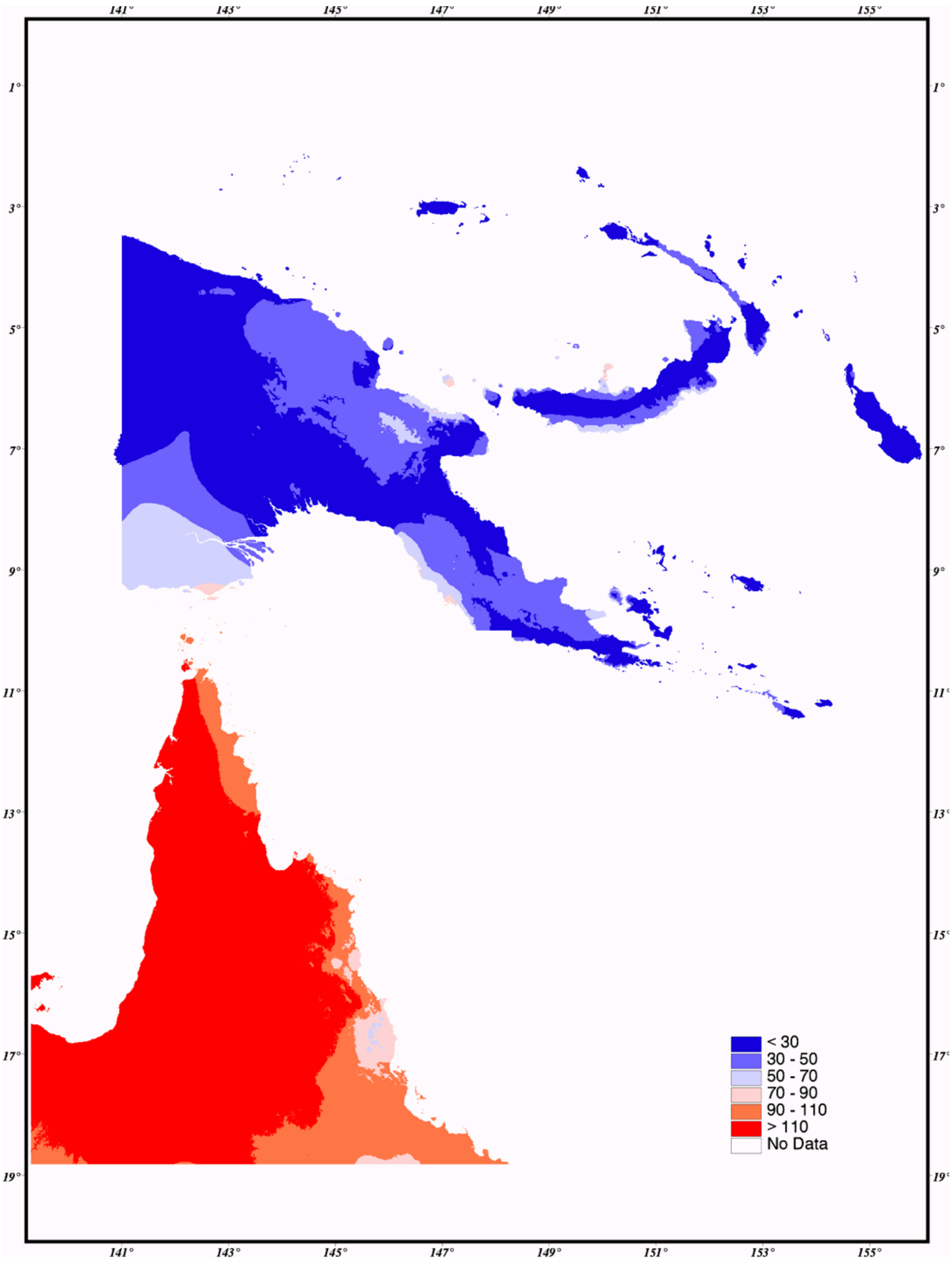


Figure 5.7 Precipitation Seasonality (%) for PNG and Cape York Peninsula.
Source: Regional GIS data base produced by CRES/ANU.

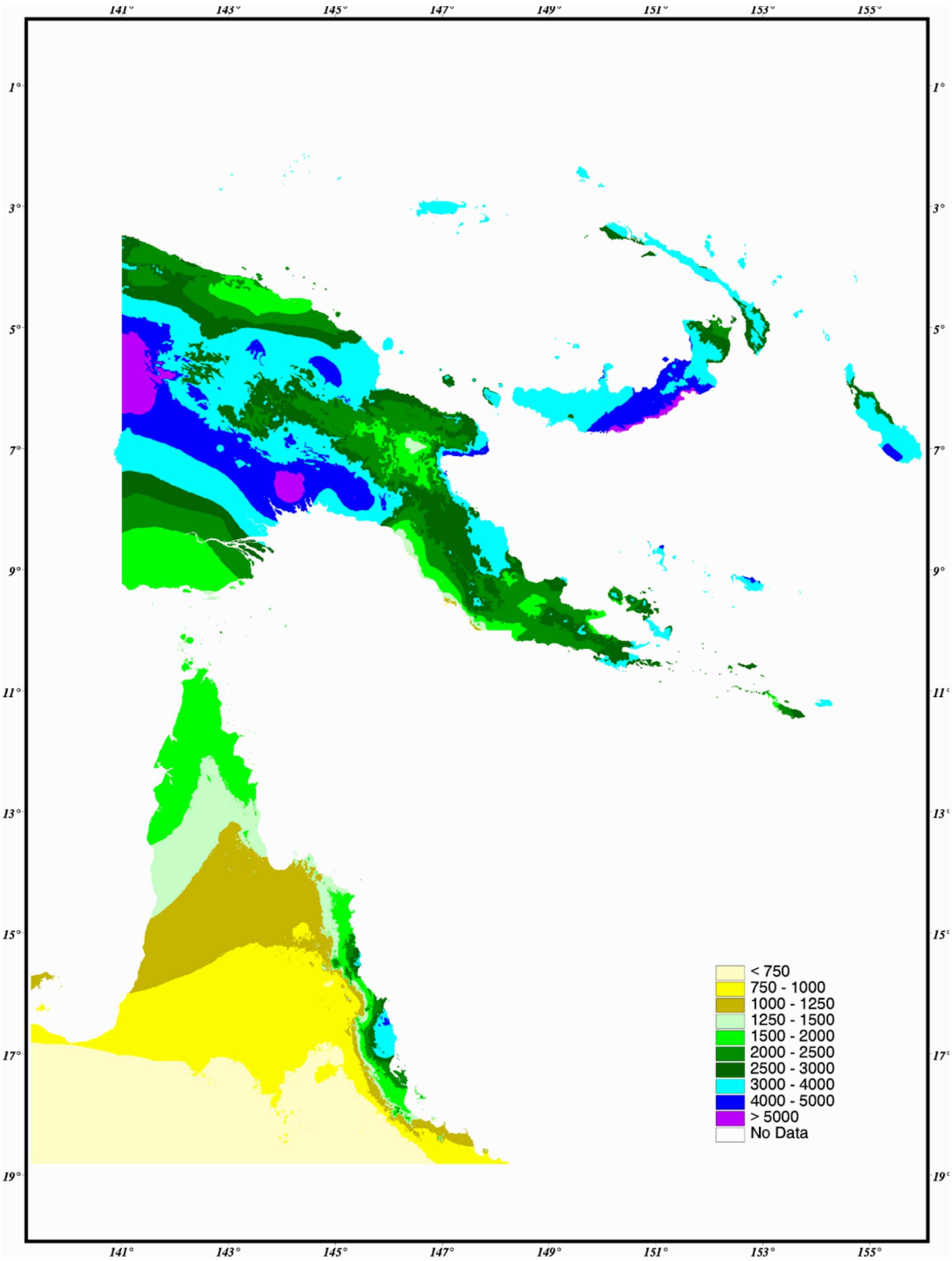


Figure 5.8 Annual Mean Precipitation (mm) for PNG and Cape York Peninsula.
Source: Regional GIS data base produced by CRES/ANU.

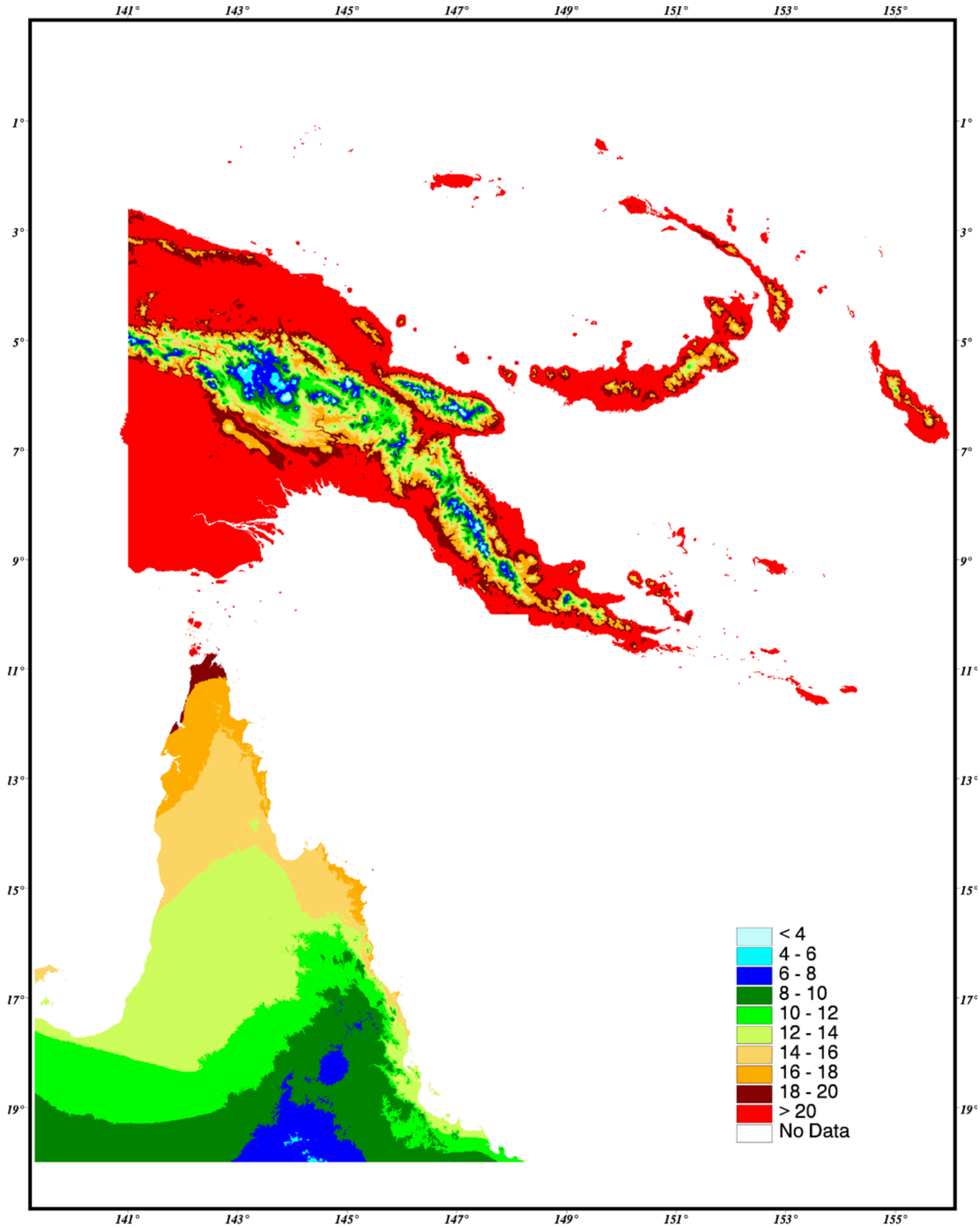


Figure 5.9 Coldest month mean minimum temperature (degrees C) for PNG and Cape York Peninsula. Source: Regional GIS data base produced by CRES/ANU.

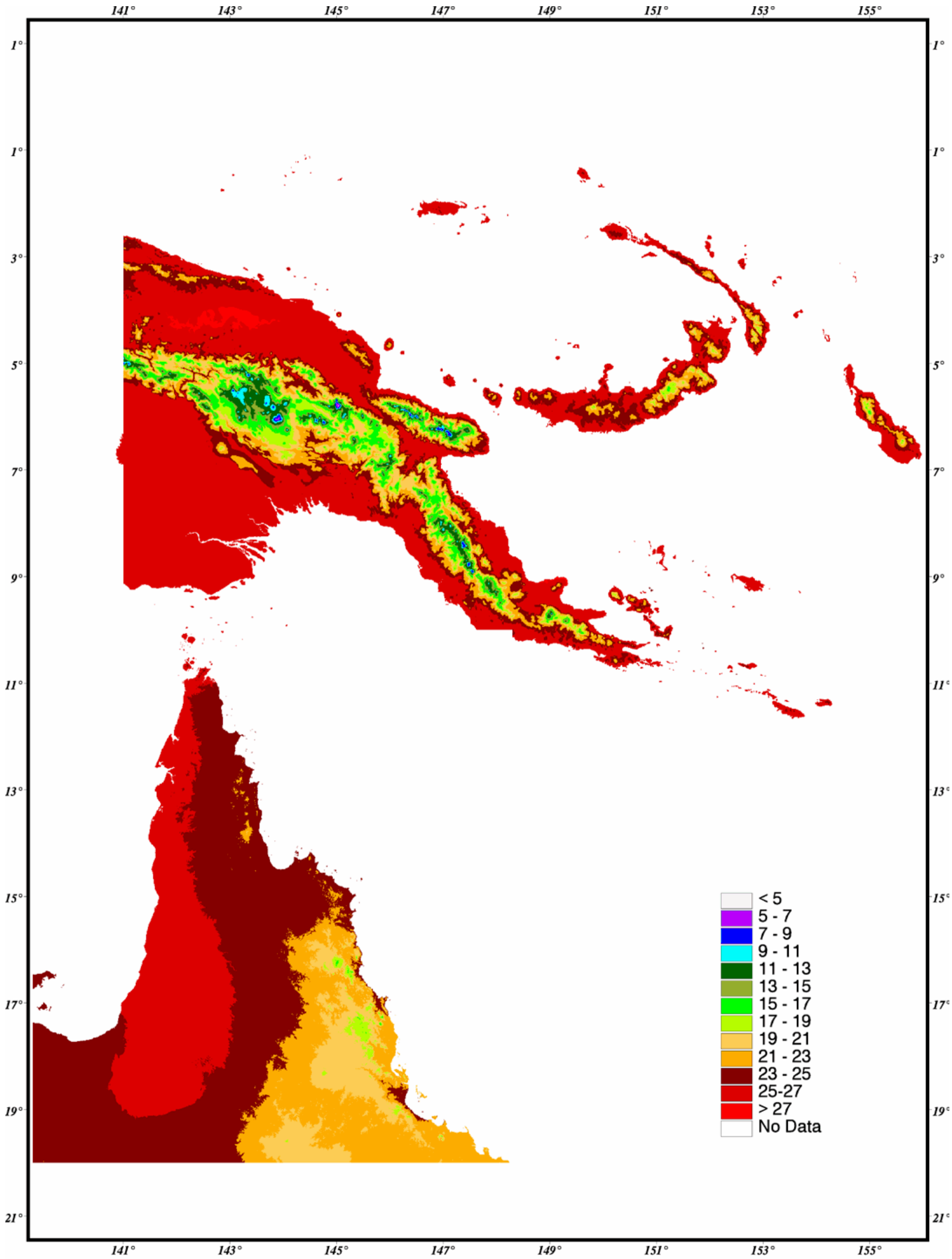


Figure 5.10 Annual mean temperature (degrees C) for PNG and Cape York Peninsula. Source: Regional GIS data base produced by CRES/ANU.

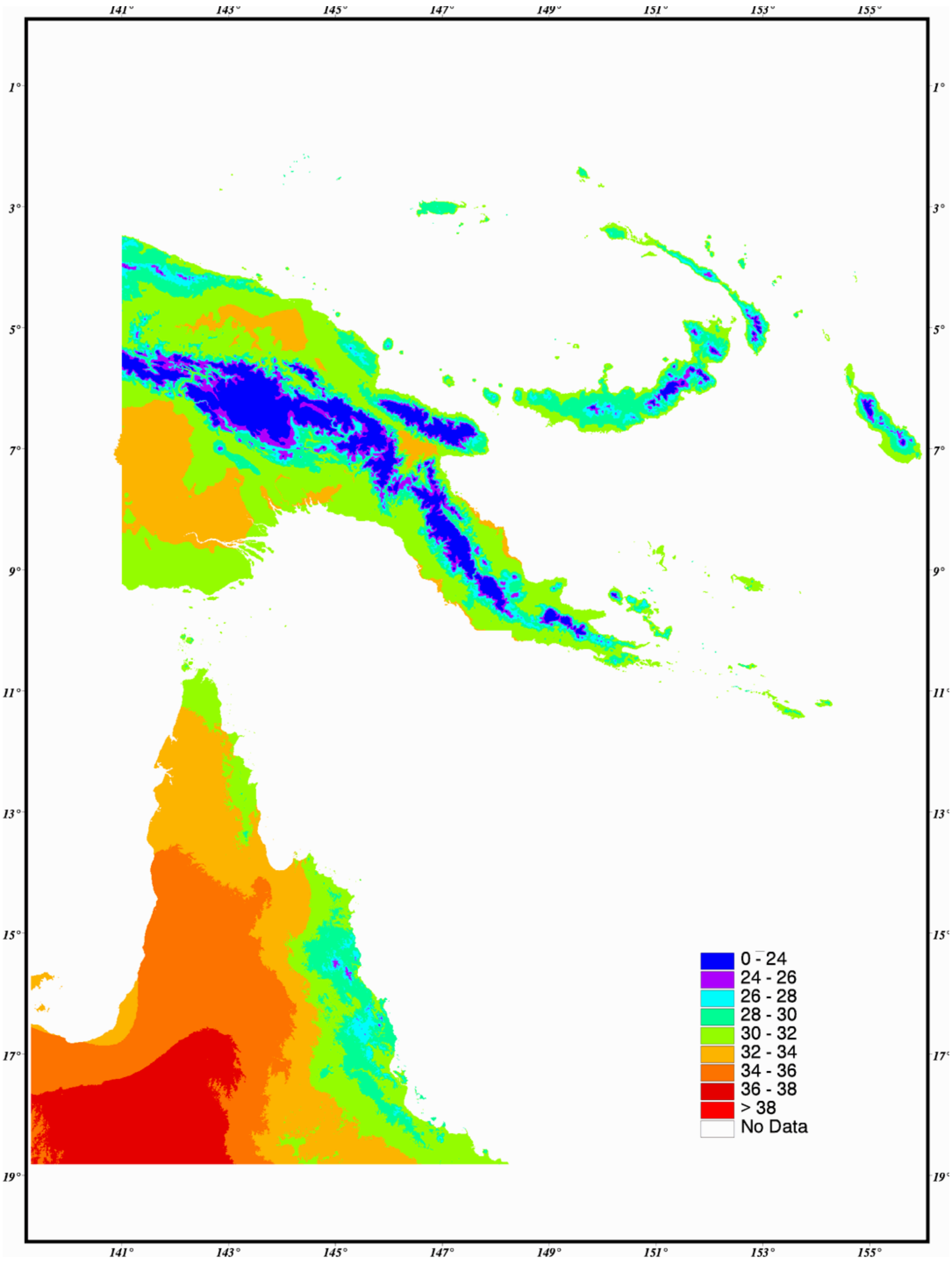


Figure 5.11 Warmest month mean maximum temperature (degrees C) for PNG and Cape York Peninsula.
Source: Regional GIS data base produced by CRES/ANU.

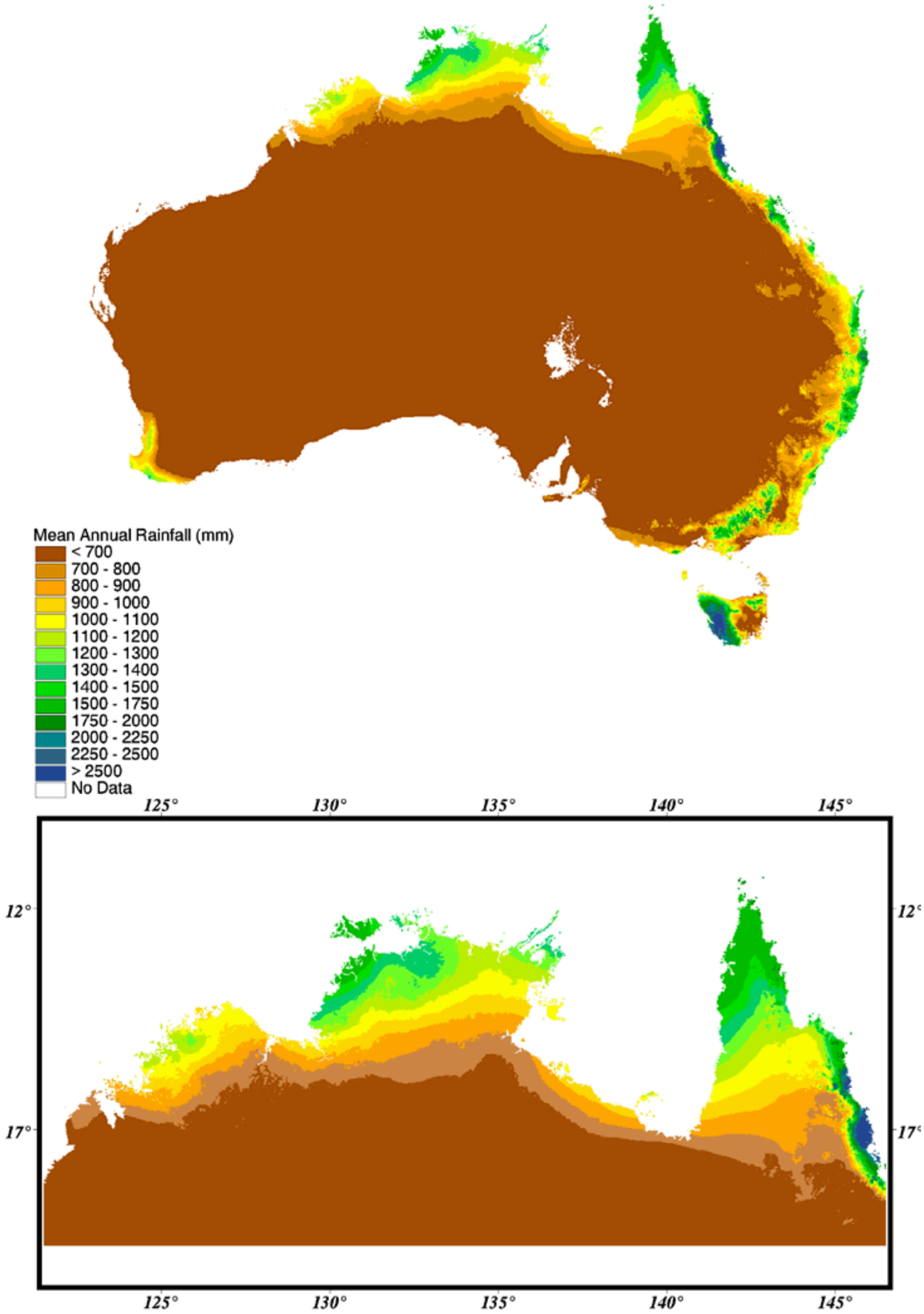


Figure 5.12 Annual mean precipitation (mm) for Australia and the Top End. Source: Regional GIS data base produced by CRES/ANU.

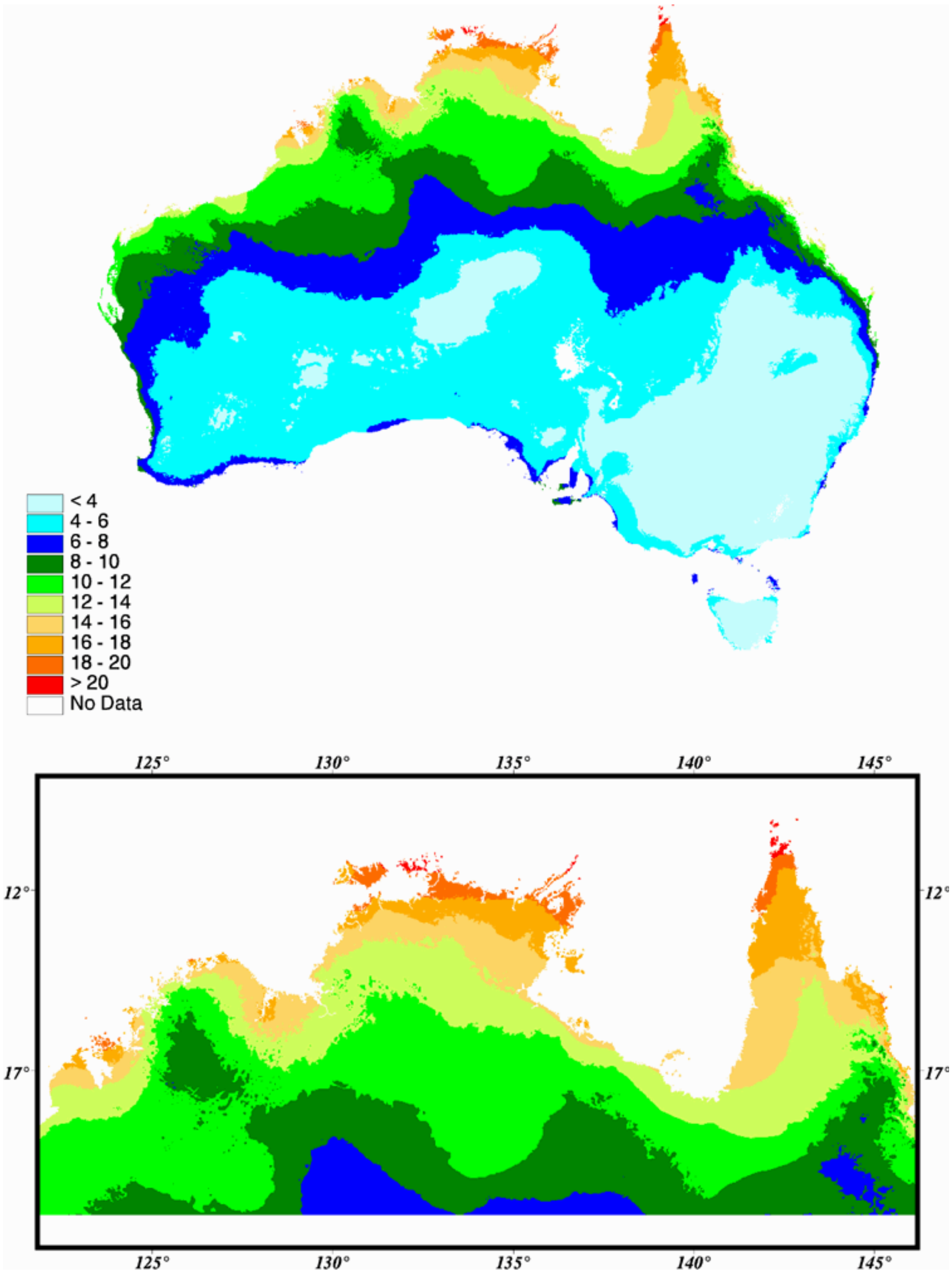


Figure 5.13 Coldest month mean minimum temperature (degrees C) for Australia and the Top End.
Source: Regional GIS data base produced by CRES/ANU.

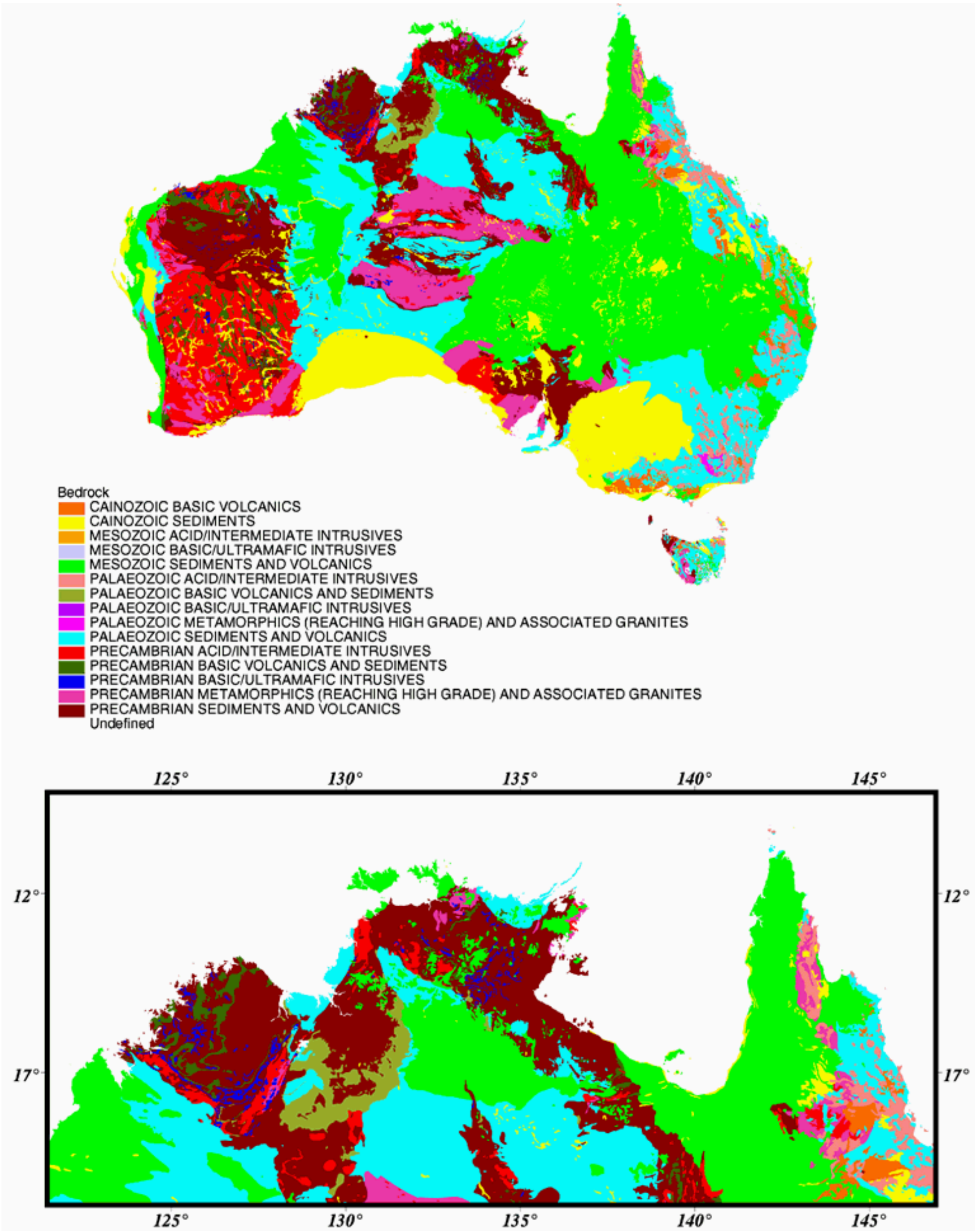


Figure 5.14 Bedrock classes for Australia and the Top End. Source: AGSO/BRS.

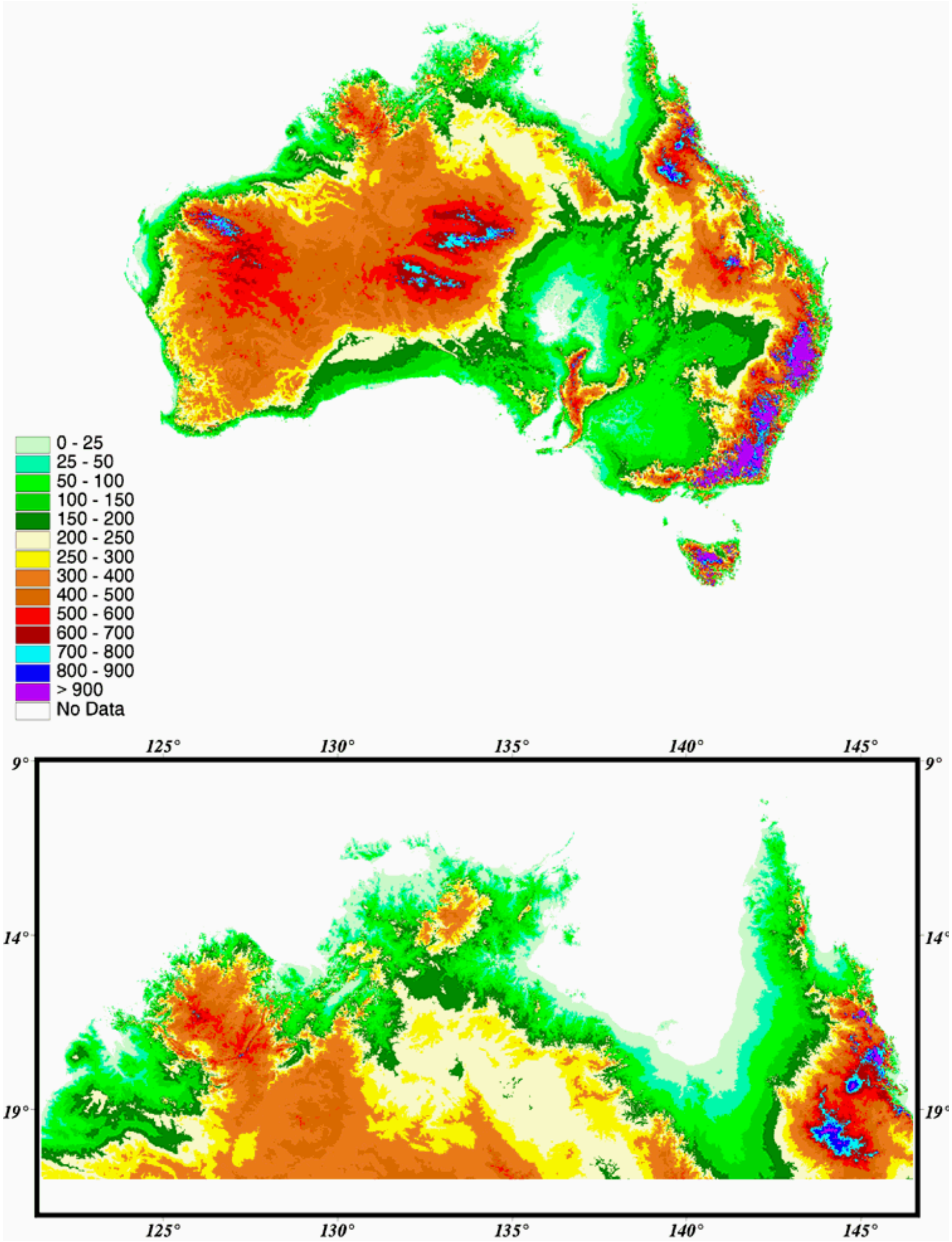


Figure 5.15 Digital Elevation Model (m) for Australia and the Top End.
Source: Regional GIS data base produced by CRES/ANU.

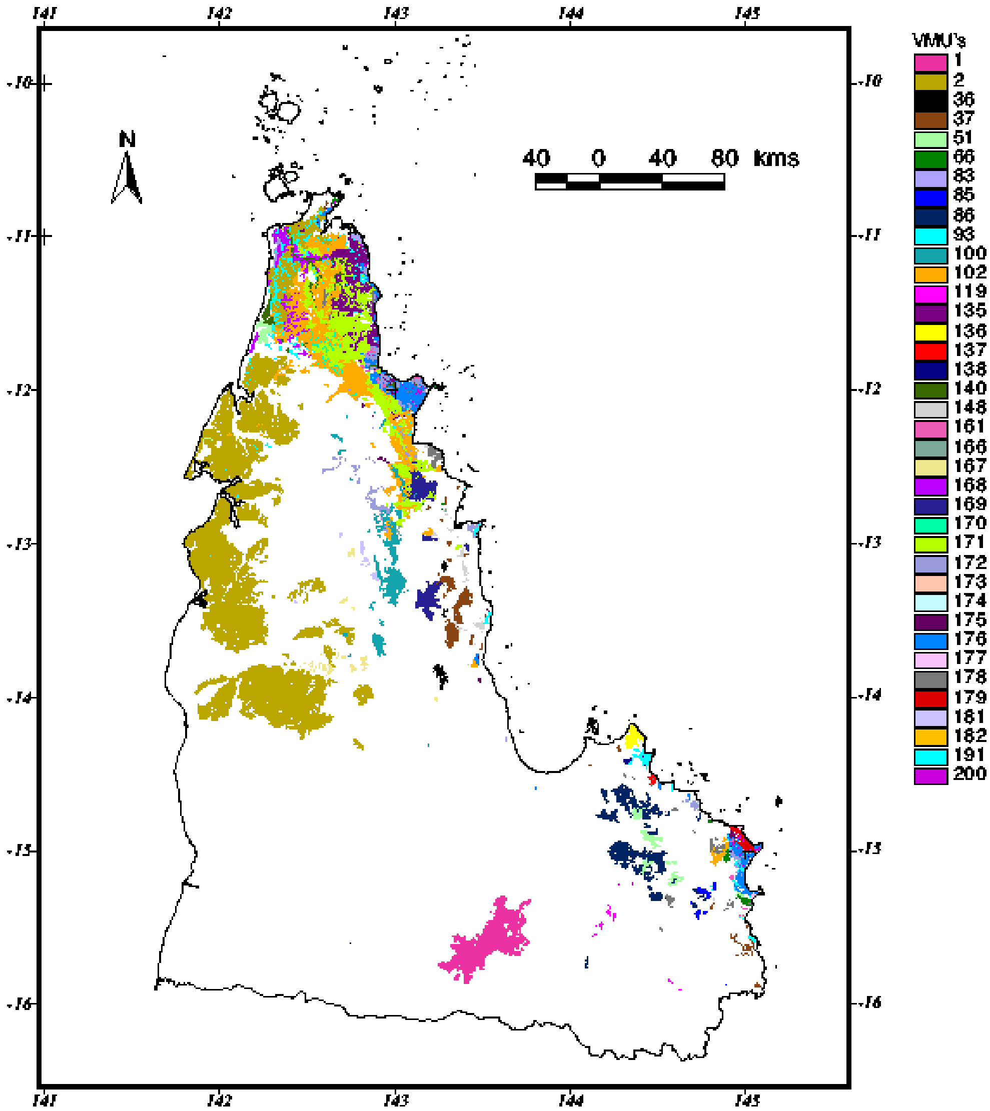


Figure 5.16 Vegetation Mapping Units unique to Cape York Peninsula based on a comparison of 1:1,000,000 scale maps for the Top End of Australia. Source: Brisbane Herbarium (J. Nelder, pers. comm.).

Descriptions of these VMUs are given in Table 5.12.

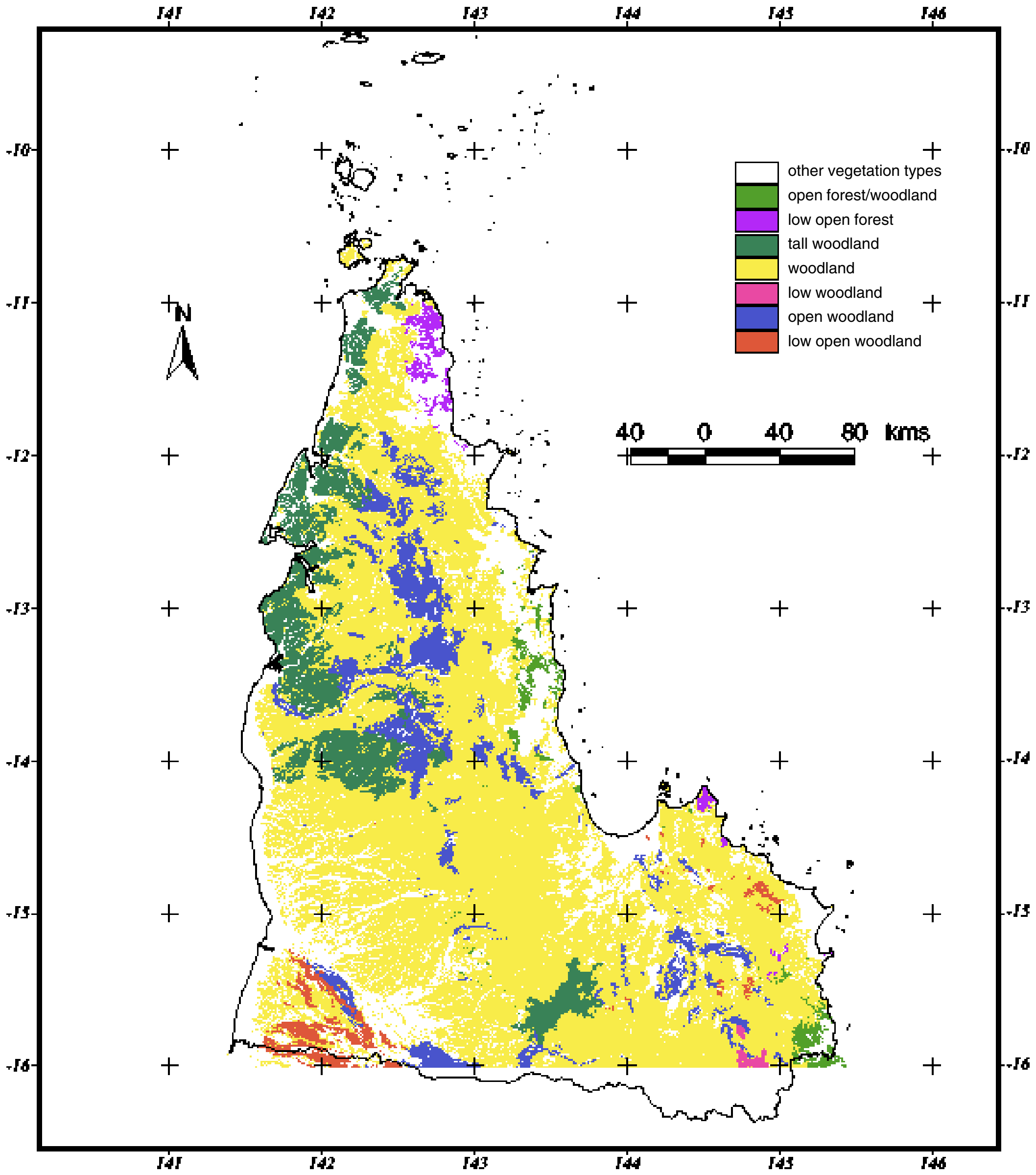


Figure 5.17 *Eucalyptus* dominated vegetation map units for Cape York Peninsula. Source: Brisbane Herbarium (J. Nelder, pers. comm.).

Detailed descriptions of VMUs are given in Nelder and Clakson (1995).

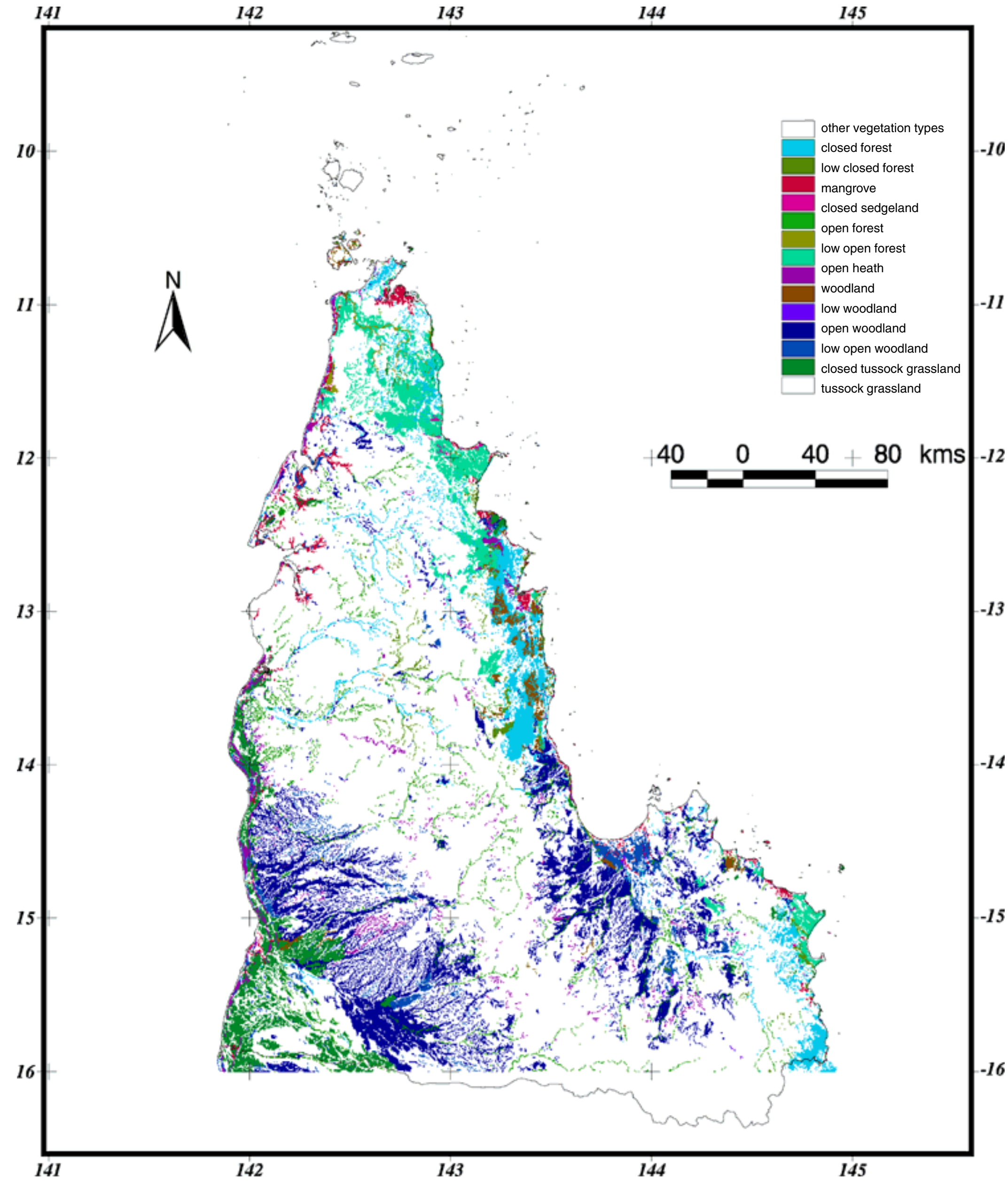


Figure 5.18 Non-*Eucalyptus* dominated vegetation map units for Cape York Peninsula. Source: Brisbane Herbarium (J. Nelder, pers. comm.).

Detailed descriptions of VMUs are given in Nelder and Clakson (1995).

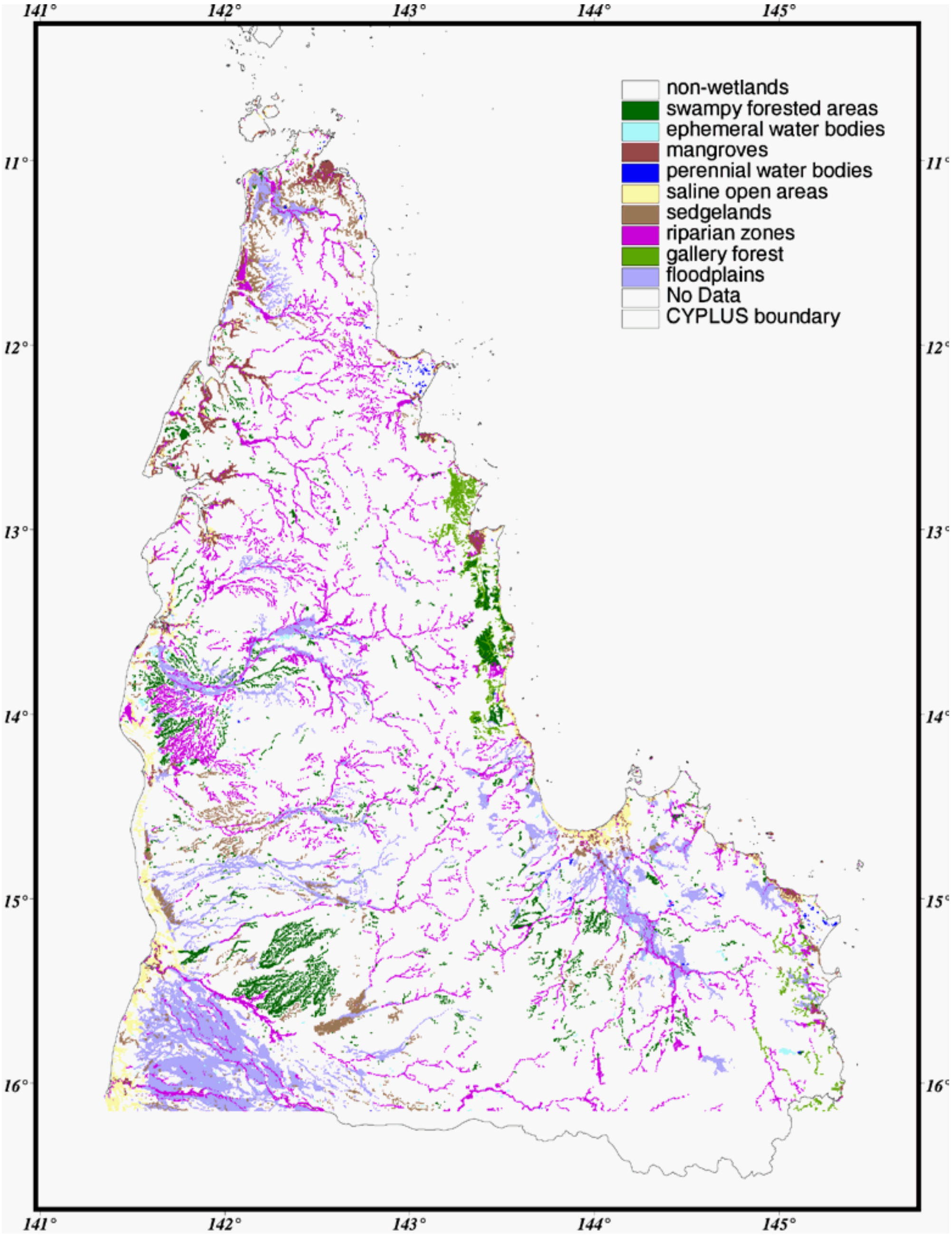


Figure 5.19 Wetland vegetation and vegetation-types associated with permanent flowing streams, groundwater discharge areas, and other forms of water holes. Source: Brisbane Herbarium, Nelder and Clarkson (1995).

Table 5.1 Climatic model of tropical savanna, modified from Nix (1983)

Climatic parameters	*Range of values*
Annual mean rainfall	1000-1500mm
Rainfall coefficient of rainfall	>75%
Wettest 6 months rainfall	>600mm
Driest three months rainfall	<50mm
Annual mean temperature	>24^{0}C

Table 5.2 Butterfly species diversity in Cape York Peninsula (CYP) and adjacent regions.

Family	**No. of Genera**	**No. of Species**	**CYP Restricted**	**New Guinea**	**Tropical Australia**	**Australia**
HESPERIDAE (Skippers)	23	54	6	34	18	30
PAPILIONIDAE (Swallowtails)	7	16	-	13	7	9
PIERIDAE (Whites)	7	26	6 (1)	18	7	13
NYMPHALIDAE (Eggflies)	27	53	17	49	13	24
LIBYTHEIDAE (Beaks)	1	1	-	-	1	1
LYCAENIDAE (Blues)	38	84	21 (2)	69	28	35
Totals	103	234	50	183	72	112
Co-occurrence (%)			21	78	31	48

Table 5.3 Freshwater fish species diversity in Cape York Peninsula (CYP) and adjacent regions

Family	No. of Genera	No. of Species	Restricted to CYP	New Guinea	Tropical Australia	Australia
PRISTIDAE (Sawfishes)	1	1	-	1	1	-
DASYATIDAE (Stingrays)	1	1	-	1	1	-
ANGUILLIDAE (Eels)	1	2	-	2	1	1
CLUPEIDAE (Herrings)	1	1	-	1	-	1
ENGRAULIDAE (Anchovies)	1	1	-	1	1	-
OSTEOGLOSSIDAE (Saratoga)	1	1	-	1	1	-
ARIIDAE (Fork-tailed Catfish)	1	4	-	4	3	1
PLOTOSIDAE (Eel-tailed Catfish)	3	8	1	3	5	2
HEMIRAMPHIDAE (Garfish)	2	3	2	3	-	1
BELONIDAE (Long Toms)	1	1	-	1	1	-
ATHERINIDAE (Hardyheads)	1	1	-	1	-	1
MELANOTAEINIIDAE (Raindowfishes)	2	6	1	2	5	-
PSEUDOMUGILIDAE (Blue-eyes)	1	3	-	2	2	1
SYNBRANCHIDAE (Swamp eels)	2	3	-	2	3	-
SCORPAENIDAE (Bullrout)	1	1	-	-	-	1
CENTROPOMIDAE (Barramundi)	1	1	-	1	-	1
AMBASSIDAE (Glassfishes)	2	6	-	4	4	2
TERAPONIDAE (Grunters)	5	8	1	1	3	4
KUHLIIDAE (Flagtails)	1	1	-	1	1	-
APOGONIDAE (Mouth Almighty)	1	1	-	1	1	-
TOXOTIDAE (Archerfishes)	1	2	-	2	2	-
ELEOTRIDAE (Gudgeons)	4	10	3	6	5	2
GOBIIDAE (Gobies)	3	8	2	4	5	1
SOLEIDAE (Soles)	1	1	-	-	1	-
Totals	39	75	10	45	46	19
Co-occurrence (%)			13	60	61	25

Table 5.4 Frog species diversity in Cape York Peninsula (CYP) and adjacent regions.

Family	No. of Genera	No. of Species	Restricted to CYP	New Guinea	Tropical Australia	Australia
MYOBATRACHIDAE (Froglet, Toadlets)	4	8	-	3	5	3
HYLIDAE (Tree-frogs, Rocket-frogs)	2	19	4 (3)	9	8	7
MICROHYLIDAE (Nursery-frogs)	2	3	3 (2)	1	-	-
RANIDAE (Wood-frog)	1	1	-	1	1	-
Total	9	31	7 (5)	14	14	10
Co-occurrence (%)			23	45	45	32

Table 5.5 Reptile species diversity in Cape York Peninsula (CYP) and adjacent regions.

Family	No. of Genera	No. of Species	Restricted to CYP	New Guinea	Tropical Australia	Australia
CROCODYLIDAE (Crocodiles)	1	2	-	1	2	-
CHELONIIDAE (Sea Turtles)	5	5	-	4	2	3
DERMOCHELYIDAE (Luth Turtles)	1	1	-	1	-	1
CHELIDAE (Freshwater Turtles)	3	7	1	2	4	2
GEKKONIDAE (Geckos)	11	15 (2)	6	6	7	3
PYGOPODIDAE (Legless Lizards)	3	4	-	1	-	4
AGAMIDAE (Dragons)	3	5	-	3	3	2
VARANIDAE (Monitors)	1	9 (1)	2	4	4	3
SCINCIDAE (Skinks)	14	39 (13)	17	7	11	9
TYPHLOPIDAE (Blind Snakes)	1	8 (1)	2	3	1	5
BOIDAE (Pythons)	5	7	2	3	3	2
ACROCHORDIDAE (File Snakes)	1	2	-	2	2	-
COLUBRIDAE (Tree Snakes)	7	9	1	9	5	3
ELAPIDAE (Front-Fanged Snakes)	10	20 (1)	2	4	5	13
Total	66	133 (18)	33	50	49	50
Co-occurrence (%)			25	38	37	38

Table 5.6 Marine bird species diversity in Cape York Peninsula (CYP) and adjacent regions.

Family	**No. of Genera**	**No. of Species**	**Restricted to CYP**	**New Guinea**	**Tropical Australia**	**Australia**
PROCELLARIIDAE (Shearwaters)	2	2	-	2	1	1
PHAETHONTIDAE (Tropicbirds)	1	1	-	1	1	-
SULIDAE (Boobies, Gannets)	1	3	-	3	1	2
FREGATIDAE (Frigatebirds)	1	2	-	2	-	2
LARIDAE (Gulls, Terns)	4	15	-	15	1	14
TOTAL	9	23	-	23	4	19
Co-occurrence (%)			-	100	17	83

Table 5.7 Waders and wetland bird species diversity in Cape York Peninsula (CYP) and adjacent regions

Family	**No. of Genera**	**No. of Species**	**Restricted to CYP**	**New Guinea**	**Tropical Australia**	**Australia**
ANSERANATIDAE (Magpie goose)	1	1	-	1	-	1
ANATIDAE (Ducks, Swans)	8	11	-	8	3	8
PODICIPEDIDAE (Grebes)	1	1	-	1	-	1
ANHINGIDAE (Darters)	1	1	-	1	-	1
PHALACROCORACIIDAE (Cormorants)	1	4	-	3	-	4
PELECANIDAE (Pelicans)	1	1	-	1	-	1
ARDEIDAE (Egrets, Herons, Bitterns)	5	13	-	13	2	11
THRESKIORNITHIDAE (Ibis, Spoonbills)	3	5	-	5	-	5
CICONIIDAE (Storks)	1	1	-	1	-	1
ACCIPITRIDAE (Eagles, Kites, Harriers)*	4	4	-	4	-	4
GRUIDAE (Cranes)	1	2	-	2	1	1
RALLIDAE (Crakes, Rails)	7	7	-	7	3	6
SCOLOPACIDAE (Sandpipers, Snipes)	10	20	-	20	-	20
ROSTRATULIDAE (Painted Snipes)	1	1	-	1	-	1
JACANIDAE (Lily trotters)	1	1	-	1	-	1
BURHINIDAE (Stone Curlews)	1	1	-	1	-	1
HAEMATOPODIDAE (Oystercatchers)	1	2	-	1	-	2
RECURUIROSTRIDAE (Stilts, Avocets)	1	1	-	1	-	1
CHARADRIIDAE (Plovers, Dotterels)	5	9	-	8	1	9
ALCEDINIDAE (River Kingfishers)	1	2	-	2	1	1
HALCYONIDAE (Kingfishers)*	1	1	-	1	-	1
SYLVIIDAE*	3	4	-	4	1	4
Total	59	96	-	87	12	85
Co-occurrence (%)			-	91	13	89

* not all members of this Family are wetland and/or wading species.

Table 5.8 Land based bird species diversity in Cape York Peninsula (CYP) and adjacent regions (Non-passerines).

Family	No. of Genera	No. of Species	Restricted to CYP	New Guinea	Tropical Australia	Australia
CASUARIIDAE (Emu, Cassowary)	2	2	-	1	1	1
MEGAPODIIDAE (Mound-builders)	2	2	-	1	1	1
PHASIANIDAE (Quail)	1	2	-	2	-	2
ACCIPITRIDAE (Hawks, Eagles)	11	13	-	9	-	13
FALCONIDAE (Falcons)	1	5	-	4	-	5
OTIDIDAE (Bustards)	1	1	-	1	-	1
TURNICIDAE (Button Quails)	1	3	-	1	1	2
GLAREOLIDAE (Pratincoles)	2	2	-	2	-	2
COLUMBIDAE (Doves, Pigeons)	8	12	-	8	1	11
CACATUIDAE (Cockatoos)	3	5	1	3	-	4
PSITTACIDAE (Parrots, Lorikeets)	8	9	3 (1)	5	1	5
CUCULIDAE (Cuckoos)	5	11	-	11	2	9
CENTROPODIDAE (Coucals)	1	1	-	1	-	1
STRIGIDAE (Owls)	1	3	-	3	1	2
TYTONIDAE (Masked Owls)	1	3	-	3	-	3
PODARGIDAE (Frogmouths)	1	3	-	3	1	2
CAPRIMULGIDAE Nightjars)	2	3	-	2	1	2
AEGOTHELIDAE (Owlet Nightjars)	1	1	-	1	-	1
APODIDAE (Swifts)	3	3	-	3	1	2
HALCYONIDAE (Kingfishers)	4	7	1	6	1	6
MEROPIDAE (Bee-eaters)	1	1	-	1	-	1
CORACIIDAE (Rollers)	1	1	-	1	-	1
Total	61	93	5	72	12	77
Co-occurrence (%)			5	77	13	83

Table 5.9 Land based bird species diversity in Cape York Peninsula (CYP) and adjacent regions (Passerines).

Family	No. of **Genera**	**No. of Species**	**Restricted to CYP**	**New Guinea**	**Tropical Australia**	**Australia**
PITTIDAE (Pittas)	1	2	1	2	-	1
CLIMACTERIDAE (Treecreepers)	1	1	-	-	-	1
MALURIDAE (Fairy Wrens)	1	2	-	-	1	1
PARDALOTIDAE (Gerygones, Pardalotes)	4	8	1	5	2	5
MELIPHAGIDAE (Honeyeaters)	13	24	3 (1)	15	14	7
PETROICIDAE (Robins)	5	7	3	6	3	1
POMATOSTOMIDAE (Babblers)	1	1	-	1	-	1
NEOSITTIDAE (Sittellas)	1	1	-	-	-	1
PACHYCEPHALIDAE (Whistlers)	2	5	-	5	2	3
DICRURIDAE (Monarchs, Flycatchers)	7	17	2	15	3	12
CAMPEPHAGIDAE (Cuckoo-shrikes)	2	6	-	6	-	6
ORIOLOIDAE (Orioles, Figbirds)	2	3	-	3	1	2
ARTAMIDAE (Magpies, Currawongs, Woodswallows)	4	8	1	5	1	6
PARADISAEIDAE (Birds of Paradise)	2	2	2	2	-	-
CORVIDAE (Ravens, Crows)	1	1	-	1	-	1
PTILONORHYNCHIDAE (Bowerbirds)	2	3	1	2	2	-
ALAUDIDAE (Bushlarks)	1	1	-	1	-	1
MOTACILLIDAE (Pipits)	1	1	-	1	-	1
PASSERIDAE (Finches)	6	9	-	2	5	4
NECTARINIIDAE (Sunbirds)	1	1	-	1	1	-
DICAEIDAE (Mistletoe birds)	1	1	-	1	-	1
HIRUNDINIDAE (Swallows, Martins)	1	3	-	3	-	3
SYLVIIDAE (Songlarks)	1	1	-	1	-	1
ZOSTEROPIDAE (Silvereyes)	1	2	1	2	-	1
STURNIDAE (Starlings)	1	1	-	1	1	-
Total	63	111	15	80	36	60
Co-occurrence (%)			14	72	32	54

Table 5.10 Non-volant (non-flying) mammal species diversity in Cape York Peninsula (CYP) and adjacent regions.

Family	No. of Genera	No. of Species	Restricted to CYP	New Guinea	Tropical Australia	Australia
TACHYGLOSSIDAE (Echidnas)	1	1	-	1	-	1
DASYURIDAE (Marsupicarnivores)	5	6	2 (1)	2	2	2
PERAMELIDAE (Bandicoots)	3	4	1	2	-	3
PETAURIDAE (Ringtail Possums, Gliders)	3	4	-	2	1	3
PHALANGERIDAE (Brushtail Possums, Cuscuses)	3	3	2	2	-	1
BURRAMYIDAE (Feathertail Gliders)	1	1	-	-	-	1
MACROPODIDAE (Kangaroos, Wallabies)	6	10	1 (1)	2	5	4
MURIDAE (Rats, Mice)	9	12	2 (2)	3	6	4
Total	31	41	8 (4)	14	14	19
Co-occurrence (%)			20	34	34	46

Table 5.11 Volant (flying) mammal species diversity in Cape York Peninsula (CYP) and adjacent regions.

Family	No. of Genera	No. of Species	Restricted to CYP	New Guinea	Tropical Australia	Australia
PTEROPIDIDAE (Fruit Bats)	5	8	2	5	2	4
MEGADERMATIDAE (Ghost Bats)	1	1	-	-	1	-
RHINOLOPHIDAE (Horseshoe Bats)	1	2	-	1	1	-
EMBALLONURIDAE (Sheathtail Bats)	1	4	1	4	3	-
MOLOSSIDAE (Mastuff Bats)	2	4	1	3	2	1
VERPERTILIONIDAE	2	2	-	2	1	1
(Bentwing Bats, Pipistrelles)	8	10	1 (1)	6	3	6
Total	20	31	5 (1)	21	13	12
Co-occurrence (%)			16	68	42	39

Table 5.12 Vegetation classes unique to Cape York Peninsula compared with 1: 1 000 000 scale vegetation mapping units of the Top End produced by Queensland Herbarium.

UNIT 1M	CYPLUSB VG	VMU	DESCRIPTION
B5	4	161	*Leucopogon yorkensis* + *Asteromyrtus angustifolia* + *Acacia spp.* (Sandplains) CS
	24	172	*Asteromyrtus lysicephala* + *Neofabricia myrtifolia* + *Thryptomene oligandra* + *Hibbertia banksii* + emergent low trees (Sandplains in dunefields) OH-CH
	24	174	*Leucopogon yorkensis* + *Asteromyrtus brassii* + *Pouteria sericea* (Torres Strait Islands) OH
	24	176	*Neofabricia myrtifolia* + *Jacksonia thesioides* + *Thryptomene oligandra* + *Leucopogon spp.* (Quaternary dunefields) OH-CH
	24	177	*Acacia humifusa* + *Myrtella obtusa* + *Grevillea pteridifolia* + *Petalostigma pubescens* (Coastal dunes and headlands) DOH
	24	179	*Neofabricia myrtifolia* + *Labichea buettneriana* + *Leucopogon ruscifolius* (Exposed sandplains, Cape Flattery) DOH
B3	19	51	*Melaleuca quinquenervia* open-forest (Coastal swamps) OF
	19	138	*Melaleuca arcana* (Dune swamps) LOF
	24	175	*Melaleuca arcana, Thryptomene oligandra, Asteromyrtus lysicephala* + *Baeckea frutescens* (Swamp sandplains) OH
	27	200	Perennial lakes with sedgelands on the margins (Lakes in dunefields) LL
B4	15	66	*Eucalyptus clarksoniana/E. novoguinensis* with mid-dense shrub layer +/- *E. platyphylla* (Coastal wet areas) W
	13	83	*Eucalyptus nesophila +/- E. novoguinensis +/- E. hylandii var. campestris* +*E. tetrodonta* (Old stabilised dunes & sandy colluvium) W
	10	85	*Eucalyptus phoenicea* + *E. nesophila +/- E umbra* (Cape Bedford & wetter sandstones) OF-LOF
	17	93	*Eucalyptus tetrodonta, E. clarksoniana* + *E. brassiana* (Stabilised dunes, Archer Pt & Barrow Pt) W
C39	27	191	*Restio tetraphyllus subsp. meiostachyus* + *Leptocarpus spathaceus* + *Nepenthes mirabilis* + *Gahnia sieberiana* (Drainage swamps) OSG-CSG
C34	22	182	*Imperata cylindrica* + *Mnesithea rottboellioides* + *Arundinella setosa* (Coastal plains,hillslopes & islands, Lockhart River) CTG
C30	24	168	*Asteromyrtus lysicephala* + *Baeckea frutescens* + emergent *Thryptomene oligandra and Neofabricia myrtifolia* (Jardine River Sandplain) OH
	24	170	*Asteromyrtus lysicephala* + *Jacksonia thesioides* + *Choriceras tricorne* + *Banksia dentata* (Adjacent streams, central Peninsula) OH
	24	173	*Asteromyrtus lysicephala, Thryptomene oligandra, Neofabricia myrtifolia* + emergent *Melaleuca arcana* OH
D18	17	86	*Eucalyptus phoenicea* + *E. tetrodonta* + *E. hylandii var. campestris* +/- *Erythrophleum chlorostachys* +/- *Eucalyptus clarksoniana* (Sandy colluvia, Laura Basin) W
D60	30	166	*Neofabricia myrtifolia, Acacia calyculata, Jacksonia thesioides* + *Leptospermum purpurascens* (Sandstone breakaways, Janet Range) TOS
	24	169	*Asteromyrtus lysicephala, Choriceras tricorne, Xanthorrhoea johnsonii, Banksia dentata* (Sand sheets, NE of Coen) OH
	24	171	*Asteromyrtus lysicephala* + *Jacksonia thesioides* + *Choriceras tricorne* + *Neofabricia myrtifolia* + emergent *Melaleuca stenostachya* (Heaths over sandstone plateau) OH
	24	178	*Asteromyrtus lysicephala, Neofabricia myrtifolia, Grevillea pteridifolia* + *Melaleuca viridiflora* DOH &/or *Schizachyrium spp.*(Sandstone plateaus)TG

Table 5.12 Continued

G21	22	119	*Terminalia aridicola var. chillagoensis, T. platyphylla* (Olive Vale, heavy clays) OW
	22	167	*Piliostigma malabaricum* (Rokeby) TOS-LOW
	22	181	*Heteropogon triticeus, Themeda arguens, Sorghum plumosum* + *Piliostigma malabaricum* (Picanninny Plains) CTG
H8	10	100	*Eucalyptus tetrodonta, E. hylandii var. hylandii* + *E. nesophila* + *E. cullenii* (or *E. crebra*) (Sandstone plateaus) W
	16	102	*Eucalyptus tetrodonta* + *E. nesophila* + *Asteromyrtus brassii* + heath understorey (Sand plains over sandstone) W-OW
H16	30	135	*Asteromyrtus brassii, Neofabricia myrtifolia, Allocasuarina littoralis* +/- *Welchiodendron longivalve* (Northern CYP, sandy plateaus) LOF
	30	140	*Neofabricia myrtifolia, Asteromyrtus brassii, Lophostemon suaveolens, Leucopogon yorkensis* + *Callitris intratropica* emergents (Elliot Creek) LOF
	30	141	*Allocasuarina littoralis* + *Acacia crassicarpa* + *Grevillea glauca* + *Melaleuca viridiflora* (Sandstone plateaus) LW
K5	15	36	*Eucalyptus brassiana, E. clarksoniana, Allocasuarina littoralis* (Western McIlwraith & wet coastal areas) OF (wet coastal areas)
	15	37	*Eucalyptus clarksoniana (or E. novoguinensis), E. tessellaris* + *Acacia polystachya* + rainforest species (Coastal ranges, McIlwraith Range) OF
	9	136	*Eucalyptus hylandii var. hylandii &/or E. crebra* + *E. brassiana* + *Lophostemon suaveolens* (southern headlands & Melville Range) LOF
	9	137	*Lophostemon suaveolens, Eucalyptus crebra* (Altanmoui Range) LOF
	30	148	*Welchiodendron longivalve, Melaleuca viridiflora and Neofabricia myrtifolia* and *Acacia brassii* (Ridge crests, Iron Range area) LW
STRUCTURALY UNIQUE VEGETATION CLASSES			
D6	16	1	*Eucalyptus tetrodonta* + *E. hylandii var. campestris* + *Erythrophleum chlorostachys* (The Desert) TW
	16	2	*Eucalyptus tetrodonta, E. nesophila* + *Erythrophleum chlorostachys* (Bauxite plateau) TW

Table 5.13 Number of seed plant species in four tropical regions of Australia defined by 10 degree resolution grid cells. Total number of species for Australia was 3,183. Data based derived from ERIN via Crisp *et al.* (in press).

Region	No. species
CY only	259
CY and KR	5
CY and WT	450
CY and AL	85
CY and KR and AL	53
CY and KP and AL and WT	242

Table 5.14 List of terrestrial vertebrates endemic to Cape York Peninsula (from Abrahams *et al* 1995, Winter and Lethbridge 1995).

Class	Species
Amphibia	*Crinia remota*
Amphibia	*Litoria nigrofrenata*
Amphibia	*Sphenophryne gracilipes*
Amphibia	*Uperoleia mimula*
Aves	*Arses telescophthalmus*
Aves	*Cacomantis castaneiventris*
Aves	*Chlamydera cerviniventris*
Aves	*Drymodes superciliaris*
Aves	*Eclectus roratus*
Aves	*Geoffrroyus geoffroyi*
Aves	*Glycichaera fallax*
Aves	*Manucodia keraudrenii*
Aves	*Microeca griseoceps*
Aves	*Monarcha frater*
Aves	*Pitta erythrogaster*
Aves	*Probosciger aterrimus*
Aves	*Ptiloris magnificus*
Aves	*Sericornis beccarii*
Aves	*Syma torotoro*
Aves	*Tregellasia leucops*
Aves	*Xanthotis chrysotis*
Mammalia	*Dobsonia moluccensis*
Mammalia	*Echymipera rufescens*
Mammalia	*Hipposideros cervinus*
Mammalia	*Petrogale coenensis*
Mammalia	*Petrogale godmani*
Mammalia	*Saccolaimus mixtus*
Mammalia	*Sminthopsis archeri*
Mammalia	*Spilocuscus maculatus*
Reptilia	*Chondropython viridis*
Reptilia	*Cyrtodactylus louisiadensis*
Reptilia	*Emoia atrocostata*
Reptilia	*Emoia longicauda*
Reptilia	*Eugongylus rufescens*
Reptilia	*Furina tristis*
Reptilia	*Glaphyromorphus nigricaudis*
Reptilia	*Glaphyromorphus pardalis*
Reptilia	*Glaphyromorphus pumilus*
Reptilia	*Nactus pelagicus*
Reptilia	*Oedura castelnaui*

Table 5.15 The distribution of CYPLUS vegetation structural classes within each environmental domain (96 group), as a percentage (note: ED classes with no records did not cover any area that overlapped with mapped vegetation data).

EDA	No data	TW	CF	OF	W	OW	LCF	LOF	LW	LOW	CS	TS	TOS	OH	DOH	CTG	TG	CSG	OSG/ CSG	CH	SH	LL
1	6.3	12.5	50.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	6.3	0.0	0.0	6.3	0.0	6.3	0.0
2	0.0	75.5	0.0	2.6	17.9	2.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
3																						
4	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5																						
6	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	26.7	13.3	0.0	53.3	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	4.8	2.4	59.5	0.0	0.0	2.4	9.5	16.7	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1.0	14.7	2.5	4.1	61.4	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.5	9.6	0.0	0.0	0.0	3.0	0.5
10	1.7	15.0	16.7	0.0	35.0	0.0	0.0	8.3	0.0	1.7	0.0	0.0	0.0	10.0	0.0	5.0	0.0	1.7	3.3	0.0	1.7	0.0
11	0.1	3.3	0.9	2.4	58.0	4.0	0.3	0.2	0.2	19.3	0.0	0.0	0.2	0.0	0.0	3.3	6.2	0.1	0.0	0.0	1.0	0.4
12	0.0	0.0	6.2	0.5	59.5	2.4	0.5	1.4	1.0	1.0	1.0	0.0	0.0	25.2	0.5	0.0	0.0	0.0	0.5	0.0	0.5	0.0
13	0.0	0.0	27.3	0.0	54.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	0.0
14	0.0	15.8	31.6	0.0	15.8	0.0	0.0	21.1	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	10.5	0.0	0.0	0.0
15																						
16	0.0	0.0	6.3	3.6	51.4	6.3	1.8	0.0	4.5	10.8	0.0	0.0	0.0	2.7	0.0	3.6	0.0	0.0	0.0	0.0	9.0	0.0
17	1.7	0.0	16.9	1.7	23.7	0.0	8.5	0.0	1.7	1.7	1.7	0.0	0.0	32.2	3.4	0.0	0.0	0.0	0.0	0.0	6.8	0.0
18	0.0	0.0	0.0	0.0	66.7	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	1.7	8.1	0.6	40.2	1.1	0.0	8.1	0.0	0.8	0.3	0.0	0.0	34.9	0.8	0.0	0.0	0.0	3.4	0.0	0.0	0.0
20	0.0	0.0	35.3	0.0	52.9	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	26.7	8.4	0.0	16.8	0.0	0.8	19.1	0.0	0.0	0.0	0.0	0.0	15.3	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0
22	0.0	13.8	0.6	2.3	66.1	10.6	0.3	0.0	0.0	4.9	0.0	0.0	0.3	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.3
23																						
24	0.0	0.0	0.0	0.0	87.5	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	16.7	16.7	0.0	5.6	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	44.4	0.0	0.0	0.0	0.0	5.6	0.0	5.6	0.0
27	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	25.0	0.0	50.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	9.6	1.8	0.9	57.0	21.9	0.4	0.0	0.0	2.6	0.0	0.0	0.0	2.6	0.0	0.4	0.0	0.0	2.6	0.0	0.0	0.0
30	0.0	0.0	20.2	5.1	56.6	0.0	2.0	0.0	12.1	1.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	2.0	0.3	51.0	34.3	1.0	0.0	1.3	3.9	0.0	0.0	0.3	3.9	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0
32	0.0	0.4	3.0	2.3	34.6	29.3	2.6	0.4	0.8	21.8	0.0	0.0	1.1	0.8	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0
33	0.0	0.7	0.2	1.5	83.9	0.9	0.0	0.0	0.4	11.8	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
34	9.1	0.0	36.4	0.0	0.0	0.0	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	0.0
35	0.0	50.3	1.8	2.3	41.3	1.8	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.3	0.0
36	0.0	0.0	28.0	4.0	28.0	0.0	2.0	0.0	16.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
37	2.6	55.5	12.2	2.6	10.0	0.0	1.3	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	3.9	3.5	1.3	0.0	0.0	4.8	0.0
38	0.0	0.0	38.0	13.0	28.7	0.9	1.9	0.0	12.0	3.7	0.0	0.0	0.0	0.9	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	2.1	2.1	82.6	2.8	1.4	0.0	1.4	2.8	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
40	0.0	0.0	39.5	5.3	35.5	0.0	2.6	0.0	6.6	1.3	0.0	0.0	0.0	5.3	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.5	4.0	1.8	73.1	18.7	0.8	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	31.3	1.6	37.5	1.6	4.7	0.0	7.8	1.6	0.0	0.0	0.0	7.8	4.7	0.0	0.0	0.0	0.0	0.0	1.6	0.0
43	0.0	0.0	0.0	2.4	87.8	0.0	0.0	0.0	0.0	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	2.2	3.4	55.1	4.4	1.2	0.0	0.3	23.4	0.0	0.0	0.0	3.7	0.0	4.0	0.3	0.0	0.0	0.0	1.2	0.6
45	0.0	0.0	48.3	18.4	20.7	0.0	4.6	6.9	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.0	43.9	0.7	2.1	33.3	17.5	0.4	0.0	0.0	1.8	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	0.0	0.0	0.0	2.9	75.0	20.2	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	4.1	0.0	6.1	0.0	2.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	40.8	0.0	0.0	0.0	36.7	0.0
49	0.0	0.0	5.4	0.0	72.0	1.1	0.0	0.0	1.1	1.1	0.0	0.0	0.0	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	2.8	1.9	86.0	1.9	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.1	0.1	0.4	2.3	59.4	2.4	0.2	0.1	0.3	27.4	0.0	0.6	0.0	0.0	0.0	4.9	1.2	0.0	0.0	0.0	0.3	0.2
52	0.0	0.4	0.0	2.5	91.8	1.7	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53																						
54	0.0	0.0	0.6	2.7	24.8	8.1	0.0	0.0	0.5	38.3	0.0	1.5	0.0	0.0	0.0	5.5	17.4	0.0	0.0	0.0	0.5	0.3
55	0.0	0.0	18.8	3.1	53.1	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	12.5	3.1	0.0	0.0	0.0	3.1	0.0	0.0	0.0

Table 5.15 Continued

56	0.0	0.0	4.3	1.4	84.1	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	2.5	94.3	1.6	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	0.0	0.0	44.4	0.0	55.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	0.0	0.0	22.7	0.0	56.1	0.0	4.5	0.0	1.5	1.5	0.0	0.0	0.0	7.6	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	35.2	0.0	0.8	55.7	0.0	0.0	0.0	0.0	7.4	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
61	0.0	6.1	0.0	2.2	67.1	4.7	0.0	0.0	0.0	18.1	0.0	0.7	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.4
62	0.0	0.0	0.0	4.6	44.8	20.7	1.1	0.0	0.0	24.1	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	2.4	7.3	87.8	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0	82.9	0.0	0.0	0.0	0.0	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	6.1	2.6	16.5	0.0	4.3	0.9	2.6	0.9	0.9	0.0	0.0	47.8	7.8	1.7	0.0	0.0	1.7	0.0	3.5	2.6
66	0.0	0.0	0.0	0.0	90.0	1.4	0.0	0.0	0.0	7.1	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	0.0	0.0	5.6	2.2	67.8	2.2	2.2	4.4	2.2	12.2	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	0.0	0.0	57.7	38.5	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70																						
71	0.0	0.0	2.4	4.9	85.4	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
72	0.0	0.0	80.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	1.3	81.6	3.9	0.0	0.0	0.0	10.5	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	0.0	70.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	78.6	7.1	0.0	0.0	7.1	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	0.0	13.0	0.0	1.6	75.3	1.6	0.0	0.0	0.3	7.5	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
77	0.0	0.0	0.0	37.9	62.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78	0.0	0.0	0.0	0.0	78.6	3.6	0.0	0.0	17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79	0.0	0.0	33.3	50.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	37.5	50.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
81	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82	2.0	0.0	2.6	0.7	14.6	0.0	1.3	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	5.3	52.3	0.7	0.0	0.0	19.2	0.0
83	0.0	0.0	33.3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
84																						
86	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	0.0	0.0	0.0	3.4	65.5	17.2	0.0	0.0	10.3	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89																						
90																						
91	0.0	0.0	42.9	42.9	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
94	0.0	0.0	0.0	1.7	91.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95																						
96	0.0	0.0	36.4	36.4	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.16 The distribution of CYPLUS vegetation structural classes within each environmental domain (40 group), as a percentage (note: EDA classes with no records did not seem to cover any area that overlapped with structural classes).

EDA	No data	TW	CF	OF	W	OW	LCF	LOF	LW	LOW	CS	TS	TOS	OH	DOH	CTG	TG	CSG	OSG-CSG	CH	SH	LL
1	1.9	9.3	37.0	1.9	24.1	0.0	0.0	9.3	0.0	0.0	0.0	0.0	0.0	5.6	1.9	1.9	0.0	0.0	5.6	0.0	1.9	0.0
2	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	4.5	0.0	63.6	0.0	4.5	0.0	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0
4	5.9	0.0	58.8	0.0	0.0	0.0	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0
5	2.3	13.6	18.2	0.0	31.8	0.0	0.0	5.7	0.0	1.1	0.0	0.0	0.0	15.9	0.0	3.4	0.0	1.1	2.3	0.0	4.5	0.0
6	0.0	20.4	7.9	1.0	28.8	0.0	0.5	14.1	2.1	4.2	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	8.9	0.0	0.5	0.0
7	0.8	0.0	24.2	2.4	30.6	0.8	6.5	0.0	4.0	1.6	0.8	0.8	0.0	19.4	4.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0
8	0.0	0.0	31.8	8.9	32.8	0.5	2.6	0.0	10.9	2.1	0.0	0.0	0.0	7.3	1.0	1.0	0.0	0.0	0.5	0.0	0.5	0.0
9	0.0	1.3	7.4	0.9	34.7	0.9	1.1	6.4	0.6	0.9	0.2	0.0	0.0	38.1	2.6	0.4	0.0	0.0	3.2	0.0	0.9	0.6
10	0.0	0.0	6.0	0.3	63.6	1.7	0.3	1.0	1.0	0.7	0.7	0.0	0.3	23.5	0.3	0.0	0.0	0.0	0.3	0.0	0.3	0.0
11	0.0	0.0	4.3	1.4	84.1	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	22.8	3.3	56.5	0.0	2.7	0.0	7.1	1.1	0.0	0.0	0.0	4.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	3.7	1.7	78.1	2.1	1.2	1.7	0.8	8.7	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0
14	0.5	45.3	3.2	2.1	33.9	8.5	0.5	0.0	0.0	1.9	0.0	0.0	0.2	0.5	0.0	0.9	0.8	0.3	0.5	0.0	0.9	0.2
15	0.0	0.3	3.0	1.6	55.1	26.7	1.4	0.1	0.6	7.7	0.0	0.0	0.4	1.5	0.0	0.7	0.4	0.0	0.3	0.0	0.1	0.0
16	0.1	2.2	0.8	2.4	63.1	2.7	0.3	0.1	0.3	19.8	0.0	0.2	0.1	0.4	0.0	3.3	3.0	0.0	0.0	0.0	0.7	0.3
17	2.5	0.0	3.5	0.5	11.1	0.0	1.5	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	5.5	49.7	1.0	0.0	0.0	23.6	0.0
18	0.4	0.0	4.3	2.7	68.1	4.3	1.6	0.0	2.7	6.2	0.0	0.0	0.0	3.5	0.0	1.6	0.0	0.0	0.4	0.0	4.3	0.0
19	0.0	7.6	0.2	2.2	79.7	4.4	0.2	0.0	0.1	5.1	0.0	0.1	0.1	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.1
20	0.0	0.0	0.5	3.0	26.5	9.3	0.1	0.0	0.4	37.0	0.0	1.3	0.0	0.0	0.0	5.4	15.8	0.0	0.0	0.0	0.4	0.3
21	0.0	14.8	0.0	1.5	63.8	3.3	0.0	0.0	0.0	14.8	0.0	0.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.3
22	0.0	0.0	0.0	2.8	85.8	9.3	0.4	0.0	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	82.9	0.0	0.0	0.0	0.0	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.7	85.6	2.7	0.0	0.0	0.0	9.6	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	2.4	73.2	14.6	0.0	0.0	7.3	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.9	85.3	5.2	0.0	0.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	44.2	11.7	27.0	0.6	4.3	3.7	3.1	1.2	0.0	0.0	0.0	2.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	2.5	6.2	86.4	2.5	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
30	0.0	0.0	14.9	38.3	46.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	33.3	50.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32																						
33	0.0	0.0	33.3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	62.9	34.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	85.7	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	37.5	37.5	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40																						

TW	Tall woodland	TOS	Tall open shrubland
CF	Closed forest	OH	Open heath
OF	Open forest	DOH	Dwarf open heath
W	Woodland	CTG	Closed tussock grassland
OW	Open woodland	TG	Tussock grassland
LCF	Low closed forest	CSG	Closed scrub grassland
LOF	Low open forest	OSG	Open scrub grassland
LW	Low woodland	CH	Closed herbland
LOW	Low open woodland	SH	Sparse herbland
CS	Closed sedgeland	LL	Lakes & lagoons
TS	Tall shrubland		

six

6 CRITERION 5 NATURAL INTEGRITY
CRITERION 6 NATURAL PROCESSES

CRITERION 5.0 NATURAL INTEGRITY

Ecosystems and landscapes which exhibit outstanding ecological and geophysical integrity.

Subcriteria:

5.1 Terrestrial ecosystems - high degree of natural integrity
5.2 River corridor ecosystems - high degree of natural integrity
5.3 Wetland ecosystems - high degree of natural integrity
5.4 Coastal and marine ecosystems - high degree of natural integrity

CRITERION 6.0 ON-GOING NATURAL PROCESSES

Geophysical, evolutionary, and ecological processes, including local and global-scaled life support systems fully functional.

Subcriteria:

6.1 Areas of sufficient size, natural integrity and other essential elements to allow or maintain significant on-going ecological, life support, and evolutionary processes
6.2 Areas of sufficient size, natural integrity and other essential elements to allow or maintain significant on-going geophysical evolutionary processes

6.1 INTRODUCTION

In Chapter 2 we identified the integrity of natural processes as being a major dimension of natural heritage values. Even the most preliminary assessment of Cape York Peninsula highlights this as an important value, given the relatively limited impact of modern technological society compared with other regions in Australia and the world. However, a complex suite of issues surrounds the concept of natural processes and these need to be examined before the new criterion can be applied Cape York Peninsula:

- What constitutes natural processes?
- What determines the integrity of natural processes?
- How can we account for the impact of human activity?

This chapter addresses these questions, and establishes the relative integrity of natural processes in Cape York Peninsula.

6.2 DEFINING NATURAL PROCESSES

The concept of natural integrity is intuitively appealing, but difficult to make operational when assessing natural heritage value. Natural integrity is used here to indicate the degree to which pattern and process in environmental and ecological systems are a function of natural processes rather than human perturbations, in particular those caused by modern technological society. Natural processes include (a) physical and chemical processes, (b) biological processes, and (c) ecological processes.

Natural integrity reflects the extent to which the dominant ecological and environmental character of a landscape (or seascape) is the result of the genetically determined responses of biota to prevailing environmental conditions, the unimpeded operation of basic laws of physics and chemistry, together with evolution and natural selection, and various correlated and competitive biological behaviours. The latter leading to ecological phenomena such as food webs, vegetation succession, and biological mediation in the local flux of energy, water and nutrients.

Physical processes include: atmospheric conditions associated with global and regional energy and moisture gradients; fluxes in energy and chemical substances due to environmental gradients established by gravity and solar radiation forcing; geothermally driven processes; tectonic plate movement; solid tectonic processes (bending, folding, warping, fracturing of Earth's crustal plates); gradation, weathering and mass movement; ground water and surface water hydrology; erosion and transformation/deposition; beach formation and coastal deposition; coastal landforms created by wave deposition; and various other geomorphological and geological process that affect landform evolution (Gabler *et al.* 1994).

Biological processes focus on the functioning of organisms and their interactions, such as: life history attributes; reproduction cycles; competition; predator/prey relations; plant/pollinator/herbivore relations; evolution and natural selection. Of particular interest in the context of Cape York Peninsula are the biological processes of dispersal and migration that occur over larger scales of space and time. Ecological processes are defined by the interactions between plants, animals, fungi, microorganisms and the physical environment, whereby living organisms mediate the flux and storage of energy, water and chemical substances, especially carbon, nitrogen and phosphorous. Ecological systems can be defined as communities of organisms together with their environmental relations within a defined spatial location and temporal domain.

In reality, these three kinds of processes - physical/chemical, biological, and ecological - are inexorably intertwined. By definition, all ecological processes involve biological and physical processes. Indeed it is the integration of biophysical processes that distinguishes Earth from it neighbouring planets. Nonetheless, there are particular natural phenomena where it is evident that physical/chemical, biological, or ecological processes dominate. Here we focus on defining the biophysical processes critical to consideration of the natural heritage value of Cape York Peninsula.

6.2.1 EVOLUTION, NATURAL SELECTION, AND ECOSYSTEM FUNCTION

It is easy to forget that the human species arrived very late in the evolution of ecosystems and their component biota. The self-generating, self-regulating, and self-regenerating properties of ecosystems therefore long predate human intervention. They are the result of the operation of fundamental laws of physics, chemistry and biology.

External environmental conditions are continually changing through a range of space and time scales. Biota must contend with both seasonal and random fluctuations in their external environmental conditions. This is a problem for species as their optimum environmental conditions are genetically programmed. Ecological systems change through space and time in response to these external dynamics. The taxonomic composition or dominance of taxa within communities may change at a given site as better adapted species move in. Similarly, individual species and assemblages may shift geographically, spreading into neighbouring systems.

Species live within ecological systems and their local environmental conditions reflect, to varying extents, local ecosystem processes. As ecological systems mature, the capacity of the biota to modify local environmental conditions tends to increase, as they provide a buffer against fluxes in water, carbon, and other nutrients (Vertessey *et al.* 1994, Gorshkov 1995). For example, the primary environmental regimes that drive biotic response of heat, light, water and mineral nutrients are very different under a primary, closed forest canopy, compared with bare ground. Also, the physical and chemical properties of soil are a function of, among other things, vegetation ecosystem processes (Jenny 1961).

Ecological systems are characterised by behaviours that operate within certain bounds. They possess a resilience to external perturbations such that they can absorb the impact of these perturbation and stay within these characteristic system conditions. However when this resilience is breached, the system behaviour can flip into a new state or range of conditions (Hollings 1996). The ability of a landscape ecosystem to absorb disturbances and perturbations is partly scale-dependent, for example, the ecosystem must be larger than the disturbance in order to be able to absorb its impact. Different system states can result from differing external conditions through time.

Ecological systems are therefore best considered as dynamic equilibrium systems (Gorshkov 1995) that for periods of time reach stability in terms of certain system-level conditions. They are not necessarily stable through time in terms of species composition or species dominance, nor in their geographical distribution. Ecosystems are therefore dynamic not static phenomena. It also follows that depending on historical conditions, the biota of a landscape at a given point in time may not be in equilibrium with the abiotic environment

However, given a state of dynamic equilibrium, one of the characteristics of ecological systems is that they are populated by species that best match extant environmental conditions. Less efficient (i.e. poorer adapted) species - should their propagules be dispersed into a new area - are removed by natural selection. Such processes are ongoing as the prevailing, external physical environmental regimes are changing through time, and plants and animals propagules are continuously dispersing. In natural systems, the resulting species composition and community relations reflect environmentally-optima assemblages based on the available evolved taxa.

Human activity can impact on ecological systems in a variety of ways. For example, by imposing external perturbations on ecological systems that breach system resilience, causing the system to flip into a new state. Land clearance for agricultural development has the effect of removing the dominant vegetation ecosystem, eliminating the 'invisible hand' of natural selection and replacing it with human imposed management objectives. Thus the landscape still supports some kind of ecological community but it is not the evolved biological community, nor is it a community that has passed through the filter of natural selection.

With few exceptions, human land use has created ecological systems that are taxonomically and structurally much simpler than the natural systems that they replaced. Thus, in forest ecosystems, where management regimes maximise for wood production, the result can be fewer older trees and less complex understorey vegetation, with a smaller number of commercially useful tree species dominating the canopy (Lindenmayer *et al.* 1991, Lindenmayer 1994, Kirkpatrick 1994). It has also been shown that the total carbon stored in a landscape is less in commercially logged forests than it is in naturally functioning forest ecosystems (Woldendorp 2000, Harmon *et al.* 1990)

As noted above, ecological systems as they mature have an enhanced capacity to buffer, and thereby regulate, environmental flows of energy, water and nutrients. Thus water flow and quality through a catchment and soil profile development reflect the interaction of biota and physical conditions through time. Systems with a high degree of natural integrity have local environmental conditions that may be strongly regulated by the biota themselves and these in turn contribute to the habitat of the biota.

We stress that ecological systems subject to natural (non-human processes) are not arbitrarily defined, but rather represent the operation of fundamental laws of science (as they are currently understood). They have characteristics not possessed by or different from human-perturbed systems.

6.2.2 HYDROECOLOGY AND NATURAL INTEGRITY

The meaning and significance of *natural integrity* is most readily understood by considering those natural processes that mediate surface and groundwater resources, and the inter-relations between hydrological process and vegetation ecosystems. The term *hydroecology* is used here to describe both the role vegetation ecosystems play in influencing catchment hydrological processes (e.g. via groundwater recharge) and, conversely, the influence these processes have on the local environmental conditions experienced by the biota (e.g. through groundwater discharge). Conventionally, the complex interactions between surface and groundwater systems are considered in terms of *hydrogeology*, which perhaps places more emphasis on physical and chemical processes.

The recent salinity audit of the Murray-Darling Basin highlighted the extent of land degradation problems. The rise of salinity in this area is argued to be symptomatic of current land uses, which have replaced natural systems, resulting in a massive hydrological imbalance that will take several hundred years to stabilize (Murray-Darling Basin

Commission 1999). The natural systems referred to here were based upon the existence of a continuous cover of native vegetation ecosystems across entire catchments. Such systems have been substantially cleared or degraded in the Murray-Darling Basin. Thus the Basin's hydroecology is characterized by a low level of natural integrity.

Since European settlement the hydrological regimes of not only the Murray-Darling Basin, but other regions in southern Australia have been dramatically degraded largely as the result of vegetation clearance. Wasson *et al.* (1996) in their review of inland waters for the State of Australian Environment Report discussed the kinds of negative environmental impacts that have resulted from post-European settlement perturbation. These included: salinisation and water logging of soils as the result of rising water tables; destruction of permanent water holes; degradation and destruction of riparian habitats; dramatic changes in water quality, including eutrophication, massive algal blooms; stream erosion; replacement of aquatic native species by exotics; and significant changes to flow regimes and groundwater recharge regimes. Wasson *et al.* (1996) also noted the generally poor state of Australia's wetlands which have deteriorated greatly since European settlement due to draining, changes to water regimes, and increased sediment and nutrient inputs. In Victoria, for example, one-third of natural wetlands have been destroyed, including one-half of the area of non-permanent fresh-water wetlands. In NSW only 18% of NSW lakes were considered to be in a good ecological condition. The extent of these problems is such that they are firmly on the public and political agenda. For example, the National Land and Water Resources Audit's (in press) recent announcement that about 5.7 million hectares are at risk from dryland nationally.

The degraded condition of much of southern Australia's inland waters is due to human disturbance of interrelated hydroecological and hydrogeological processes. Wasson *et al.* (1996) noted that Australian aquifers are suffering from dual pressures: the level of exploitation of the resource is increasing at the same time as they are sustaining increased levels of pollution. They further observed that groundwater resources are of vital importance. In about 60% of the Australian continent people are totally dependent on groundwater. Groundwater allows streams to flow through prolonged dry periods. It is inextricably linked to the surface environment, sustains many wetlands and supports vegetation. In turn, disturbances to the land cover and surface environments affect the recharge of groundwater resources.

6.3 QUANTIFYING HUMAN IMPACTS

If we consider the role of humans in the degradation of atmospheric ozone layer and increasing atmospheric concentrations of CO2, there is probably no longer any location in the Biosphere (*sensu* Vernadsky 1926) where the environmental conditions are totally uninfluenced by human activity. However, if we focus on the condition of terrestrial landscapes, the impact of human activity is best considered as a continuum. At one end is Antarctica where human impact , particularly that of modern technological society, is minimal. At the other end of the human disturbance spectrum, urban centres represent largely artificial environments where little wild nature remains. In between, it is possible to examine the relative degree to which a landscape's environment is function of natural processes versus the forces of human activity.

Unfortunately, quantifying even the relative impact of human activity on natural processes is no easy task. The significance of human perturbations is often only apparent at larger scales as the result of the accumulated impact of many smaller scaled activities over a long time period. Indeed, comprehensive analysis of the total impact on terrestrial ecosystems of human activity is impossible due to the lack of suitable surrogate data for pre-Holocene environments, and systematic observation of conditions prior to the advent of modern industrial society.

Given these limitations, Lesslie (1997) provided a framework for quantifying human impacts based on measuring spatial variation in the following indices:

- settlement activity; exposure to technological activity associated with permanent human occupation;
- infrastructure activity; exposure to technological activity associated with built infrastructure; and
- land use activity; the intensity with which land resources are unambiguously utilised by humans for production purposes.

This model builds upon his earlier wilderness inventory analysis (e.g. Lesslie *et al.* 1988, 1992, Lesslie and Maslen 1995). The theoretical basis for this methodology lies in the seminal work of Hagget (1965) and Forman and Gordron (1986). Lesslie (1997) noted that the representation of technological activity using settlement, infrastructure and landuse represent, at a landscape scale, a complex of strategies and mechanisms humans have developed for resource procurement, transformation and consumption. The extent to which a landscape is urbanised, suburbanised, or retains a cultivated or natural character derives directly from the configuration of these features.

The most difficult index to implement concerns the extent to which human landuse has impacted on a landscape. Landuse impacts associated with modern technological society can be examined along a gradient from (at the intensive end) deforestation and conversion to agriculture, through varying intensities of logging, grazing, and the impoundment and diversion of water resources.

A review by Mackey *et al.* (1998) highlighted some of the major relationships between ecological integrity, biodiversity conservation, and the impact of modern industrial society. The use of wilderness indices, and related technological exposure, were examined in this context. They were found to spatially correlate with many critical measures of ecological degradation, especially habitat loss, habitat fragmentation, and habitat degradation. However certain impacts that affect the condition of the land cover could not be adequately accounted for by these indices. These include stock grazing pressures around water points in central Australia (Landsberg *et al.* 1997), and the spatially diffuse distribution of invasive organisms such as feral animals and certain weeds. Thus these wilderness quality inventories (*sensu* Lesslie *et al.* 1988, 1992) provide significant, but still incomplete assessments of the total impact of modern technological society. Nonetheless, the Lesslie methodology provides a quantitative and explicit approach to quantifying many of the impacts of modern technological society on natural processes. It follows that the integrity of natural processes will tend to be high in landscapes that are only minimally exposed to infrastructure and landuse associated with modern technological societies.

Wilderness inventories (based on the Lesslie measures of landscape exposure to technological activity) have now been completed for the whole planet. Figure 6.1 shows the global analysis undertaken by the World Conservation Monitoring Centre. A national disturbance database has also been completed for Australia based on the National Wilderness Inventory method of Lesslie and Maslen (1995). The result is shown in Figure 6.2.

6.4 ASSESSMENT OF INTEGRITY

We noted in Chapter 3 the important of assessing natural heritage value at four different scales, namely, global, regional, national and local. Again this is a matter of providing appropriate contextual data, in this case, about the relative exposure of landscapes to human infrastructure and land use activity and the impact this has had on key natural patterns and processes. In the discussion that follows, we examine the intersection of wilderness quality and biophysical naturalness data with modelled and mapped bioclimatic and vegetation data at global, national and local scales.

6.4.1 GLOBAL SCALE

Figure 6.1 illustrates the extraordinary global reach of modern human activity. Aside from the Amazon Basin and areas within Australia, the only extensive areas remote from exposure to human infrastructure and landuse activity are in the boreal and arctic/antarctic biomes. Compare the global wilderness inventory analysis presented in Figure 6.1, with Figure 5.1 (global prediction of savanna climatic domain), Figure 5.2 (original and current extent of global forest cover), and Figure 5.3 (global climatic classification). According to Loh *et al.* (1998) the original coverage of tropical dry forest was about 11.99 million km2. This has now been reduced to 3.69 million km^2 - a 70% reduction. Figures 5.1, 5.2 and 5.3 reinforce how globally restricted is the geographical distribution of the tropical savanna biome.

Figure 5.1 does not provide an indication of the relative integrity of the remaining 30%. Visually intersecting Figure 6.1 and Figures 5.1, 5.2, and 5.3, suggests that much of the tropical dry forest-savanna biome outside Australia has been largely degraded by intensive human activity. Bioclimatic group I1 (Figure 5.3) has been extensively perturbed in Africa, Asia, India, Central and South America. Similarly, bioclimatic Group J1 has been perturbed in Africa, Central America, and Asia. The most extensive areas that have been least disturbed by modern technological society are the Australian tropical savanna landscapes. Note also that the only relatively intact areas of J1 outside of South America are those in Cape York Peninsula.

6.4.2 NATIONAL SCALE

As discussed above, the values presented in Figure 6.2 (wilderness inventory of Australia) are based upon (a) the relative extent to which the natural vegetation cover has been removed, fragmented or degraded by landuse activity, and (b) the relative remoteness of a location from human infrastructure including settlement (towns, cities) and roads/access networks. Note that this wilderness index does not include the impact of exotic invasive organisms such as weeds, feral herbivores and predators introduced as the result of European settlement.

The key feature to note in Figure 6.2 is the extent to which habitat has been cleared, fragmented and degraded by human infrastructure and land use activity in the humid and subhumid landscapes of eastern and southern Australia; in particular, Queensland, south east NSW, Victoria, South Australia, and south-west Western Australia. To the extent to which the NWI is an indicator of ecological integrity (see discussion in Mackey *et al.* 1998), Cape York Peninsula, together with parts of Arnhem Land and the Kimberley Region, remain the largest and most substantial intact areas of higher rainfall landscapes in Australia. Most of the remaining landscapes with high NWI values, aside from South West Tasmania, are in arid climates.

Another important note is that the western half of Cape York Peninsula is part of the Great Artesian Basin, which extends west underneath the Gulf of Carpentaria. This occupies about 1/5 of Australia, and largely underlies arid and semi-arid regions where surface water is sparse and unreliable. The groundwater basin consists of multi-layered confined aquifer systems. Recharge occurs mainly in the eastern marginal zone (Habermehl 1980). This means that the high integrity of the area's hydrological systems is therefore of national significance

6.4.3 CAPE YORK PENINSULA SCALE

Many of the issues concerning the within-region extent and variability of the environmental, ecological, and biological characteristics of Cape York Peninsula, were discussed in Chapters 3 and 4. Only a few of the data sets of Cape York Peninsula are considered sufficiently geographically comprehensive and ecologically adequate on which to base Cape York Peninsula-wide analyses. In terms of further assessment of the integrity of natural processes within Cape York Peninsula, vegetation was considered the least problematic. Consequently we undertook additional analyses based on intersecting available human disturbance data with the CYPLUS mapped vegetation data.

As part of CYPLUS data base development activities, a new Biophysical Naturalness data set was generated for Cape York Peninsula. Biophysical Naturalness is one of the four original NWI indices. It is intended to reflect the impact that human landuse activity has on landscapes, particularly in terms of habitat clearance, fragmentation, and degradation. Its calculation is therefore complicated by the need for detailed information on the nature and intensity of past and present landuse practices. These data are generally unavailable, and in their absence a rather complex methodology was developed for Cape York Peninsula based on a heuristically determined combination of indirect, modelled, and surrogate variables - for example, grazing impacts were inferred from land tenure, soils and vegetation types. Given these limitations, the Biophysical Naturalness index should only be viewed as indicative.

Figure 6.3 shows the NWI for Queensland, while Figure 6.4 shows the Biophysical Naturalness index for Cape York Peninsula. The main difference between these two maps is that the NWI includes indices based on distances from settlement and infrastructure, while Figure 6.4 reflects the modelled land use disturbance attributes.

Stein *et al.* (1999) completed a Wild Rivers analysis of continental Australia. Based on a digital elevation model with a resolution of about 250m, the surface drainage network was calculated for all of Australia. This enabled stream segments and associated microcatchments to be delineated. These surface flow, stream segment, and microcatchment data were then integrated with information about catchment and in-stream disturbance to produce a Catchment Disturbance Index. For Cape York Peninsula, the Wild Rivers study used the CYPLUS Biophysical Naturalness data set noted above. The CDI provides a surrogate for the relative exposure of a landscape's hydrological processes to the impacts of modern technological society on Cape York Peninsula.

Figure 6.5 shows the integrated Catchment Disturbance Index (CDI) for Cape York Peninsula, mapping the relative degree of disturbance (though note the caveats on the source data noted above). The CDI is reported on a dimensionless index from zero to unity. For convenience, this index was arbitrarily divided into four classes where class 1 = high disturbance and class 4 = low disturbance. We then intersected these data with the CYPLUS coverages for the 30 Broad Vegetation Groups identified in the Neldner and Clarkson CYPLUS vegetation map (Figure 6.6).

The most important outcome is the extent to which Cape York Peninsula substantially comprises a continuous (i.e. uncleared and unfragmented) native vegetation cover. The analyses reveal a spectrum of perturbation within Cape York Peninsula, but with two important caveats. First, the level of perturbation within Cape York Peninsula needs to be considered within a state, continental and global context. Thus the higher levels of catchment disturbance within Cape York Peninsula are relatively low compared with elsewhere in Queensland and in other seasonal tropical environments. Second, due to the use of modelled data, the extent to which those areas predicted to be relatively perturbed are actually impacted is not known. Conversely, relatively unperturbed areas may be impacted by feral species for which relevant data were not available.

Broad Vegetation Groups (BVG) vary in their relative geographical coverage, with four BVG accounting for 54% of Cape York Peninsula and eight BVG accounting for 72.6% of Cape York Peninsula. Of the most extensive, BVG 10 (woodlands and open woodlands of the Hylandii Ranges), BVG 16 (woodlands and tall *E. tetradonta* woodlands on plateaus/remnants) and BVG 17 (*E. tetradonta* woodlands on erosional surfaces and residual sands) appear remarkably unperturbed, while BVG 18 (low/low open woodlands dominated by *Melaleuca* on depositional plains) shows some moderate level of impact.

The six most perturbed BVGs cover a total of only 14.6 of Cape York Peninsula: BVG 15 (open forests and woodlands on coastal plains and ranges); BVG 7 (Box *E. chlorophylla* dominated woodland and open woodlands); BVG 11 (open woodlands and woodlands - riparian and northern undulating plains); BVG 12 (woodlands in SE on undulating hills and plains); BVG 21 (tussock grasslands on marine and alluvial plains); BVG 22 (closed tussock grasslands and open woodland on undulating clay plains). These are BVGs that were preferentially selected and developed for pastoral activity. The BVG with highest CDI values reflect the influence of development activities associated with settlement, mining and grazing activities. Consistent with elsewhere in Australia, the most accessible and productive landscapes are the most heavily perturbed.

It is apparent that in Cape York Peninsula, key hydrological processes remain intact, such that entire catchments function unimpeded from watershed ridges through to coastal wetlands. The only significant structure on rivers is the small water supply dam on the Annan River near Cooktown in the extreme south-east. Also, the Palmer River has had more than a century to recover from massive disturbance by miners in their quest for alluvial gold deposits. Otherwise, the streams of Cape York have been minimally disturbed by the works of human activity, though the impact of domestic livestock and feral animals does represent a longer term threat to their natural integrity.

Maintenance of the integrated subsurface/surface hydrological processes is essential to the biology and ecology of Cape York Peninsula, including the seasonal movement and breeding of fish fauna, riparian forest and gallery forest, and the distribution and availability of refugia during the extended dry period. The ecological function of these landscapes in the dry season is particularly sensitive to the persistence of geographically restricted surface water/near surface water resources, and hence the continued functioning of systems that affect groundwater recharge and discharge (including, perennial springs and water holes, the maintenance of river base flows, and perennial stream flow). The condition of the native vegetation cover is a key factor in the functioning of these processes.

6.4.4 DISCUSSION

As discussed in Chapter 5, Cape York Peninsula contains three globally significant bioclimates. Each of these has landscapes that are relatively undisturbed compared with analogous landscapes elsewhere in the world. Arnhem Land and the Kimberley Region share with Cape York Peninsula a set of tropical savanna landscapes that are globally significant in their levels of naturalness. However Cape York Peninsula is distinguished by possessing a high degree of naturalness over a greater diversity of bioclimates.

Habitat clearance, fragmentation and degradation, are recognized as three of the most threatening processes to the conservation of biodiversity (Zuidema *et al.* 1996, Recher and Lim 1990). The condition of the native vegetation cover is therefore a critical index of the integrity of natural ecological processes. McIntyre and Hobbs (1999) discussed how human land use activity can be viewed as impacting on habitat with increasing intensity producing a gradient of intact, variegated (graduated change), fragmented, and relictual landscapes. Despite the very long history of human habitation, in general terms Cape York Peninsula belongs to the first category. This is in contrast with the rest of Queensland and southern, humid Australia where the other three classes dominate. The continuous cover of native vegetation-soil ecosystems throughout Cape York Peninsula means that habitat clearance, fragmentation and degradation are not yet wide-spread problems as they are elsewhere in the humid zones of southern Queensland and elsewhere in southern Australia.

In Cape York Peninsula, despite tens of thousands of years of occupation by indigenous Australians, and more recent Post-European settlement, the hydrological processes, that drive and couple the surface-groundwater resources, remain essentially intact. This reflects, amongst other things that: Cape York Peninsula retains a continuous cover of native vegetation/soil landscape ecosystems; and that human exploitation of water resources remains at a low level due to the overall small size of the human population and the limited extent of industrial activity. Thus the hydrological processes of Cape York Peninsula have a high level of natural integrity from both a national and global perspective.

This has important ecological implications. As discussed in Chapter 4, Cape York Peninsula experiences a tropical monsoonal climate with a wet and a dry season. The persistence of many plant and animal species during the dry season depends on the availability of surface water in permanent water holes, groundwater discharge areas, and groundwater fed streams. The distribution of key vegetation types and associated fauna is closely associated with the distribution of surface and near surface water during this dry winter period. The low level of disturbance across the region means that recharge areas remain in a natural state with their native vegetation/soil cover and continue to function optimally. Similarly, hydrological processes continue to maintain perennial springs and other important dry season refugia remain. Thus the hydroecological processes of Cape York Peninsula have a high degree of natural integrity.

The intricate landscape matrix of vegetation types with open and closed canopies across much of Cape York Peninsula emphasizes the point that the ecology of Cape York Peninsula can be comprehended only from a total catchment perspective. The surface and groundwater (seasonal and long term) fluxes of water and nutrients are intimately interconnected with the heterogeneous vegetation matrix that remains intact across Cape York Peninsula. Irrespective of the scale considered, Cape York Peninsula remains a remarkably unfragmented set of landscape ecosystems.

Nelder and Clarkson (1995) noted that there are 77 plant species in Cape York Peninsula that are considered *rare* but not *endangered*. They interpreted this an indicator of the region's high level of ecological integrity and the minimal impact of land use associated with modern technological society. This may be true, but rarity is commonplace and is not a prerequisite to endangerment. A better indicator perhaps is the percentage of exotic invasive species that are present. Clarkson and Kennealy (1988) similarly noted that Cape York Peninsula has a low number of 'naturalised' alien plant species. They estimated that Cape York Peninsula has about 5% of the total number comprising weedy plants (though Nelder and Clarkson now estimate this at 7.4%), and (as of 1988) Queensland with 12.8%, W.A. with 10.5%, and Victoria 22%

Cape York Peninsula emerges from this analysis as a large, environmentally and biologically diverse network of interconnected landscape ecosystems whose natural processes possess a high degree of integrity at global, national and local scales.

6.5 FIRE REGIMES AND NATURAL HERITAGE VALUES

In considering the impact of human activity on the integrity of natural environments, a distinction is usually drawn between the impact of modern technological society and indigenous societies prior to European settlement. This distinction is made on the basis that following European settlement an order of magnitude increase in human impact occurred. However this is not say that indigenous peoples prior to European settlement had no impact on the natural processes of Cape York Peninsula. In particular, as discussed below, it is generally accepted that indigenous Australians managed landscapes through the use of fire. While fire regimes represent a natural process, their manipulation by humans represents a perturbation.

Indigenous Australians use fire for ceremonial, domestic, hunting and habitat management purposes. The latter has been referred to as fire stick farming (see discussion in Hill *et al.* 1999) and is an accepted cultural practice of indigenous communities. It is now acknowledged that indigenous cultural practices reflect an intimate coupling of landscape, resource use, and spirituality. Accordingly, it is not sensible to try and separate the cultural heritage of indigenous communities from their country. From this perspective, the authors appreciate why indigenous peoples consider all of Australia a cultural landscape.

The authors are sensitive to the difficulties faced by indigenous communities. Consequently it is not possible to discuss fire regimes in isolation from considering the social, economic and political situation of these communities. Clearly, the basic human rights of indigenous Australians have not been respected over much of the 200 years since European settlement. Consequently, the authors of this report support principles 12 and 12b of the recently released Earth Charter (the full document and background information can be found at www.earthcharter.org), namely:

- Principle 12: Uphold the right of all, without discrimination, to a natural and social environment supportive of human dignity, bodily health, and spiritual well-being, with special attention to the rights of indigenous peoples and minorities.
- Principle 12b: Affirm the right of indigenous peoples to their spirituality, knowledge, lands and resources and to their related practices of sustainable development.

We believe these two principles should guide long term planning and management in Cape York Peninsula.

6.5 1 FIRE REGIMES AND VEGETATION

It is now axiomatic that prevailing fire regimes influence the types of vegetation in a landscape and their spatial patterning. The concept of fire regimes was defined by Gill (1975) and refers to the frequency, intensity, seasonality and type of fire experienced by a location. Additional characteristics are the patchiness or graininess at a landscape scale, and for each fire event its areal extent and the degree of spatial variability in fire intensity within the overall fire boundary. The two main fire types are above-ground and peat fires. The latter do not occur in Cape York Peninsula.

Gill (1977) noted that the fire regime is the determinant of vegetation change associated with fires. He suggested that flora are not adapted to fire *per se* but rather a fire regime. Similarly, annual communities, soil stability, tree survival and quality, soil fertility and water yield of catchments respond to fire regimes rather than fire *per se.* A major conclusion in his seminal paper was that 'fire is a natural environmental variable whose effects vary according to the fire regime and ecosystem properties'.

The influence of fire regimes on vegetation can be attributed to the differing responses of plant species. Fire intensity can affect plant survival, soil properties, light intensity near ground, and subsequent plant germination. Plant species evolve life history characteristics that constitute different fire response strategies. For example:

- fire heat and smoke chemicals can stimulate the germination of soil-stored seed
- a species which has fire sensitive populations and individuals killed by a fire can re-establish from seed arriving from unburnt areas
- individuals of a plant species may not be substantially affected by a fire
- individuals may be killed by a fire but carry fire resistant fruits which are stimulated to open by fire
- plants may survive destruction of aerial parts by vegetatively re-sprouting
- plant species may be killed by a fire or fire regime and be rendered locally extinct.

Some plant species may persist only within specific fire intervals. For example, certain plant species can be rendered locally extinct if the fire interval is less than the time needed for them to reach reproductive maturity, or if the interval is longer than the time period within which they remain reproductively active.

6.5.2 INDIGENOUS FIRE REGIMES

Given the potentially critical role of fire regimes in structuring vegetation patterns in the landscape, it is important to consider two questions. First, to what extent are the current patterns of vegetation and related elements of biodiversity in Cape York Peninsula the result of prevailing or historic fire regimes? Second, to what extent were the historic fire regimes the result of indigenous fire management practices?

Prevailing weather and climatic conditions dominate the fire regime, determining patterns of ignition and net primary productivity (and hence biomass). Fuel types, loads and wetness, fire intensities and rates of spread are further modified by topographic and edaphic factors.

It is now generally accepted that people have continually occupied Australia for at least 40-50,000 years (Mulvaney and Kamminga 1999). Prior to this, fire regimes were a function of only natural (used here to mean non-human) agents. Humans can vary fire regimes from those determined by natural agents by increasing ignition frequencies, together with their seasonal occurrence and spatial distribution, thereby decreasing the interval between fires and producing less intense fires. Some authors have argued that pre-European settlement, indigenous Australians exerted a major influence on fire regimes (see discussion in Crowley and Garnett 1998a, 2000). Indeed the concept that indigenous Australians extensively burnt the Australian landscape has gained widespread support amongst scientists, natural resource managers, and even the general public. As discussed by Gill (2000), the most popular idea is that indigenous Australians in pre-European times deliberately burnt country in a tight mosaic pattern.

Unfortunately, quantifying historic fire regimes and their impact on vegetation and biodiversity is extremely difficult. Many fire and ecological experts have concluded that data inadequacies prevent making substantial estimates of fire regimes and their impact on vegetation landscape patterning in the pre-European settlement period (e.g. Gill 1977, Gill 2000, Crowley 1995). Thus while various authors have attempted to infer pre-European Aboriginal fire regimes from surrogate evidence (including indigenous oral history, current indigenous practice, historical reports by European settlers, palynological records, and dendrochrological studies) we agree that for Cape York Peninsula the available data limit any substantial conclusions. For particular local areas there is usually no substantive evidence for fire regimes as the description of this, by definition, must be based on observation at that point or in that small area over a substantial proportion of time - rather than attempting to infer the fire regime from a large area observed for a short time. Thus the notion that wall-to-wall mosaic burning was extensively practised in Cape York Peninsula remains to be substantiated.

Amongst those who support the view that indigenous manipulation of fire regimes was a widespread practice, there is disagreement as to the geographical scale of both individual planned fires and the aggregate affect of the imposed fire regime. For example, Flannery (1994) suggested that across the extensive semi-arid/arid zone of Australia many species of semi-arid ground dwelling mammals (the so-called critical weight fauna) were depended on the vegetation habitats generated by this mosaic burning. He argued that cessation of indigenous fire practice indirectly resulted in the extinction of these species. However this idea carries little support amongst the ecological science literature (see Morton 1990, and discussion in Mackey *et al.* 1998). Others have argued that indigenous Australians' use of fire while a fundamental component of their cultural practices was nonetheless relatively geographically restricted within a given landscape. Hill *et al.* (1999, 2000) for example, in examining indigenous land management in the Wet Tropics of Queensland, suggested that planned fires were of the scale of 1-20ha within specific clan estates. Gill (pers.comm.) noted that Leichhardt (1847) reported systematic firing around water sources through the lower Cape York Peninsula and Gulf - he assumed for hunting of animals coming to drink.

At a continental scale, the geographical extent of indigenous influenced fire regimes is likely to have varied with ecosystem type, reflecting fundamental differences in climatic, topographic and edaphic controls on primary productivity and the availability and density of biological resources used for food, tools etc. Also, indigenous fire practices will have varied between ecosystem types as prevailing environmental conditions constrain the extent to which people can manipulate fire regimes.

We support the proposition of Gill (1977) that the most likely scenario is that indigenous Australians only regularly burnt relatively limited areas around their frequent camping areas and travelling routes, otherwise fuel accumulated until touched off by lighting. Hence ignitions were more likely to follow particular travelling routes. Fires may have spread out from these locations, but if this occurred before the grasses were fully cured then fire spread may have been limited.

6.5.3 ENVIRONMENTAL AND BIODIVERSITY CONSERVATION

In acknowledging the role that humans play in modifying natural fire regimes, it is critical not to confuse: (a) what has to be done to bring about meaningful reconciliation for indigenous Australians that delivers social and economic justice; (b) fire management necessary to promote specific culturally-based values; and (c) what is scientifically needed to maintain natural heritage values, especially those related to the conservation of biodiversity and environmental conservation.

Indigenous and non-indigenous Australians have and continue to manipulate fire regimes in landscapes in order to achieve specific goals that reflect culturally-based value systems. For example, across much of Australia, the main purpose of fire management for the last 40 years has been to reduce the hazard of uncontrollable high intensity fires in order to protect human life and property (see discussion in Gill 1977). Indeed managers are always under political, legal and social pressures to suppress or control unplanned fires. Crowley and Garnett (1998a, 1998b, 2000) discussed various reasons why pastoralists in Cape York Peninsula burn vegetation including the desire to maintain forage and control cattle movements. Hill *et al.* (1999) documented how the Kuku-Yalanji people of the Wet Tropics of Queensland used fire management in relatively small areas to promote certain food plants.

Fire management is also proposed as a tool to protect the conservation of elements of biodiversity. For example, Garnett and Crowley (1995) concluded that a particular fire regime is needed to decrease the probability of extinction of the endangered Golden-shouldered Parrot *Psephotus chrysopterygius*. There is a broad base of support for the manipulation of fire regimes in particular landscapes to promote the persistence of populations of usually rare or endangered species or assemblages of species. Indeed, Crowley (1995) has suggested a range of fire regimes needed to maintain the local occurrence of different animals and plant associations across Cape York Peninsula.

It can be argued that rare and endangered species may have little ecological significance. For example, such species may not constitute a significant part of any other species habitat, nor contribute significantly to ecosystem processes. Conversely, some species, in spite of low population density, have profound ecological impacts (Terborgh *et al.* 1999). Furthermore, the rare species, communities, and ecosystems of today may become the dominant ecological features under future climatic conditions. The protection of ecological elements that are currently only minor components of ecological systems represents vital insurance against the uncertainties of both natural and human-induced global (and subsequent meso-scale) climate change.

However, in the absence of long term and detailed studies, it is not possible to determine the ecological significance or otherwise of a rare and endangered species. In these circumstances, the decision to intervene and manipulate natural processes in a landscape to reduce the probability of its extinction can stem simply from a culturally based value reflecting a sense of stewardship for the fate of vertebrate species. Similarly, manipulating fire regimes in order to maintain vegetation patterns as they currently exist, or were thought to exist pre-European settlement, may reflect a culturally based preference to preserve existing conditions. Such a value is evident in both contemporary indigenous and non-indigenous cultures.

Biodiversity encompasses genetic, species, populations and ecosystem diversity. Genetic diversity includes the genetic variation found between populations of a species, while ecosystem diversity refers to the complex sets of plant-animal-fungal communities that develop in locations together with their associated environmental relations. One commonly used measure of species diversity is species richness, that is, the number of species found in a given area. But what is the geographical extent of the target area? The answer is that there is no single spatial unit of analysis. Rather, species richness can be calculated at a range of spatial and temporal scales. By convention, letters of the Greek alphabet are used when examining species richness to identify levels in a nested spatial hierarchy. Many formal definitions have been proposed (see discussion in Halffter 2000), and consistent with these we identify here the following scales:

- *alpha* diversity is the diversity at a site, such as a 40x40m area of similar habitat
- *beta* diversity is the diversity between different and neighbouring habitats; this can be viewed as species diversity at the landscape scale
- *gamma* diversity is the species richness within a geographical area, such as Cape York Peninsula.

We can also consider *omega* diversity, i.e. global species richness. It follows that a species may become extinct at an *alpha* (site) scale but exist elsewhere, i.e. at *beta, gamma* and *omega* scales.

A substantial body of popular and professional opinion supports the view that the environment we experience and the characteristic biodiversity of an area can simply be a matter of human choice, reflecting culturally based preferences. In which case, environmental and biodiversity conservation becomes a social decision-making process (see discussion in Hill *et al.* 1999). From this perspective, a decision to change land management practices in order to increase the richness and population densities of selected bird species at *alpha* and *beta* scales on the basis that these animals are popular is perfectly valid.

We argue an alternative perspective: invariably human intervention interrupts natural processes and produces environmental conditions and characteristic biodiversity that differ from the unimpeded operation of fundamental laws of physics, chemistry and biology. Natural processes result in ecological systems having different characteristics to human dominated systems in relation to net biome productivity, and their capacity to buffer physical fluxes in water and nutrients. Furthermore, an unfragmented region-wide mantle of vegetation ecosystems ensures there is a continuous supply of plant, animal, microbial and fungal propagules being generated and dispersed. We have also noted that under these conditions hydroecological processes critical to habitat conditions are intact. Natural selection remains as the dominant 'management tool' ensuring that only those species establish and persist which are best adapted to prevailing environmental conditions. Ecological systems dominated by natural processes represent self-generating and self-regulating dynamic-equilibrium systems. While biota must contend with effectively random fluctuations in external physical environmental conditions, ecological systems can reach, for periods of time, stable states in their internal environmental conditions. These stable conditions can be maintained even though taxonomic composition changes.

Ecological systems are also dynamic through space. As noted above, propagules are continually being generated and dispersed, subject to the filter of natural selection. Thus in a continually changing and fluctuating external physical environment, the spatial distribution of vegetation will alter as natural selection determines the best adapted suite of species. From this perspective it is inaccurate to describe these processes of vegetation dynamics and succession as the 'invasion' of one vegetation community by another.

The significance of the natural processes of evolution, natural selection, and ecosystem self-generation and self-regulation is further highlighted by the changes potentially being wrought by global climate change as a result of greenhouse gas forcing (IPCC 2000). The high degree of natural integrity of Cape York Peninsula means that ecological systems have the capacity to alter their taxonomic composition and ecosystem functioning in response to an external environment characterised by increasing extremes in meso-scaled climatic conditions. From a global perspective, Cape York Peninsula will constitute a critical natural laboratory of how natural ecological systems respond to future climates.

6.5.4 PRINCIPLES FOR FIRE REGIME PLANNING AND MANAGEMENT

Human-decision making is not a substitute for natural evolutionary and ecological processes. As noted by Kriirskii (1974, cited in Gill 1977) 'Man's help should be thoroughly thought out; he should not lightly and arrogantly re-carve nature'. The question then arises as to what principles should be adopted to guide planning and management in Cape York Peninsula, particularly in relation to fire management.

We have established that the key characteristic of Cape York Peninsula is its high degree of natural integrity. Given this, we argue that planning and management should proceed in a way that is consistent with this value. Thus wherever possible human intervention in natural processes should be kept to a minimum. Therefore we recommend that in Cape York Peninsula, human manipulation of fire regimes only be considered in the following circumstances.

1. To protect species or biological communities threatened with extinction at *gamma* (CYP-wide) or *omega* (global) scales. In the context of Cape York Peninsula (given its high state of natural integrity), intervention to promote the persistence of elements of biodiversity is generally only warranted when a species is endangered at *gamma* and *omega* scales. Intervention to promote the presence of a species if it is only threatened with local extinction at alpha and beta scales is generally unwarranted, as such action will usually represent interference in natural processes of vegetation dynamics and succession. Exceptions include where non-native weed species are out-competing native species. Where intervention is warranted due to a high threat of extinction at *gamma* and *omega* scales, then it is necessary to first undertake the research necessary to acquire the knowledge about the fire regimes necessary for the ongoing survival of the particular species and communities of concern (e.g. Garnett and Crowley 1995).

2. Human intervention can also be socially warranted at *alpha* (site) and *beta* (landscape) scales in order to promote specific culturally based values that are deemed significant. Thus, two additional recommended principles are that manipulation of the fire regime at *alpha* and *beta* scales is warranted:

a. To ensure the safety of human life, settlement or infrastructure, and
b. Where specific land management practices are required by traditional law and customs to help ensure indigenous community well-being.

6.6 FURTHER COMMENTS

In applying Criteria 5 two critical problems are (1) how to measure the impacts of human activity, and (2) how to determine the ecological consequences of these activities. The first issue has been substantially addressed by the various methodologies of Rob Lesslie and colleagues. Though we note that this method does not adequately capture the influence of weeds and feral predators and herbivores that have dispersed in a diffuse manner away from human activity and infrastructure. The Wild Rivers methodology of Nix and colleagues takes us one step further to answering the second question as it integrates biophysical naturalness measures with indices of potential catchment water flow. However precise coupling of NWI and Wild Rivers indices to actual ecological impacts (both at ecosystem and species levels) has yet to be achieved.

The general absence of habitat clearance, fragmentation and degradation in Cape York Peninsula means that connectivity is not currently a major problem for the conservation of biodiversity. In the heavily perturbed landscapes of southern Australia, recent conservation efforts (e.g. the Regional Forest Agreement process, RFA website 2000) have focussed on expanding reserve systems to enhance their representativeness of biodiversity and to promote connectivity. Enhancing connectivity between the remnant patches in a fragmented landscapes is necessary to maintain ecologically viable and effective populations of species, particularly wide-ranging species, and to enable the effective flow and exchange of energy (Soulé and Terborgh 1999). We have discussed in more detail the role of landscape connectivity in maintaining the integrity of hydro-ecological processes. The concept of connectivity is also relevant to the migration of plants and animals at continental and regional scales. As discussed in Chapter 4, Cape York Peninsula, in respect of certain suites of organisms, provides historic and ongoing connectivity between New Guinea and The Wet Tropics bioregion.

Application of Criteria 5 is further complicated by the fact that Australia has been occupied by humans for around 40-60,000 years. We argue however that in the context of Cape York Peninsula, and Australia generally, it is ecologically meaningful to distinguish between the impact of human activity pre- and post-European settlement. This largely stems from the fact that post-European settlement, the human populations of Australia engaged in new landuse activities of a scale and intensity that were orders of magnitude greater than that of humans pre-European settlement. This is not to say the pre-European settlement human activity had no impact on the ecology of Cape York Peninsula, as Indigenous Australians prior to European settlement did use fire as a land management tool. However the precise nature of the influence of humans on fire regimes through time is difficult if not impossible to satisfactorily determine.

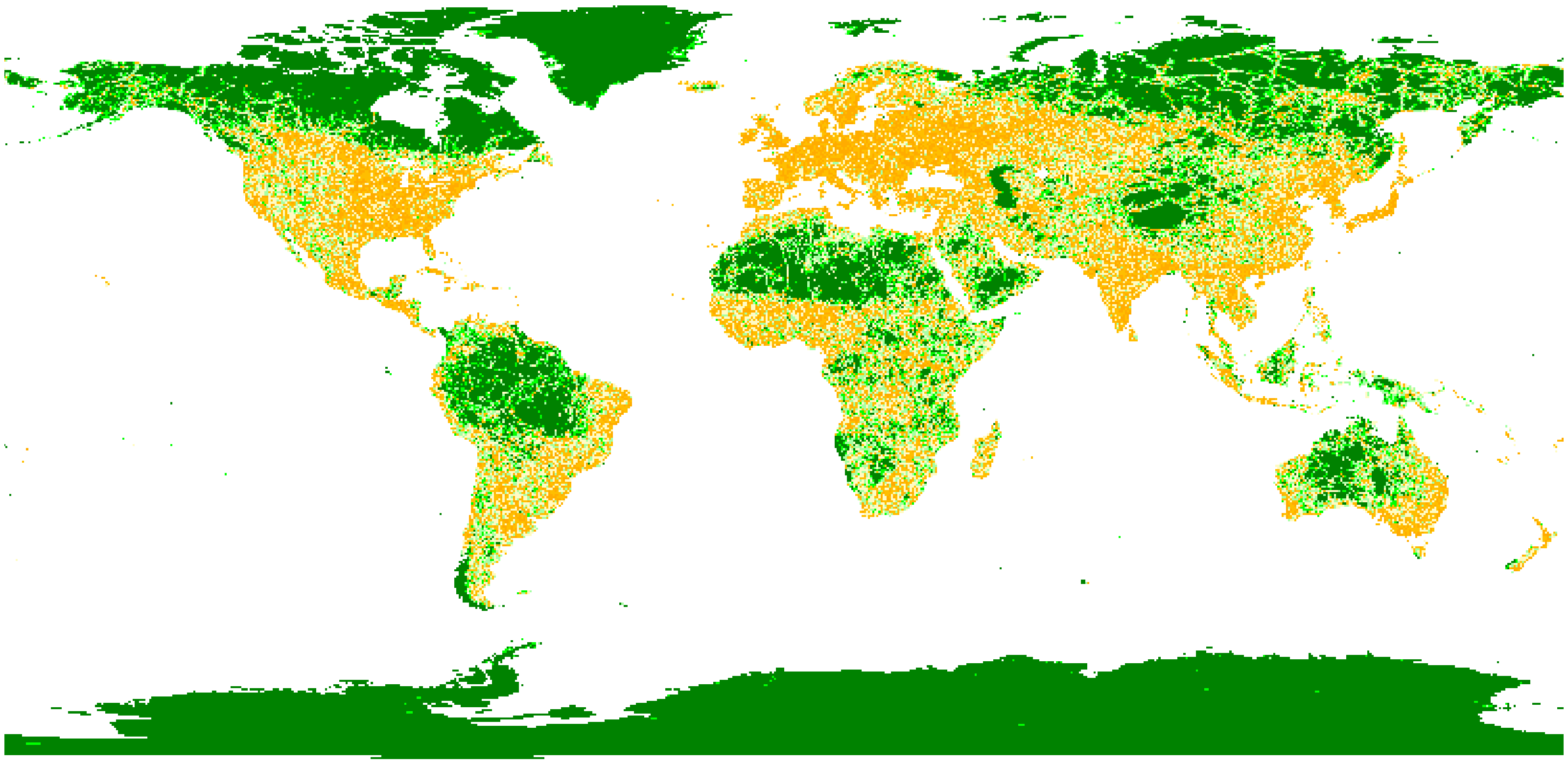
Any major development on Cape York Peninsula threatens its natural integrity. Currently, bauxite mining is the single major disturbance. Rehabilitation of mined areas is mandatory and, for the most part, has been successful, but it is very unlikely that these will return to anything like their original state. Large areas on the western side of Cape York Peninsula are reserved for bauxite mining and if continued to exhaustion of deposits will eliminate the distinctive tall woodland vegetation type. A proposed satellite launching site on the east coast would have a major impact on the biologically significant Olive River catchment (Lees and Saenger 1989) and inevitable associated visitation and recreational disturbance to the nearby dunefields. The proposed gas pipeline from New Guinea down through Cape York Peninsula to Central Queensland poses a major threat to natural integrity. While the actual trench and pipeline, in themselves, are relatively minor intrusions, the associated clearing for machine access, source deposits and pipe storage can be major if previous experience is any guide. Such developments may be inevitable, but given the world natural heritage value of Cape York Peninsula the onus must be placed on the developers to show how these developments can proceed without significant threat to the natural integrity of ecosystems and component processes. Extreme care will be necessary in every case.

6.7 CONCLUSION ON ASSESSMENT AGAINST CRITERIA 5 AND 6

The type and quality of data available for Cape York Peninsula provided a reasonable basis for assessment of its natural integrity and operation of natural processes. Our analyses highlight the high degree of natural integrity of Cape York Peninsula as a key and distinguishing characteristic. This value is significant at the national, regional and global levels.

As noted in the discussion on Criteria 3 and 4, Cape York Peninsula contains three globally significant bioclimates. Each of these has landscapes that are relatively undisturbed by human impact compared with analogous landscapes elsewhere in the world. Irrespective of the scale considered, Cape York Peninsula remains a remarkably unperturbed set of landscape ecosystems. The cover of vegetation/soil ecosystems remains largely intact from watershed divides to the coast. Consequently, the hydroecological processes of Cape York Peninsula have a relatively high degree of natural integrity from both a national and global perspective. Similarly, wildlife habitat is largely uncleared, unfragmented and undegraded.

The combination of regional scale connectivity and high natural integrity of the lands and waters of Cape York Peninsula contribute to its high rating against Criterion 6.0. Retention of the global and regional significance of this value depends on maintaining the spatial continuity of lands of high natural integrity in the Cape York Peninsula landscape and their respective connectivity to the hinterlands of New Guinea and the Wet Tropics region.



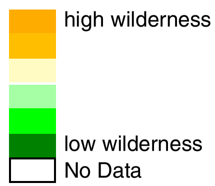


Figure 6.1 Global wilderness quality index based on Lesslie (1997) measures of landscape exposure to technological activity. Source: World Conservation Monitoring Centre.

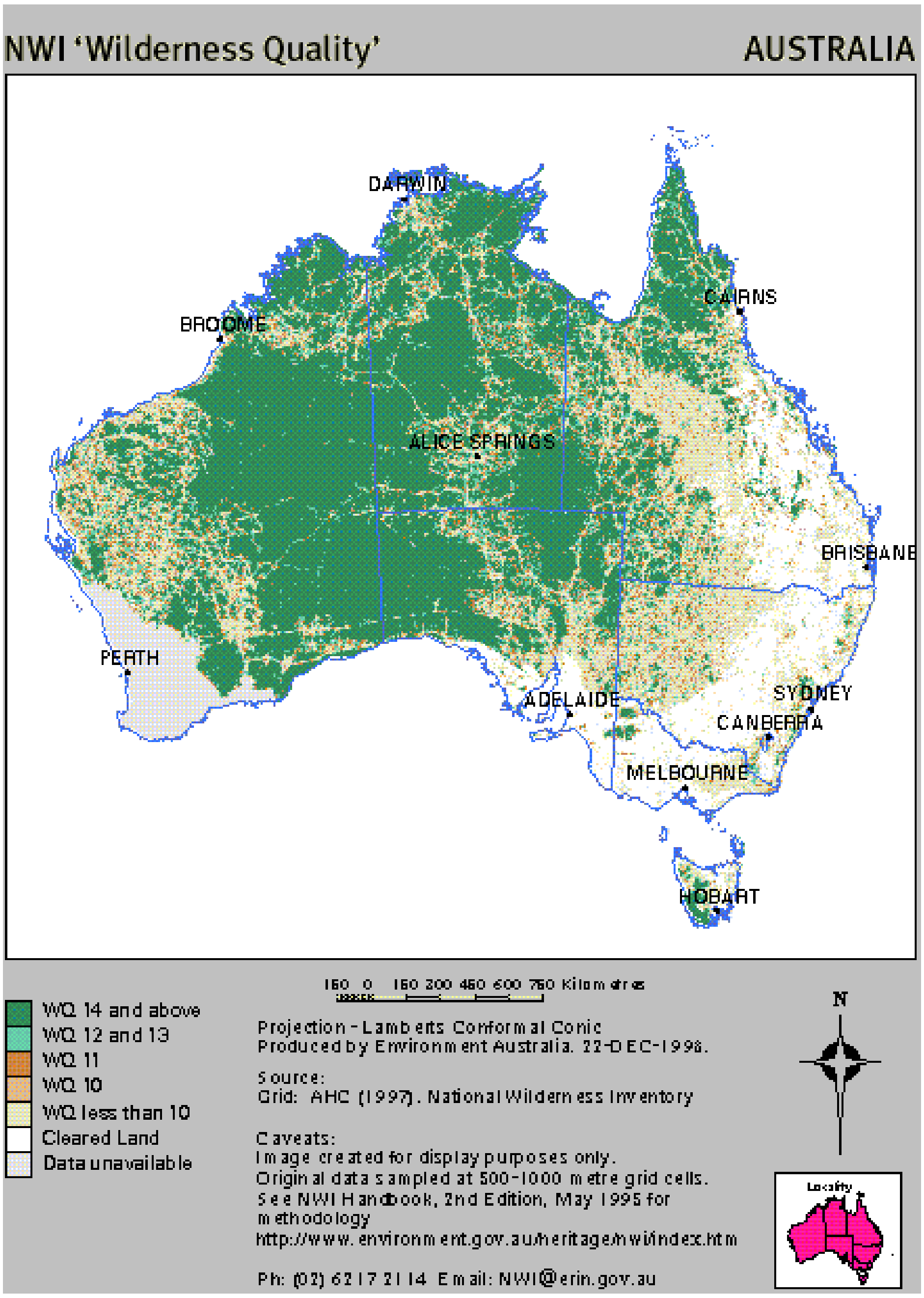


Figure 6.2 Wilderness quality index for Australia.
Source: Environment Australia, National Wilderness Inventory.

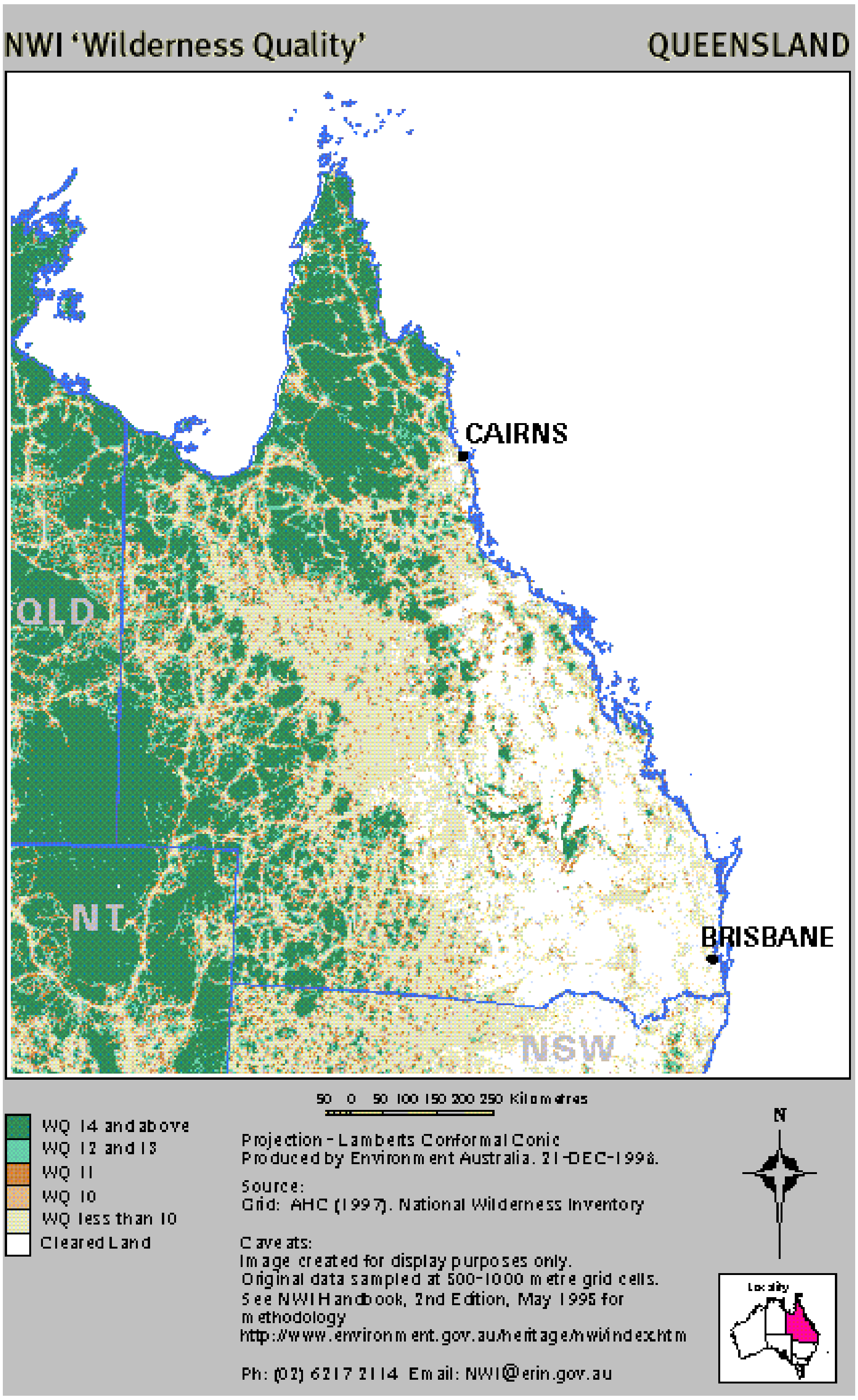


Figure 6.3 Wilderness quality index for Queensland.
Source: Environment Australia, National Wilderness Inventory.

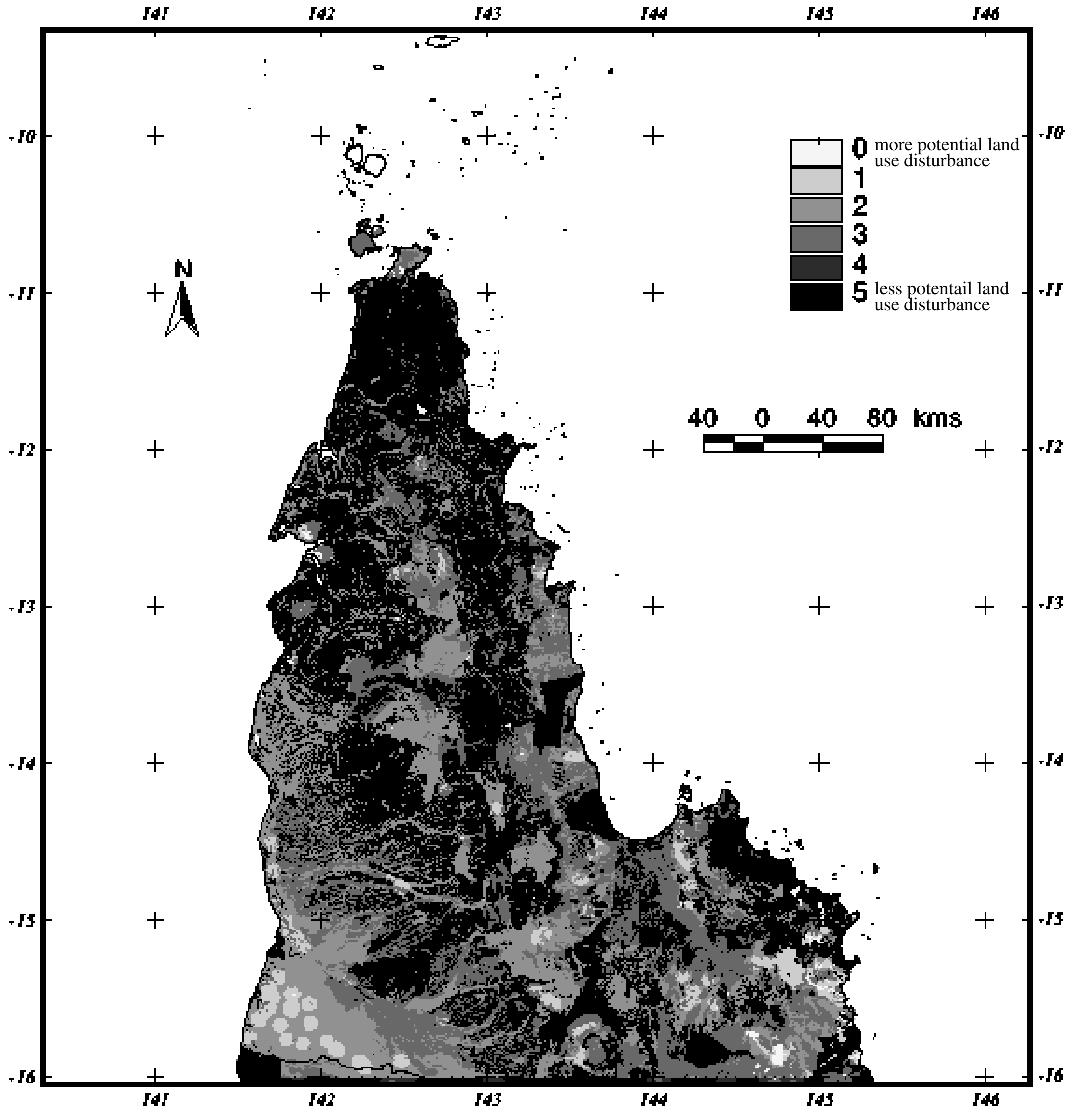


Figure 6.4 Biophysical naturalness of Cape York Peninsula.
Source: CYPLUS GIS data base

This is a relative, indicative measure, largely modelled from inferred influences of potential land use impact associated with different vegetation, soil types, and land tenure.

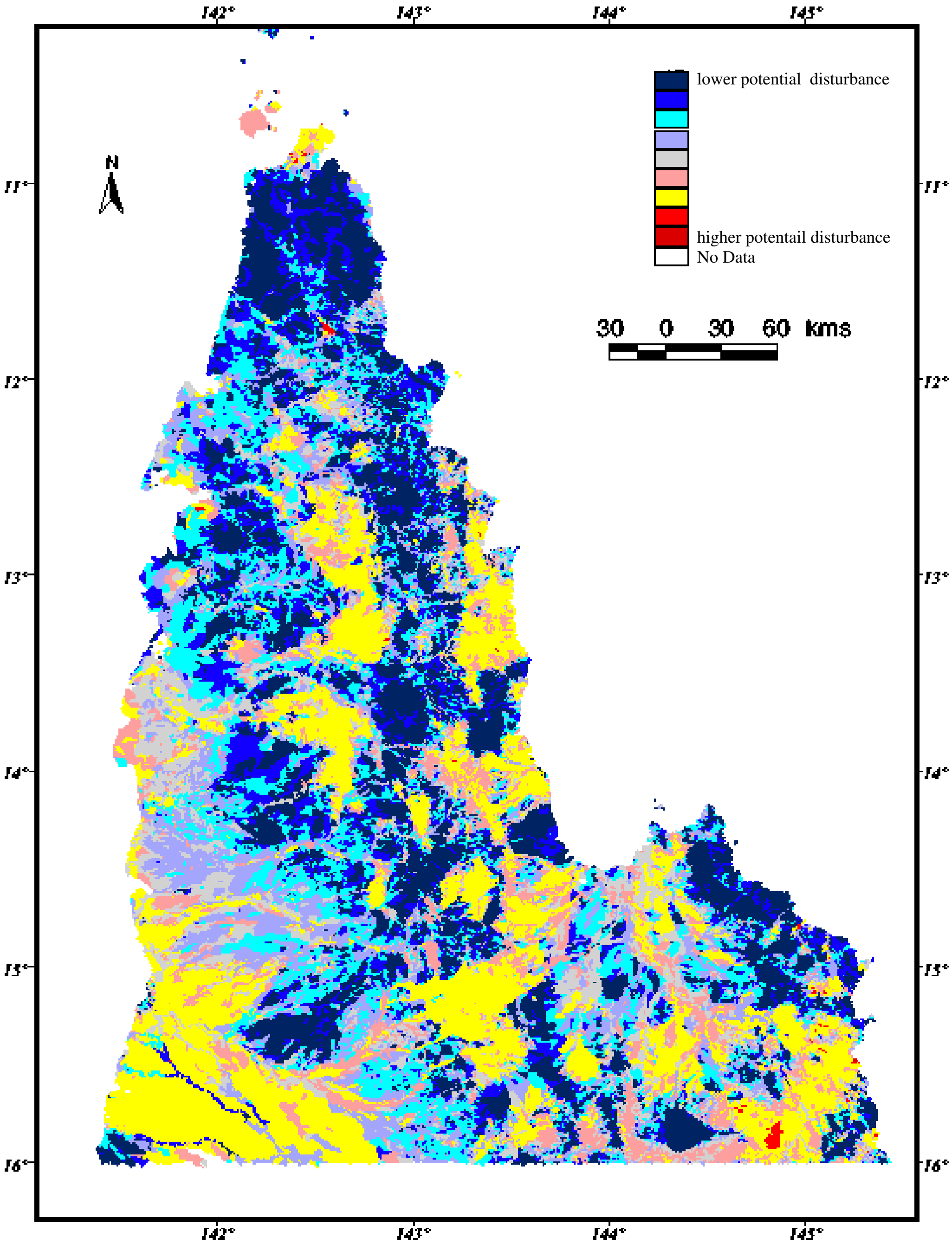


Figure 6.5 Catchment Disturbance Index (CDI) for Cape York Peninsula. Source: CRES/ANU.

Disturbance data are largely based on the modelled Biophysical Naturalness index shown in figure 6.4. Here those data have been intersected with modelled estimates of potential surface catchment flow.

Figure 6.6 Distribution of Catchment Disturbance Index (CDI) values for each Broad Vegetation Group (BVG) in Cape York Peninsula. Compared to the rest of Australia, little vegetation clearance and fragmentation has occurred. Predicted disturbance is largely a function of modelled potential grazing impact. Source: CRES / The ANU

Note: CDI class 1 = higher disturbance
CDI class 4 = lower disturbance

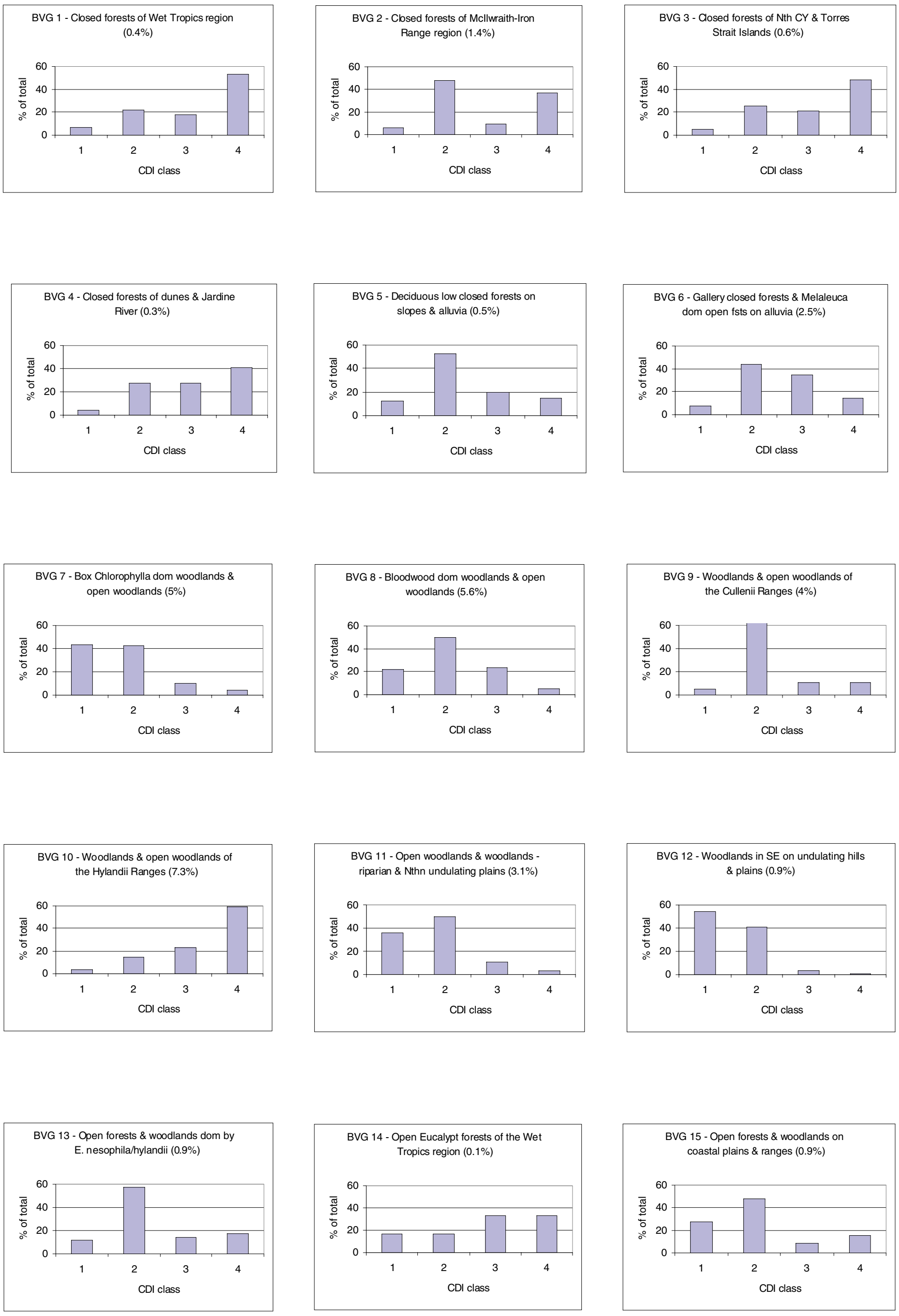
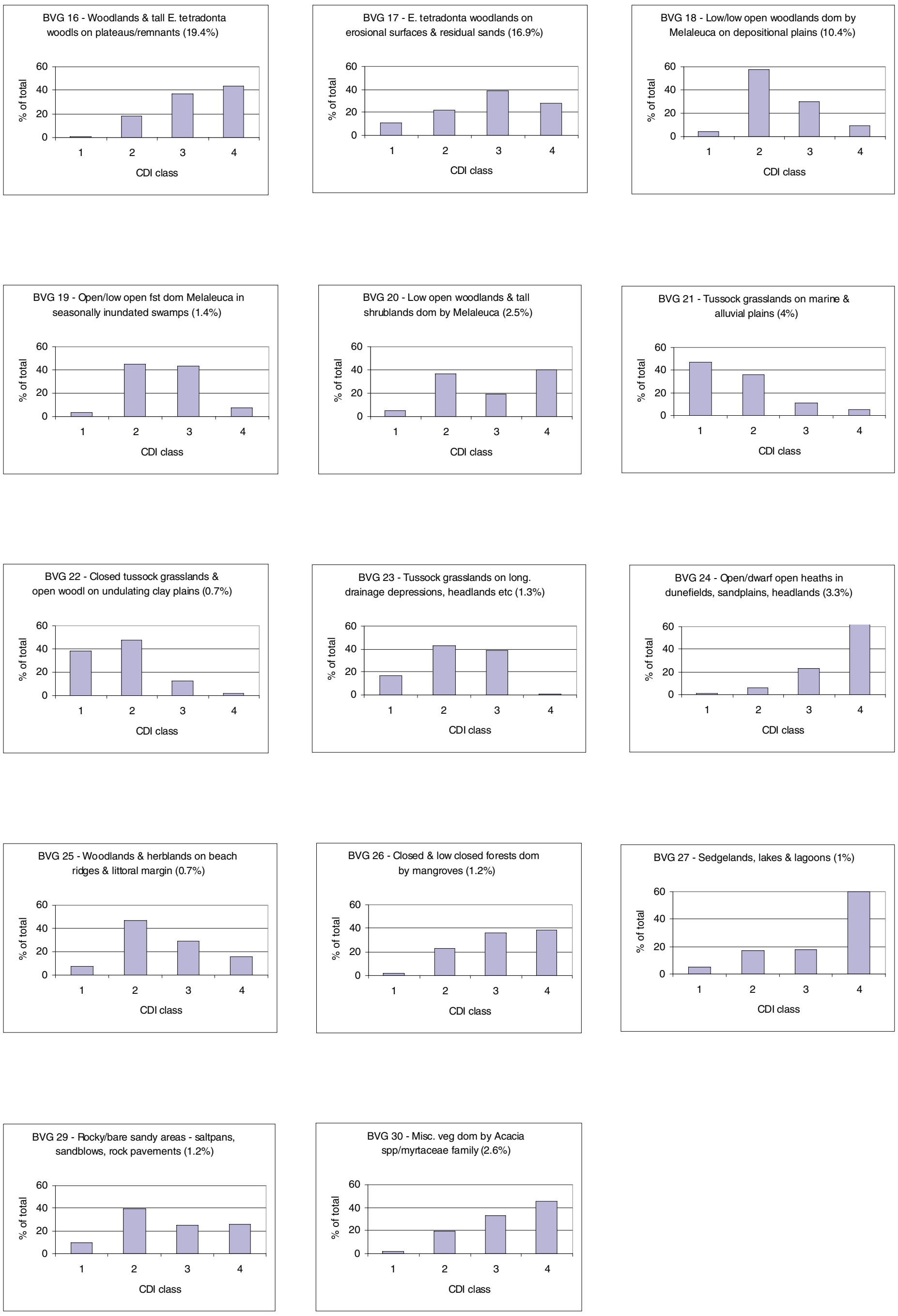


Figure 6.6 Continued.



7 CRITERION 7 CONTRIBUTION TO KNOWLEDGE
CRITERION 8 AESTHETICS

CRITERION 7.0 CONTRIBUTION TO KNOWLEDGE

Examples of geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena, the study of which has, or is continuing to, contribute significantly to an understanding of natural history beyond that place.

Subcriteria:

7.1 Geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena - significant contribution to understanding of natural history.

7.2 Geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes - significant contribution to direct educational value.

CRITERION 8.0 AESTHETICS

Superlative natural phenomena or areas of exceptional natural beauty or aesthetic importance.

Subcriteria:

8.1 Natural phenomena - superlative

8.2 Natural beauty - exceptional

7.1 APPLICATION OF CRITERION 7.0

The core attribute for meeting Criterion 7.0 is that the area, if already studied or if studied in the future, will contribute significantly to knowledge and understanding of natural history of the assessed area, but also beyond the assessed area. Alternatively, the study area will have features that are conducive to facilitating direct education use for the teaching of natural history.

For Sub-criterion 7.1, the area being assessed will either have already contributed significantly to knowledge and understanding as a result of past studies and research or, is particularly conducive to studies which have the potential to contribute to knowledge and understanding of natural history beyond the study area.

Example:
The study of aquatic animals of the Jardine River on Cape York Peninsula facilitated the comparison of the aquatic fauna of the Fly River in the adjacent section of Papua New Guinea. That comparison contributed to the hypothesis that prior to the last rise in sea level, both rivers flowed into a common large freshwater lake centred on the Gulf of Carpentaria and hence shared their aquatic fauna. The study of the Jardine River clearly contributed significantly to an understanding of natural history beyond the Jardine catchment.

For Sub-criterion 7.2, the attributes which contribute to the value of the study area for educational purposes will not be limited to natural values alone, but will include such matters as access, proximity to teaching institutions and the level and diversity of existing information.

Example:
The Endeavour River, Grassy Hill and Mount Cook precincts near Cooktown have a high potential for being *valued for direct educational use for the teaching of natural history* particularly because of the globally historic botanical collections made in 1770 by Banks and Solander, only the second comprehensive botanical survey on the Australian continent. The fact that much of the original vegetation present in 1770 remains intact is also very significant. These precincts are also readily accessible for educational studies. The value of these precincts for educational purposes is greatly enhanced by their natural ecological diversity, the level of protection, their historic botanical significance and of course, the proximity to accommodation and services in Cooktown. These precincts are of global significance for direct educational use.

7.1.1 ASSESSMENT OF CAPE YORK AGAINST CRITERION 7.0

Other sections of this report describe parts of Earth which are environmentally comparable with Cape York Peninsula. The main areas of comparable climate and vegetation structure include Sub-Saharan Africa, parts of South America and parts of India. However, as discussed in Chapter 6, Cape York Peninsula is one of the few major tracts of tropical savanna landscape which retains a high level of natural integrity. Study of at least the savanna landscape of Cape York Peninsula does have the potential for contributing to a global knowledge of the ecology of tropical savannas generally.

A number of attributes were identified which contribute to an assessment of the value of Cape York Peninsula against Criterion 7.0, including:

Natural Integrity:
Cape York Peninsula in general retains a high natural integrity. (see Criterion 5.0) It is unlikely that any of the identified tropical monsoon savanna landscapes elsewhere in the world have a comparable or superior natural integrity to that of Cape York Peninsula. The sub-Saharan savanna's have been grossly impacted by humans and are the subject of

an on-going ‘desertification’ process. The Indian savannas are similarly grossly modified - though small reserved areas are reasonably intact, including small populations of the larger mammals. The South American savannas are similarly under intense population driven pressure for grazing and other development.

Apart from Australia, the world’s tropical savannas are located in developing countries with population driven development pressures. Within Australia, the tropical savannas can be divided into three discrete regions, the Kimberley region in Western Australia, the *Top End* region in the Northern Territory, and Cape York Peninsula in North Queensland. Other parts of this study distinguish between these three areas and highlight the special significance of Cape York Peninsula.

The whole of the seas adjacent to the east coast of Cape York Peninsula are protected as part of the Great Barrier Reef World Heritage Area, contributing in an important way to the natural integrity of the coastal environment and hinterland. Only small parts of the Gulf of Carpentaria littoral of Cape York Peninsula are protected in a number of small Fish Habitat Reserves. The Gulf coast is remote and access is difficult or restricted except at Karumba on the southern extremity and Weipa in the north west. Both are special purpose ports. The present protection and management regimes of the seas adjacent to Cape York Peninsula, especially the current protection regime in the adjoining Great Barrier Reef World Heritage Area, contributes greatly to maintenance of a high level of natural integrity on at least the coastal margins of the Peninsula.

Cape York Peninsula is a large tract of tropical monsoon savanna and associated woodlands, open forests, rainforests and wetlands which retain a high degree of natural integrity, is not subject to desertification, is mostly managed under restrictive Government tenure and which is subject to only limited and manageable threat. The high natural integrity of Cape York Peninsula is therefore very suited to research and benchmark studies of natural processes. Cape York Peninsula can therefore be considered globally significant as a major tract of land ideally suited to research of natural processes at a regional scale and which can contribute to a knowledge of natural processes relevant to other parts of the globe (an example would be the dunal processes operating at Shelburne Bay, a major active dunal area remote from human development activities).

‘Bridge and Barrier’ Landscape:
As discussed under Criterion 1, Cape York Peninsula represents a relict landscape of what was, during the last ice age, part of a continental/sub-continental isthmus connecting Australia and the present island of New Guinea. Prior to that rise in sea level, Cape York Peninsula was the scene of an on-going development in a climatic divide, and consequently a biological divide. As such Cape York Peninsula has been both a bridge and a barrier to biological interaction between Australia and New Guinea. The extant flora and fauna provide relictual evidence of this important bridge or corridor landscape. For example, the fragmentation of the once continuous rainforest into now scattered separate stands represents a valuable landscape for researching the impact of climatic change (drying) and physical impedance of past wildlife movement.

As noted in Chapter 4, some plants and animal groups and species on Cape York Peninsula are shared with New Guinea to the north and the Wet Tropics to the south; some are shared only with New Guinea. From an Australian research perspective, some of the Cape York populations are eminently more accessible on Cape York Peninsula than in New Guinea (e.g. spotted cuscus, southern cassowary, tree kangaroos, electus parrot, great palm cockatoo).

The Torres Strait Islands continue to provide ‘biological stepping stones’ between Australia and New Guinea for some species. The scatter of rainforest remnants down the east coast of Cape York Peninsula, together with the Torres Strait Islands, similarly provide ‘stepping stones’ for the annual migration of rainforest birds and flying mammal species between the rainforests of New Guinea and the rainforests of the Wet Tropics and Lower Cape York Peninsula. (e.g. Shining starling, Koel, Torres Strait Pigeon)

Cape York Peninsula is distinguished from the savanna landscapes of the Kimberley Region and Arnhem Land Region by having been almost permanently linked to New Guinea whereas the Arnhem Land and Kimberley connections have been less frequent and of shorter duration.

Access:
At the Global level, Cape York Peninsula is comparatively readily accessible with good global air services via the city of Cairns on the south eastern coast of the Peninsula. Daily air services are available from Cairns to parts of Cape York Peninsula. Road access is available to a large proportion of the Peninsula in the dry season (approximately June-November). Indeed, organised commercial eco-tourism excursions enter Cape York Peninsula almost daily. Ground access to northern Cape York Peninsula is strictly limited during the ‘wet’ season, December to May.

Whereas most of Cape York Peninsula has a low level of all weather road access, it is traversed by a series of low standard roads, including a 4-wheel drive road along the spine of the peninsula. In terms of access for research and educational purposes, it provides a range of access standards from all-weather road access to rarely used 4-wheel drive track access. Cape York Peninsula is eminently more accessible and safer than any of the small but comparable areas on adjacent sections of the island of New Guinea. Cape York is undoubtedly one of the most readily accessible of the tropical monsoonal savanna landscapes in the world, if not the most accessible.

Tenure:
Most of Cape York Peninsula remains in some form of Queensland Government land tenure, namely national park, pastoral lease and various forms of Aboriginal lands. The national parks in particular represent valuable research and education resources with an appropriate land tenure. Natural Heritage conservation is already a recognized land use and management objective for most if not all of the area. Cape York Peninsula is already recognized as a unique area deserving of special land use and land management planning, hence the CYPLUS process and the *Cape York Heads of Agreement*.

Past Studies:
Cape York Peninsula has already been the subject of a concerted series of natural heritage studies which have produced valuable material for education purposes, thereby contributing significantly to the potential of the area for educational use and researching of natural history.

In the 1970’s, the Commonwealth in conjunction with the Queensland National Parks and Wildlife Service facilitated a Queensland wide ‘Rapid Assessment’ of the natural environment to identify Key and Endangered Sites (RAKES) (Stanton and Morgan 1976) Of the 44 key and endangered sites identified by the RAKES study, four of the five highest priority sites are part of Cape York Peninsula (1. Eastern Cape York Peninsula, 2. Jardine River and 3. Upper Daintree River - Windsor Tableland, 5. Daintree - Cooktown). This study was the first study to place the conservation significance of Cape York Peninsula into at least a State-wide context and contributed valuable knowledge of the region.

Indeed the CYPLUS study, not withstanding the scientific limitations, ranks as one of the most important regional scale environmental studies undertaken in Australia. The data derived from that study have already made a major contribution to knowledge of the Peninsula and in turn the continental, regional and global context of much of its biodiversity. The CYPLUS data is a nationally and internationally important data base, providing a very sound foundation for on-going research and study to contribute to understanding of the natural heritage of the greater region embracing the Wet Tropics and New Guinea.

The CYPLUS data base also reveals major gaps in our knowledge of Cape York Peninsula and the need for further systematic survey and research. For a host of reasons, not the least of which is the proximity to the Cairns campus of James Cook University, Cape York Peninsula will continue to attract research and to contribute to our knowledge of the processes operating in this minimally modified regional landscape. The Experts Workshop conducted as part of this study revealed a range of research studies which are current or recently conducted on Cape York, particularly by or in conjunction with James Cook University, and the CSIRO Division of Sustainable Ecosystems with its laboratory in Atherton. Both of these key organisations together with others are represented on the CRC for Tropical Rainforest Ecology and management, based at the Cairns campus of JCU.

Historic Studies:
The Endeavour River and Grassy Hill precincts at Cooktown deserve special mention as the site of the first comprehensive botanical collection on the continent of Australia. It was here that Banks and Solander spent 6 weeks collecting plants in 1770 as a part of an enforced stay occasioned by the holing of Captain Cook's ship the Endeavour on the nearby Great Barrier Reef. Given that the river and headland have remained more or less undeveloped provides an outstanding opportunity to revisit the site for historical botanical reasons. These precincts are of at least regional and global significance given its past contribution to global botanical knowledge, and further, because of the excellent condition of the site, will continue to be of great value for education.

The precinct probably has global cultural heritage significance both as the site of a globally historic biological survey and as a European/Indigenous contact site.

Proximity to Research and Teaching Institutions:
Cape York Peninsula is adjacent to the city of Cairns where the Cairns Campus of James Cook University is located. The Co-operative Research Centre for Tropical Rainforest Ecology and Management is based on the Cairns Campus. Cape York Peninsula, compared with comparable landscapes elsewhere in the world, is therefore well placed for the conduct of major research and education programs focussing on tropical monsoon savannas and rainforests, in particular the regional scale impacts of climatic change.

7.1.2 CONCLUSIONS

At the Global level, Cape York Peninsula represents one of the most intact, (if not the most intact) relatively protected and accessible major tracts of tropical monsoonal savanna and rainforest complexes. As part of a biological corridor between a continent and a sub-continent, Cape York Peninsula potentially has much more to tell about climatic change and the severing and joining of biological links between major land masses. This is of global significance.

Compared to other comparable landscapes in the world, Cape York Peninsula is more accessible and potentially has more to offer as a site to make a major contribution to knowledge of natural processes and natural history. Cape York Peninsula is considered particularly valuable as a study site for researching the effects of on-going global climate change and the associated changing relationship of the landscape to the new subcontinent of New Guinea - from bridge to barrier.

Cape York Peninsula as a whole is considered to readily meet sub-criterion 7.1 on the basis of the contribution that it has already made to knowledge of natural history and the great potential that it has for on-going contribution of knowledge.

Cape York Peninsula also has the potential to be *valued for direct educational use for the teaching of natural history* (Sub Criterion 7.2). In particular, the Lower Cape York Peninsula and Cooktown sub-region is clearly identified as being *valued for direct educational use for the teaching of natural history* and is presently utilised accordingly.

At the whole of Cape York Peninsula level, its value as a site for *contributing significantly to an understanding of natural history beyond that place* (Sub Criterion 7.1) is paramount.

The finding of this study, is that a sound case can be made for Cape York Peninsula[1] meeting Criterion 7.0 (Contribution to Knowledge), principally on the basis of it *contributing significantly to an understanding of natural history beyond that place.* The strength of the case became increasingly evident during the course of this study and can no doubt withstand further examination and scrutiny.

1 The whole of Cape York Peninsula exclusive of grossly modified areas such as towns, mines, port facilities etc.

7.2 CRITERION 8.0 AESTHETICS

Heritage value assessment: *It is as important to consider the process of synthesis as it is to analyse the components* (Schapper 1993).

Note: This paper addresses only *natural heritage* as defined.
It specifically does not address the cultural aspects of the landscape.

7.2.1 APPLICATION OF CRITERION 8.0

Criterion 8.0 is derived from Natural Heritage Criterion (iii) of the World Heritage Operational Guidelines which is a routine part of the assessment for World Heritage. However, it is very unlikely that any area would be World Heritage listed on this criterion alone. This suggests that the relative subjectivity of this anthropocentric value has been recognized. In the case of Cape York Peninsula, Criterion 8 needs to be applied very carefully in the case of important land use determinations.

Whilst wording of the derived criterion adopted for this study could be improved, the original components of Criterion (iii) of the World Heritage criteria have been retained to allow direct translation. The concept of *natural phenomena* is open to interpretation and could be a static feature (like a volcano) or could be a dynamic process (such as volcanic lava outpourings). A feature is likely to be of limited extent, but could also extend across a whole region like the Undara Lava Tube south of Cape York. For such a phenomenon or feature to be described as *superlative* it would need to be particularly distinctive and represent an outstanding example of type. Based on the extensive documentation of lava tubes in the world, Undara Lava Tube would, for example, readily qualify in the category of *superlative natural phenomena*.

Defining Natural Beauty and Aesthetics:

Natural beauty tends to be regarded as a construct of the visual senses whereas *aesthetics* is the more generic term, not limited to the visual senses but including all the senses such as smell, touch and hearing. Here the term *aesthetics* will be used as the generic term to include *natural beauty*.

> *It must be recognized that there may not, necessarily, be a common meaning to aesthetic value.* (Schapper 1993)

Natural beauty and *aesthetics* are conventionally accepted as being not limited by scale and so theoretically can range from microscopic to very extensive regional landscapes. Although the sensing of natural beauty is conventionally associated with the visual senses, it need not be so limited. Related to the issue of scale is the perspective or point of viewing a place. For example, at ground level a woodland on a vast plain may not be considered something of *exceptional natural beauty* or of *aesthetic importance* but that same landscape viewed from a vantage point could well be widely agreed as being of *exceptional natural beauty* or of *aesthetic importance*. This distinction frequently leads to debate about aesthetic attributes and whether it is acceptable to make an assessment based on say, a single vantage point.

The following definitions have been extracted from the literature. Although they are somewhat different they are not incompatible.

Aesthetic Value 1
Aesthetic value is the response derived from the experience of the environment or of particular natural and cultural attributes within it. This response can be either to visual or non-visual elements and can embrace emotional response, sense of place, sound, smell and any other factors having a strong impact on human thoughts, feelings and attitudes" (agreed definition in workshop reported in Ramsay and Paraskevopoulos 1993).

Aesthetic Value 2
Those natural and cultural features of the landscape which elicit one or more sensory reactions and evaluations by the observer, particularly in regard to their pleasurable effect (Grinde and Kopf 1986 cited in Schapper 1993).

The concept of aesthetics is generally considered to extend beyond the seen view, visual quality or scenery and may include landscape character, sense of place and the ambience of the place. Some argue that aesthetics is mostly about experience derived from a landscape. The literature acknowledges that human perception of a landscape or landscape feature is highly sensitive to such things as previous life experiences (e.g. education, culture, occupation, age), the conditions prevailing at the time of the experience (weather, time of day, time of year) and the social context of the experience (accompanying persons, purpose of visit etc.). The perception is also undoubtedly influenced by knowledge about the landscape and familiarity with the landscape such as whether it is untracked natural land or about to be cleared or protected as national park. Given that a common objective and outcome of visitor interpretation programmes is to 'impart knowledge' and to 'build support' for a landscape, familiarity with a landscape can be expected to create a sense of 'support' or 'affection' for that landscape.

7.2.2 ASSESSMENT OF AESTHETIC VALUES
A review of the limited relevant literature on the subject of assessment of landscape aesthetics indicates a strong commitment in the 1960's and 1970's to the *Expert* and *FormalAesthetic* models. By the early 1980's there was increasing acknowledgement of the importance of the experiential approach so assessments moved to the right of the spectrum in the 1980's and 1990's (Ramsay 1999). Lamb (1993) has argued that the aesthetic experience is indeed a complex of factors and that the assessment process should reflect that. To further add to the difficulty of addressing the matter of aesthetics as a heritage value is the idea that *aesthetic value is complex and may be hard to separate from other components of heritage value* (Schapper 1993).

Lothian (1993) cited Zube's classification of four models of aesthetic assessment methodologies, and Daniel and Vining's five models.

Classification of Landscape Assessment Methods (Lothian 1993)

Zube				
	Expert	Psychophysical	Congitive	Experiential
Daniel & Vining				
Ecological	Formal	Psychophysical	Psychological	Phenomenological

The models at the left side of the spectrum apply objective techniques and focus on physical qualities of the landscape, to the almost complete exclusion of the observers experience. At the right side, the techniques are more subjective and the observers experiences are paramount, almost to the total exclusion of physical attributes. The psychophysical methods in the middle of the spectrum combine both techniques and provides an avenue for assessment of the physical attributes of the landscape through measurement of observer preference.

The Australian Heritage Commission opted to use what is described as a *multi-layered approach* but which is essentially an experiential driven model, though in some cases in Victoria, incorporated the Visual Management System (VMS) maps when available, an *expert* based model.

The trend over the past 30+ years for aesthetic assessments to move across the spectrum from *Expert* and *Formal* approaches to the *Experiential* and *Phenomenological* should not be interpreted as an invalidation of the *Expert/Formal* approach but rather appears to represent a change of emphasis to respond to the demand to involve communities in more open and accountable processes on public lands, in particular in the Australian forest estate. Both types of assessment are valid and indeed are complementary, suggesting that the most defensible model for application across large tracts of land is a more eclectic multi-strand approach which incorporates elements of the two ends of the spectrum of models.

An important contribution made during the course of this study was the introduction by John Reid (pers. comm.) of the concept of Aesthetic Potential. The formal or expert models can only identify and delineate what Reid describes as Aesthetic Potential and cannot substitute for actual human experiences (accommodated in the phenomenological models) which are necessary to determine aesthetic value. Zube's Expert Model therefore equates to Reid's Aesthetic Potential. It follows that Aesthetic Potential can be assessed and mapped with little or no input of human experience but must not be presented as actualised aesthetics without some measure of experiential input. Zube's Experiential model can be equated to Reid's (realised) Aesthetic Value.

Given the foregoing explanations, the identification and mapping of components of the physical landscape is an appropriate way of representing Aesthetic Potential and therefore provides a valuable first step towards assessment of realised Aesthetic Value. This approach also provides a way of assessing extensive landscapes which have not been visited by or are not readily accessible to visitors as in the case of Cape York.

Aesthetic Values can therefore be thought of as comprising a combination of physical characteristics of a landscape (Aesthetic Potential) and human responses to those elements (Visitor Experience), that is:

$$\textit{Aesthetic Value} = \textit{Aesthetic Potential} \; * \; \textit{Visitor Experience}$$

Ideally the experiential component requires direct assessment of human responses, preferably using inputs from sampling surveys. However, it is important to be cautious about applying a stratified approach to a region where it might be argued that the aesthetic potential can equally apply at the holistic level of the total landscape. Cape York Peninsula is one such region where the aesthetic potential can be readily stratified, but where at least a large proportion of the experiential aesthetic value may attach to the whole of the region and not be as readily subdivided as the physical landscape or aesthetic potential suggests.

Nonetheless, regional landscapes such as Cape York Peninsula can be stratified according to forecasted human responses to different landscape elements. For example, the shorelines, waterways, gallery forests along waterways and rocky escarpments can be mapped and an aesthetic potential of each applied to provide an indicative map of the aesthetic potential across the region. This approach can serve to highlight at least the pattern of aesthetic potential across the region, perhaps to the point where one could convert the results into an *iso-aesthetic potential* contour map of a region.

Human responses to some physical elements in a landscape can be accurately predicted and may therefore require less direct survey. For example, human responses to shady forest and water features in a dry season environment on Cape York Peninsula can be readily predicted as a positive response. In some instances, surrogates may provide at least partial confirmation of predicted human responses with varying degrees of confidence. For example, tour brochures for Cape York very commonly illustrate water features (river crossings, waterfalls), suggesting that either such features are being sought by tourists or, less likely, the tour operators are 'double guessing' what their clients are seeking. Given the maturity of the tourist industry in this region, it should be safe to interpret that water features are indeed appreciated if not sought out by tourists. Water features can therefore be recorded as being a distinctive element of the Cape York Peninsula landscape likely to provide the stimulus for a rewarding experience in the observer.

It would therefore be appropriate to identify certain landscape features or types which, by virtue of their physical characteristics, are likely to provide sufficient visual and other stimulus to invoke a rewarding human experience in a majority of observers. The physical characteristics of the landscape provide the framework for assessing Aesthetic Potential but the Aesthetic Value can only be assessed by monitoring responses or extrapolation by modelling responses.

In additional to the physical attributes of a place, other factors may significantly influence the human experience. For example, provision of knowledge about the place, conditions prevailing during the experience, language and many more can be influential.

7.2.3 Assessment of Cape York Peninsula[1]

There is no single data base available which provides direct insight into aesthetic values on Cape York Peninsula. However, some physical landscape elements can and have been mapped for a variety of purposes and which can provide the basis for assessment of Aesthetic Potential. Surrogate data about human responses to the Cape York Peninsula landscape provide the basis for converting at least part of the assessable Aesthetic Potential to at least indicative Aesthetic Value.

For a major tract of land as large as Cape York Peninsula, it would be very difficult to undertake a comprehensive experiential survey of the whole region. Such a survey would of necessity be limited to sampling of the more accessible parts of the region. Even with survey of actual experiential information for accessible sites there would be a need to extrapolate across the region. Extrapolation can be achieved by one or both of two approaches.

The first approach, primarily using an Experiential methodology, would be to workshop communities in the region in a way similar to the AHC methodology, thus drawing on local knowledge. However, the reliability of this approach might come into question given the sensitivity of local politics and the lack of vehicular access to many parts of the region. Local input would need to be broadened and supplemented by interview of visitors/tourists to the region. Even so, actual experience is likely to be biased towards existing vehicular access. Notwithstanding the limitations of this way of assessing actual experiences, it could make a significant contribution to understanding the aesthetics at a 'whole of Cape York Peninsula' level.

The second approach, using an Aesthetic Potential or Expert methodology, would be to map landscape elements whose physical characteristics have been established as likely to provide the stimulus for a rewarding human experience. This approach could be enhanced by incorporating surrogate information to test the reliability of predictions of value based on Aesthetic Potential.

Ideally, assessment of a place or region for Aesthetic Value must comprise a combination of the two above approaches, using the mapped Aesthetic Potential to extrapolate the reports of experiential data gathered from all relevant sources. The current study did not provide for research of experiential data other than any existing published or unpublished survey data. Indeed, it was apparent that little or no such data of significance to this study had been gathered.

Given the limitations of this study, assessment of aesthetics on Cape York Peninsula was essentially limited to an assessment of Aesthetic Potential with a limited level of validation from surrogate sources of human responses to the landscape.

[1] The authors acknowledge their adoption of a conventional Euro-centric approach to the assessment of aesthetics on Cape York Peninsula and recognise that different ethnic or cultural backgrounds may result in a different result. In particular, the indigenous inhabitants of Cape York Peninsula may view the landscape differently, a factor which may become apparent if a cultural heritage assessment of Cape York Peninsula were to be conducted.

7.2.4 AESTHETIC POTENTIAL ON CAPE YORK PENINSULA

The Cape York Peninsula landscape can be conveniently divided into a number of component parts for the purpose of assessing the Aesthetic Potential.

MACRO-LANDSCAPE:	MICRO-LANDSCAPE:
Coastal foreshore	**Coastal features**
• *Beaches*	• *Forest and woodland*
• *Headlands*	• *Rainforest*
Marine	• *Woodland and scrub*
• *Reef*	**River landscapes**
• *Island*	• *Gallery forests*
Interior	• *Water features*
• *Extensive natural wooded landscapes*	**Subterranean landscapes**
• *Prominent and distinctive landscape features*	• *Caves*

There has been no systematic study of these landscape elements for the whole of Cape York Peninsula from an aesthetic viewpoint. However, some have been mapped for other purposes and an assessment could be made for some of the more distinctive elements.

A. MACRO-LANDSCAPE:

Coastal foreshore

Cape York Peninsula is bounded on three sides by a coastal foreshore, fronting the lagoon of the Great Barrier Reef to the east, Torres Strait to the north and the Gulf of Carpentaria to the west. This represents a coastline of more than 1800 kilometres. A few small coastal towns such as Weipa and Cooktown and small villages such as Pompuraaw and Lockhart River punctuate this otherwise continuous natural coastal landscape. From a landscape assessment view point, the most important attribute of the coastal foreshore of Cape York Peninsula is the exceptional visual integrity arising from the undeveloped, natural condition of the coast and immediate hinterland. Most of the coastal foreshore can be readily described in at least an aesthetic sense as wild coast or wilderness coast. Not only does the coastline present an image of exceptional visual integrity but studies have also demonstrated the exceptional biological integrity of the coastal lands of the Peninsula (Danaher 1995).

• *Beaches*

Long sandy beaches are a feature of both the western and eastern coastal foreshores of Cape York Peninsula and are highly regarded for their aesthetic values, especially their high degree of naturalness. The eastern coastline is generally more visually stimulating with its more dynamic coastal processes, higher rainfall and often higher and more rugged hinterland.

• *Headlands*

Headlands are a feature of the eastern foreshore of Cape York Peninsula but are rare on the west coast. Some are very visually distinct and exhibit a high degree of natural beauty.

Marine

• *Reef*

The aesthetics of the coral reefs adjacent to Cape York Peninsula are assumed to be at least as valued as other parts of the Great Barrier Reef World Heritage Area to the south.

• *Island*

Rugged continental islands occur in the south-east, in Princess Charlotte Bay and in Torres Strait, while coral cays occur along the eastern margins of the Great Barrier Reef.

Interior

• *Extensive natural wooded landscapes*

Cape York Peninsula is often characterised in the literature as a vast area of natural forest and woodland stretching uninterrupted to the horizon. However, because of the extensive subdued landscape in the northern and western part of the Peninsula, there are few places where vistas of this expanse can be obtained from existing access tracks on the ground. Such landscapes are never-the-less frequently viewed from the air by visitors entering Cape York Peninsula. Further south there are more numerous accessible elevated places which facilitate viewing of the vast wooded landscapes of Cape York Peninsula. A classic and readily accessible viewing point is Grassy Hill at Cooktown where, notwithstanding the town in the foreground, the vista is not just vast but presents an interesting skyline of distinctive flat-topped mountains.

• *Prominent and distinctive landscape features*

Notwithstanding the generally subdued landscapes of at least the northern and western parts of Cape York Peninsula, the south and east presents a variety of prominent and distinctive landscape features such as Black Mountain, Roaring Meg Falls, Mount Mulgrave, Mitchell River Falls, Cape Melville, Iron Range and Mount Cook, only some of which are readily visible from roads. Many smaller landscape features occur throughout the Peninsula.

B. MICRO-LANDSCAPE:

Coastal features

The vast coastal foreshore is the scene of many coastal features, large scale and small scale, which are of aesthetic importance or of outstanding natural beauty.

• *Forest and woodland*

Forest and woodland dominates the Cape York Peninsula. However, visitor appreciation of the interior is often closely linked with the exceptional vegetation rather than the typical vegetation. For example, many visitors tend to seek out the cool and shady gallery forests and rainforests.

• *Rainforest*

Although much of the rainforest on Cape York Peninsula is not readily accessible, many smaller stands are accessible and utilised by visitors.

• *Woodland and scrub*

River landscapes

The strong seasonality of the rainfall on Cape York Peninsula means that the flow levels of rivers is highly variable. Notwithstanding, most rivers have a sustained dry season flow and well defined gallery forest, often of rainforest

- *Gallery forests*
- *Water feature*s

Subterranean landscapes

- *Caves*

Only one extensive area of karst is known from Cape York Peninsula, located on the far south of the Peninsula between the Mitchell and Palmer Rivers. This karst is considered to be one of the best examples of tower karst in Australia. The caves have been explored to a limited extent and reports are available (Nott pers. comm.). The caves and vicinity are habitat for a number of rare and endemic species including local cave fauna and Godman's Rock Wallaby (*Petrogale godmani*), a Cape York endemic. The karst has been listed on the National Estate Register for geological and biological reasons. The aesthetic values of the karst and caves could not be assessed in this study.

Mapping of each of the more specific landscape components presents a network of streams and gallery forests, a scatter of special features and rainforest areas, with the whole area being bounded by wild coastlines. The extensive natural landscapes effectively fill in many of the 'blanks'. The net result is that the whole of Cape York Peninsula contains significant potential aesthetic values. The physical environmental potential is therefore present - it remains only to assess the realised aesthetic experiences.

There is extensive indirect evidence to indicate that Cape York Peninsula is highly regarded for the distinctive and memorable experiences available, that together build to a total experience of this vast region.

7.2.5 ASSESSMENT OF THE EXPERIENTIAL AESTHETIC VALUES

An assessment of aesthetic values of a regional scale landscape needs to establish if the region has an identity in the public mind. Cape York Peninsula can be readily demonstrated to have a well developed identity, widel y known in Australia as Cape York or in Queensland as simply *The Cape*. Numerous books, maps, tour guide books and tourism brochures consistently identify *Cape York*. Given that it has a clear regional identity, it is legitimate to assess the whole region as a single landscape entity.

Reid (pers. comm.) described how *the aesthetics of a landscape is the extent to which the land evokes an aesthetic expression of meaning*. Reid further described how the expression of meaning for Cape York Peninsula, if it exists, will be reflected by such manifestations as *…cultural study, cinema, paintings, dance, books, literature, poetry, theatre, visual arts, music, craft and be the object of scholarly interest*. The landscape will likely have stimulated the emergence of community leaders and scholars.

Preliminary analysis indicates a high level of cultural celebration of 'Cape York' as a special landscape:

Books
Numerous books have been published on the natural and cultural history and heritage of Cape York, a number of which are current (for example, Frith and Frith 1995).

Dance
The Laura Dance Festival held every two years on Cape York Peninsula is an outstanding example of a distinctly 'Cape York' indigenous cultural phenomena, recently extended to embrace the Torres Strait Islands communities. The Festival now attracts international interest.

Tour Promotions
Cape York is the feature of many specific tour brochures and other promotional material. The image promoted is one of a vast wild landscape requiring special transportation arrangements to access it. Although there is usually some cultural features promoted, the primary focus in on the natural landscape, especially landscape features such as waterfalls and rivers. Cooktown receives a distinct sub-set of this promotion but is often featured as an integral part of the Cape York Peninsula experience.

Art
Indigenous art is distinctive and reasonably well known. The paintings of Tresize and his contemporaries such as Ludij Pednhave have played a part in creating an art image of Cape York. Distinctive landscape features such as Black Mountain are a recognisable part of the huge art resource marketed through Cairns. Many landscapes painted on Cape York Peninsula are of landscape types which are not wholly confined to the area and may be promoted as part of the *Outback* genre.

Scholarly Interest
Cape York has attracted scholarly interest since the late nineteenth century, especially scholarly research of the indigenous culture which was less disrupted by European settlement than most of east coast Australia. The natural history of the region has attracted a great deal of scholarly interest, especially that component which related to New Guinea.

Many of the cultural manifestations of Cape York Peninsula are integrated into commercial tours and self guide literature, all creating a distinctive image of the region.

7.2.6 ASSESSMENT OF CAPE YORK PENINSULA AGAINST CRITERION 8.0

As discussed in Chapter 6, fire regimes are an important natural phenomena on Cape York Peninsula. The burning of native vegetation elicits mixed Euro-centric responses such that few would describe such burnt landscapes as beautiful. There is no requirement for a *superlative natural feature* to exhibit *natural beauty* or be aesthetically appealing though commonly this would be the case.

One discrete feature on Cape York Peninsula which can be readily described as a superlative natural phenomena is Black Mountain adjacent to the Cooktown Development Road. Such description is justified by:

- high visual impact of a mountain comprising a huge jumble of jet black boulders
- high visual and geological contrast with the surrounding landscape
- traditional speculation about its formation, including various published and highly speculative or mythical explanations
- traditional stories and myths, indigenous and non-indigenous, associated with its treacherous cavernous formations
- an outstanding example of its type at the continental and regional level.

Black Mountain is already part of the Wet Tropics World Heritage Area and is widely recognized as a highly distinctive landscape feature. Its phenomenological appeal is already evidenced by the extent to which it features in tourism literature, film and published books.

There are various other geographically circumscribed features on Cape York Peninsula which also readily qualify against Criterion 8.0. as superlative natural phenomena, and as well qualify as areas of outstanding natural beauty.
These include (but are not limited to):

- Melville Range, including Cape Melville (similar geomorphology to Black Mountain but on foreshore) described by Stanton and Morgan (1976) thus *"A spectacular range of mountains consisting largely of huge lichen covered granite boulders which represent a major landscape component unique in the State except for a small area south of Cooktown (See Black Mountain)*
- Shelburne Bay dunefields
- Cape Flattery dunefields
- Iron Range rainforests.

Other places on Cape York Peninsula which may be less obvious but which most likely qualify as superlative natural phenomena include:

- Jardine River Catchment (a superb natural stream and protected catchment with strong aquatic and terrestrial faunal affinities with New Guinea).
- Large sections of the wild eastern coastline of Cape York Peninsula, especially when considered in conjunction with the immediately adjacent waters of the Great Barrier Reef; the Cape York Peninsula eastern coastline is the only substantial section of Queensland east coast draining into the lagoon of the Great Barrier Reef which retains a high degree of natural integrity.
- The Quinkan landscape near Laura.
- The beach chenier system and associated Pleistocene Carpentaria foreshore dune north and north east of the Mitchell River.
- The Princess Charlotte chenier system.

There is also a case for considering the whole of Cape York Peninsula in *toto* (i.e. as a single landscape entity) as a superlative natural phenomenon. This case rests on several distinctive features especially:

- Cape York Peninsula is not only a distinct geographical entity, it is recognized as a single entity in terms of evidence of human experiences of the region. It is marketed by the tourism entity as a single landscape.
- Cape York Peninsula is distinctive in the high level of natural integrity on a continent which has suffered a massive rate of clearing of native vegetation and high species extinctions since European settlement, particularly in the humid zones. No species are known to have become extinct on Cape York Peninsula in this period. Whereas even the extensive undeveloped arid zones of interior Australia have lost mammal and bird species to extinction as a result of European settlement, Cape York has to date escaped such degradation.
- Cape York Peninsula is from a global context, an unusually large tract of remote and largely undeveloped tropical land. The combination of the large tract of land, a high natural integrity and the great extent of the undeveloped/wild coastline is of continental, regional and global significance.
- Cape York Peninsula is specially significant as a biological corridor between a continent and a recently evolved sub-continent.

As discussed throughout this report, there are many other distinctive features of Cape York Peninsula which are only now beginning to be appreciated. These values are further reinforced by the specialist eco-tourism industry which has developed on Cape York, where much of the emphasis is on the vastness of the perceived wilderness character of the landscape. This industry is promoted globally and foreigners represent a large proportion of the visitors to the region.

In conclusion, the available evidence indicates that there are a series of specific geographical features which qualify as superlative natural phenomena. There is also a case for considering the greater part of Cape York Peninsula in *toto* as being a superlative natural phenomena within the meaning of Criterion 8.0.

7.2.7 CONCLUSION ON ASSESSMENT AGAINST CRITERION 8.0:

8.1 *Natural phenomena – Superlative*

The evidence available to this study indicated that there are a series of specific geographical features which qualify as *superlative natural phenomena*. The most obvious examples are Black Mountain and Melville Range. There is also a clear case for considering Cape York Peninsula in *toto* as being a superlative natural phenomena of significance at the continental, regional and global levels.

8.2 *Natural beauty – Exceptional*

Cape York Peninsula is a well recognized and defined landscape entity, usually described more simply as 'Cape York' or simply 'The Cape'. It has a complex network of physical landscape components which can be confidently defined and mapped as Potential Aesthetic Values. There is ample evidence of a distinctive and highly valued visitor experience associated with 'The Cape'.

Mapping of potential aesthetic values and overlay with indicative experiential information leads to the conclusion that Cape York is a recognized landscape entity, has a high and diverse aesthetic potential revolving around the 'wild' natural landscape, and a well defined and valued visitor experience.

A more definitive assessment of the aesthetic values of Cape York Peninsula would require address of the experiential component of the aesthetic value of the region.

In summary, application of Criterion 8.0 (Aesthetics) to Cape York Peninsula results in the identification and delineation of a number of specific landscape features that qualify as natural heritage. Similarly, because there are sound geographical and experiential reasons for recognising the whole of the Cape York Peninsula as a single entity, it has the potential to qualify against Criterion 8.0. as *superlative natural phenomena or of exceptional natural beauty or aesthetic value*. However, further confirmation of the experiential evidence for recognition of Cape York Peninsula in *toto* is recommended.

To conclude, part or all of Cape York Peninsula meets Criterion 8.0 for the purposes of this study.

7.2.8 CONCLUSION ON ASSESSMENT AGAINST CRITERIA 7 AND 8

The finding of this study, is that a sound case can be made for Cape York Peninsula meeting Criterion 7.0 (Contribution to Knowledge), principally on the basis of it contributing significantly to an understanding of natural history beyond that place. The strength of the case became increasingly evident during the course of this study and can no doubt withstand further examination and scrutiny. This value is especially significant at the national level but also has global significance.

Our findings from assessment against Criterion 8.0, (Aesthetics), are that Cape York Peninsula in *toto* has a high aesthetic potential and that many of the elements of an outstanding aesthetic experience are evident. Cape York Peninsula therefore qualifies as an area of *exceptional natural beauty and aesthetic importance.* These values are significant at least at the national level and with further analysis part or all of the area may prove to be significant at the global level.

A number of specific landscape features readily qualify as being *superlative natural phenomena*, and it is evident that the whole of Cape York Peninsula can similarly be regarded as a superlative natural phenomenon of significance at the continental, regional and global levels.

eight

8 SUMMARY

8.1 INTRODUCTION

This section provides the basis for the Executive Summary which is being published separately by the State Government of Queensland, and will be available from the Queensland Environmental Protection Agency.

We ask the reader to keep in mind the terms of reference for this report. These included (a) defining a set of criteria for assessing natural heritage significance, (b) reviewing the suitability of available data, (c) applying the criteria using available data, and (d) preparing a draft statement of natural heritage significance.

8.2 DEFINING NATURAL HERITAGE

The idea of *heritage* has been in use for many decades and is enshrined in international, national and state law. The natural heritage significance of a place is usually considered separately from its cultural heritage value. Here, *natural heritage* has been defined to exclude any Indigenous heritage values or historic heritage values associated with European settlement. This should not be interpreted as casting any opinion on the significance of cultural heritage values. Rather, they were not considered simply because their assessment fell outside the terms of reference for this study.

The authors appreciate of the fact that indigenous peoples have occupied Cape York Peninsula for around 40-60,000 years, and continue to have an influence on the landscape, including components of the natural heritage of the region. The relationship between indigenous communities and natural heritage values needs to be more closely addressed in subsequent studies, and at both the policy and land management levels.

Various published definitions of natural heritage were examined. Of note was the definition used in the Australian Natural Heritage Charter. Based on that definition, we defined natural heritage as:

> *Those elements of biodiversity, geodiversity, and those essentially natural ecosystems and landscapes which are regarded as worthy of conservation or preservation for transmission to future generations in terms of their existence value or for their sustainability of life and culture*

8.3 DEFINING THE CRITERIA FOR ASSESSING NATURAL HERITAGE SIGNIFICANCE

The challenge is to identify natural heritage in a way that is *explicit* (i.e. people can understand how the assessment was undertaken), *minimises subjectivity* (i.e. other people could apply the same method and reach similar conclusions) and is *universal* (i.e. allows comparison of heritage values across a continent, region, or the world).

What we call *natural heritage* reflects those natural phenomena that are valued by the community - which usually refers to the present-day community (though the act of valuing can sometimes be a selfless attempt to identify those things that we think our grandchildren and their children might value in the future). Identifying what constitutes natural heritage on Cape York Peninsula, or any region, therefore must be based on what is valued by the community. Two different approaches are possible. The *ad hoc* approach takes the form of extensive consultation and interviews with the community. The *Systematic* or *Expert* approach uses documentation and assessment against a predetermined list of values. Any combination of the two approaches can be applied. Given the terms of reference for this project, the large geographical scale of Cape York Peninsula, and the extensive CYPLUS documentation, we adopted the systematic approach.

Natural heritage comprises a spectrum of values that can, for convenience, be classified into categories. Natural heritage criteria are a mix of identified categories of values and thresholds for assessing presence or absence of those values in a given place. We reviewed natural heritage criteria used to assess places for listing as World Heritage and on the register of the National Estate. Our recommended set of criteria for assessing natural heritage significance is based largely on criteria from these two sources. In addition, we went back to first principles and identified criteria we thought would be most appropriate for Cape York Peninsula. It became apparent that some natural phenomena which are valued by the community, and therefore qualify as natural heritage, are not adequately addressed in either the World Heritage or National Estate criteria. Therefore two additional criteria were added to fill this gap. We consider the final set of criteria to be more comprehensive, up-to-date and systematically presented than previous schemas.

The two new criteria relate to *Natural Integrity* (Criteria 5) and *Contribution to Knowledge* (Criteria 7). Natural integrity *per se* is not recognized as a value under the World Heritage Criteria, though it is used as a quality assurance test. Lands of high natural integrity have been recognized *de facto* under the National Estate criteria for many years. Landscapes that are relatively unperturbed by modern technological society are increasingly rare in the world and have come to be valued as a part of a nation's natural heritage, more or less independent of other natural heritage attributes. We therefore had no hesitation is recognizing it as a legitimate value component of natural heritage for the purpose of the study.

Contribution to Knowledge (Criterion 7) embraces various elements of both the World Heritage and the National Estate Criteria, but we chose an umbrella title for this group of values. Given the comprehensive review and formulation of these new criteria, we believe they are relevant beyond Cape York Peninsula and have universal application.

Criteria for the identification of natural heritage values can be best expressed as a combination of the various categories of *values* and some measure of *threshold* beyond which that natural heritage value is deemed to be present, i.e.: *Criteria = Values x Thresholds*

This is the conventional way of expressing World Heritage and National Estate criteria. The criteria adopted here for assessing Natural Heritage significance are presented in Table 2.3. It is also standard practice to identify subcriteria that articulate specific values associated with each main criterion. These are listed in table 2.4.

8.4 METHODOLOGY

Wherever possible and appropriate, this report has drawn upon and has been informed by scientifically based information and understanding. However there is a limit to the role of science in assessing natural heritage significance. All the criteria reflect cultural perspectives, and involve some degree of subjectivity that constrains the use of quantitative measures. This is especially true of Criteria 7 (*Contribution to Knowledge*) and 8 (*Aesthetics*). Indeed, some might argue that these are really cultural heritage values. However, their inclusion is justified as they are defined in terms of natural phenomena and natural landscapes.

The basic method used in this study was to systematically compare the natural heritage values of Cape York Peninsula with the values of other locations. This comparison was undertaken at a range of scales, namely, *Global, Regional, Continental* and *Local*. As used here, *Regional* refers to the Austral-Pacific/New Guinea region, and *Local* refers to Cape York Peninsula. At each scale, natural phenomena characterizing Cape York Peninsula were identified and compared with similar phenomena elsewhere. Phenomena can be considered to have natural heritage significance because they are somehow unique to Cape York Peninsula. However, heritage value can also derive from connections between Cape York Peninsula and other locations.

The main limitations to applying the criteria were the lack of (a) accepted concepts, methods and analytical tools, and (b) appropriate data and information. For example, the concept of *Geodiversity* is not well registered in the geological scientific literature. Furthermore, while we were able to identify key elements of geodiversity in Cape York Peninsula, we were unable to find comparative information in the Austral-Pacific region/New Guinea region. The criteria of *Natural Integrity* and *Ongoing Natural Processes* similarly lacked standard operating procedures, and we were forced to review existing approaches in arriving at a methodology suited to the project brief. The *Bio-evolution* and *Biodiversity* criteria were better defined and addressed in the scientific literature. Also, the CYPLUS process had brought together substantial biodiversity data sets and information.

The CYPLUS reports were made use of wherever possible. New analyses were also undertaken, using databases and computer-aided techniques available at The Australian National University. These helped place Cape York Peninsula in a global, regional and continental context, and proved crucial in assessing natural heritage significance. Extensive use was made of Geographical Information Systems (GIS). For example, we undertook a global climatic analysis, and generated a new microcatchment-based, environmental domain classification for Cape York Peninsula. It proved impossible to use such quantitative methods in applying the criteria of *Contribution to Knowledge and Aesthetics*. The lack of data and information means that our assessments of these criteria can only be considered indicative.

8.5 WHY IS CAPE YORK PENINSULA SPECIAL?

Following adoption of the new set of values and criteria outlined above, the criteria were applied to the study area using the available and supplemented data and information.

At the global and most general scale, Cape York Peninsula contains three globally significant bioclimatic domains, and a wide range of ecosystems. Rainforests, open forests, woodlands, shrublands, heaths, sedgelands, grasslands, mangroves, seagrass, coral reefs and saltmarsh systems are well represented and relatively undisturbed by modern technology. It is this retained integrity of natural systems and processes, over such a vast area across entire watersheds, that gives Cape York Peninsula its unique character and global environmental significance. Australia, alone among nations with large areas of monsoonal wet/dry tropical environments, has an opportunity to avoid the mistakes of ill-advised development with attendant land and groundwater degradation, water pollution, and biodiversity loss. As the CYPLUS process itself has demonstrated, there has been a developing community desire, matched by political support, for a total bioregional approach to the sustainable development of Cape York Peninsula.

One possible avenue is for the Queensland Government to provide special status for the whole of Cape York Peninsula, recognizing its special values and the unique opportunity it provides for a regional scale and truly integrated planning and sustainable development regime. At the very least, the whole of the area deserves recognition as a MAB Biosphere Reserve or similar. A substantial proportion of Cape York has the potential to qualify as World Heritage under the World Heritage Convention and thereby be provided even greater recognition and protection. Irrespective of the status and strategic planning outcomes, as far as possible, long term land use and land management objectives should be achieved through co-operative and partnership arrangements with the Cape York communities of interest.

The high level of natural integrity (*Naturalness*) particularly in relation to land cover and related hydroecological processes, demands that the concept of Total Catchment Management be given its fullest expression in any considerations about the future of Cape York Peninsula. The tyranny of the theodolite may be ending, but the legally imposed linear property boundaries still vivisect natural vegetation-soil, hydroecological and other biological units, as exemplified by the proposed natural gas pipeline from Papua New Guinea gas fields which, if enacted, will bisect Cape York Peninsula from north to south, challenging the natural integrity of Cape York Peninsula. Very careful planning will be critical, at all scales, local, catchment and bio-regional.

The key findings of the study in relation to each criterion are summarised below.

CRITERION 1.0 GEO-EVOLUTION

Outstanding examples representing major stages of Earth's evolutionary history, including significant geological processes which have contributed to the development of landforms, or significant geomorphic or physiographic features.

Subcriteria:

1.1 Geological features – outstanding or representative.

1.2 Geomorphological and landform features – outstanding or representative.

CRITERION 2.0 GEODIVERSITY

The most important and significant lands for *in situ* conservation of geodiversity, including those containing rare or threatened features of outstanding (universal/regional/continental/local) value from the point of view of science or conservation.

Subcriteria:

2.1 Geological and geomorphological features or processes - outstanding or representative examples.

2.2 Geological and geomorphological features or processes - rare or threatened.

Cape York Peninsula is testament to the processes that led to the opening of the Coral Sea; the gradual submergence of the Queensland Plateau to the East and the truncation of west flowing drainage systems; terranes that slid north and west to become part of the evolving landmass of New Guinea; development of the Great Escarpment to the east of Cape York Peninsula and extensive colluvial/alluvial plains in the west; some minor volcanic activity; and long periods of stability.

Possibly there is no match globally for evidence of very long-term stability of a tropical landscape. A recent, published claim (Nott and Horton 2000) suggests the Kimba Plateau, in the south of the study areas, provides evidence for the oldest known continental drainage divide in the world, at 180 million years. Even were this to be disproved, geologists are in no doubt that Cape York Peninsula includes landscapes of very great age.

The New Guinea/Australia link via Cape York Peninsula is a regional scale landscape providing graphic evidence of the progressive and on-going physical and biological separation of the New Guinea sub-continent from the Australian continent. The process is largely driven by the global process of climatic change, including, but not limited to, inundation of part of the Australian continent by rising sea level. The combined processes are effectively converting Cape York Peninsula 'from a bridge to a barrier'.

Much of the key evidence for this dramatic creation of a new separate sub-continent is found in the largely intact landscapes of Cape York Peninsula but also extends to the adjacent regional landscapes of southern New Guinea and the Wet Tropics and Gulf of Carpentaria on the mainland. Whilst climatic change and associated rising sea levels have created many new islands around the world, none of these phenomena are of such scale, complexity and scientific interest as that of the on-going physical and biological separation of the New Guinea from Australia. This phenomenon is of continental, regional and global significance.

The chenier ridges of Princess Charlotte Bay provide an exceptional record of cyclone activity over the past 6,000 years, during which sea-levels have approximated those of the present. This surrogate record is important both for a better understanding of global and regional climate systems and for assessment of the frequency of cyclonic events and storm surges, and in terms of its extent and natural condition is globally without equal.

The very extensive beach barrier landform systems on the western lowlands of Cape York Peninsula represent an outstanding record of the on-going process of progradation of the Carpentaria shoreline. The innermost strand line dates to around 120,000 years B.P. These very extensive and intact systems also have the potential to provide a scientific resource of global significance.

Some additional geological and morphological features on Cape York Peninsula which have been identified and are generally accepted as significant for geodiversity include:

- The extraordinary Black Mountain/Melville Range 'boulder mountain' formations
- The Shelburne Bay and Cape Flattery dunefields
- The Carpentaria topographic sill (submerged in Gulf)
- The bauxite formations on the west coast, especially stratigraphic cross-sections.
- The Quaternary landforms of Cape York Peninsula may well represent an important natural heritage resource.

CRITERION 3 BIOEVOLUTION

Outstanding examples representing major stages of Earth's biological evolutionary history, including the record of life

Subcriteria:

3.1 Palaeobotanical and palaeozoological (fossil records) - outstanding or representative

3.2 Plant and animal species or communities which are evidence of Earth's biological evolutionary history – outstanding or representative

CRITERION 4 BIODIVERSITY

The most important and significant natural habitats for *in situ* conservation of biological diversity, including those containing rare or threatened species, communities or ecosystems of outstanding (universal/regional/continental/local) value from the point of view of science or conservation

Subcriteria:

4.1 Species, populations or ecosystems - representative examples

4.2 Species, populations or ecosystems - rare, threatened or endangered

4.3 Species, populations or ecosystems – endemic

4.4 Species, populations or ecosystems - other outstanding scientific or conservation value

Cape York Peninsula contains many outstanding examples, representing major stages of Earth's biological evolutionary history, including the record of life.

Fossil locations throughout Cape York Peninsula are documented with representations from the Carboniferous (300-280 m.y.), Permian (280-255 m.y.), and Lower Cretaceous (135-65 m.y.) eras. These hold important evidence for Australia's Gondwanic heritage of plant life.

Potentially of critical importance to understanding of palaeo-climate and palaeo-ecology in the lowland, megatherm environments of northern Australia and New Guinea, are the most northerly known Pleistocene fossil fauna sites, located in the Glen Garland Swamps on the relict land surface of the Coleman Plateau. Although not yet investigated, these 20 swamp depressions are likely to contain fossil pollen and sedimentary materials that can illuminate conditions around the last full glacial time.

So far, 104 relict Gondwanic plant species have been recorded on Cape York Peninsula. These include Austral conifers in the *Araucariaceae* and *Podocarpaceae* families, the *Proteaceae* genera *Carnavonia* and *Placospermum*, and some orchid genera. These old endemics tend to be concentrated in closed-forest and especially complex mesophyll vine forest to the south, as well as the notophyll vine forest of the mid-Peninsula ranges, and the semi-deciduous mesophyll vine forest of the lowlands along the Claudie and Normanby Rivers. This globally significant group of plant species played an important part in the nomination of the Wet Tropics Bio-region for World Heritage Listing.

Cape York Peninsula is a treasure-house of biodiversity that illustrates the stages in evolution extending back in time to the break-up of Gondwana and well before the final separation of Australia from Antarctica. It holds the key to our understanding of the evolutionary biogeography of northern Australia and New Guinea. The breakup or fragmentation of Gondwana by plate tectonics was the primary breakup of the Gondwanan biome.

Cape York Peninsula encompasses a living mosaic of interlocking habitats that provide a globally outstanding resource for the *in-* conservation of biodiversity, both for widespread and common species as well as the more localized, rare and endemic biota. Threatening processes exist, but have not yet had extensive impact, though grazing, weeds, and altered fire regimes have selectively impacted in some areas.

Contrary to the popular view that it is a climatically homogenous region, Cape York Peninsula encompasses three well-defined and globally significant bioclimates. These are reflected in their distinctive complement of flora and fauna which in turn reflect the long-standing biological connections with both tropical northern Australia and New Guinea. Cape York Peninsula holds much more of the tropical lowland, megatherm biological inheritance that is shared with New Guinea. By contrast, the World Heritage Wet Tropics Bioregion to the south, holds much more of the temperate, upland, meso-therm biological inheritance shared with New Guinea. Both are of global, regional and national significance.

A significant proportion of plant and animal species recorded on Cape York Peninsula do not occur anywhere else in Australia. Of this quantum, a correspondingly high percentage of species also occurs across Torres Strait in New Guinea. However Australia is in a much better position to provide a safe haven for these *bidomicilic* (i.e. living in two places) taxa.

While Cape York Peninsula shares a wide-spread northern Australian monsoonal (wet/dry) megatherm biota with Arnhem Land and the Kimberley Region, there are significant taxonomic and ecological differences. Cape York Peninsula contains 39 floristically unique vegetation types identifiable at a map scale of 1: 1, 000, 000. Endemism is well developed, with strict endemics (that is, not found in other parts of Australia, New Guinea, or elsewhere in the world) so far totalling 3 genera and 264 plant species, and 40 terrestrial vertebrate species. Invertebrate endemicity is expected to be high, but assessment is not possible because of lack of data.

The mangroves are among the world's most species rich with respect to mangrove plants and recorded orchid species. Also of global and national significance are the extensive wetlands, tall woodlands, woodlands (dominated by Eucalyptus or Melaleuca species), tropical heath, seagrass beds, and coral reefs and cays.

Significant percentages of all marine bird species recorded in northern Australian waters have major breeding, roosting and foraging locations in the coral reef platform off the east coast of Cape York Peninsula.

Australia is not noted for its diversity of freshwater fish species, but Cape York Peninsula rivers compare internationally with tropical catchments of similar size. The Wenlock River may have the richest known freshwater fish fauna in Australia, with the Jardine River not far behind. The high aquatic fauna richness of these two catchments is attributed to past freshwater linkages with the Fly and Digul catchments of New Guinea when New Guinea was a part of the Australian mainland. This represents important evidence of the bio-geographic evolution of the region.

The wide structural variety of vegetation and its admixture (such as the network of gallery forests and the scattered vine thickets that occur throughout vast expanses of *Eucalyptus* and *Melaleuca* woodland, littoral thickets on mainland beaches and offshore islands, sandplain heath, mangroves and a range of other vegetation types) facilitates migration and seasonal movements of bird and bat species. Cape York Peninsula is a vital component of the Eastern Australian Bird Migration System for species in transit to and from New Guinea, species that over-winter and other species that arrive from New Guinea to breed in Cape York Peninsula, as well as wetland species that have seasonal movements within the larger framework of north-eastern Australia and New Guinea.

Cape York Peninsula is of national, regional and global significance both as an area of outstanding biodiversity in a largely intact landscape, and as a largely intact bridge retaining valuable evidence of the evolving and on-going, fragmentation of the biomes of northern Australia and New Guinea.

CRITERION 5.0 NATURAL INTEGRITY

Ecosystems and landscapes which exhibit outstanding ecological and geophysical integrity.

Subcriteria:

5.1 Terrestrial ecosystems - high degree of natural integrity
5.2 River corridor ecosystems - high degree of natural integrity
5.3 Wetland ecosystems - high degree of natural integrity
5.4 Coastal and marine ecosystems - high degree of natural integrity

CRITERION 6.0 ON-GOING NATURAL PROCESSES

Geophysical, evolutionary, and ecological processes, including local and global-scaled life support systems fully functional.

Subcriteria:

6.1 Areas of sufficient size, natural integrity and other essential elements to allow or maintain significant on-going ecological, life support, and evolutionary processes
6.2 Areas of sufficient size, natural integrity and other essential elements to allow or maintain significant on-going geophysical evolutionary processes.

The lands of Cape York Peninsula exhibit outstanding natural integrity in a global, regional, or continental context. Indeed this is one of the key overarching qualities that defines the character of the entire region. Cape York Peninsula has relatively small, isolated human populations, minimal infrastructure development, and the land use activity in place is either highly localized or extensive rather than intensive.

The meaning and significance of natural integrity is most readily understood by considering those processes that mediate surface and groundwater resources. A recent salinity audit of the Murray-Darling Basin highlighted the extent of land degradation problems. The rise of salinity in this landscape is argued to be symptomatic of current land uses, which have taken the place of natural systems, resulting in a massive hydrological imbalance that will take several hundred years to stabilize (Murray-Darling Basin Commission 1999). The natural systems referred to were based upon the existence of a continuous cover of native vegetation ecosystems across entire catchments. These systems have been substantially cleared or degraded in the Murray-Darling Basin. However, in Cape York Peninsula they remain largely intact. Hence we can say that its hydroecology retains a high degree of natural integrity. Indeed, the integrity of the study region's integrated (groundwater-surface water) hydrological systems is a condition not shared by most landscapes elsewhere in humid Australia where hydrological life support systems are in peril.

In Cape York Peninsula, key hydrological processes remains intact, such that entire catchments function unimpeded from watershed ridges through to coastal wetlands. The only significant harnessing of rivers is the water supply dam on the Annan River. Otherwise, the streams of Cape York have been minimally disturbed by the works of human activity (though the impact of feral animals does represent a longer term threat to the natural integrity of many streams).

The ecological function of these landscapes in the dry season is particularly sensitive to the persistence of geographically restricted surface water/near surface water resources, (including perennial springs and water holes, the maintenance of river base flows, and perennial stream flow) and hence the continued functioning of systems that affect groundwater recharge and discharge. The western area is underlain by and is a recharge zone for the Great Artesian Basin. Thus its high degree of natural integrity is of national significance.

The fact that Cape York Peninsula with an area of around 13.5 million ha. has, in effect, a continuous cover of tropical, native vegetation ecosystems is globally significant. This is importance for biodiversity conservation given that the greatest threats are from habitat loss, habitat degradation and habitat fragmentation. Every major vegetation group - with only a handful of exceptions - posses a high degree of natural integrity (not withstanding the unsatisfactory state of data regarding the impacts in Cape York Peninsula of feral animals such as pigs, and weeds). The national and global significance of this can be grasped if we consider the extent to which coastal systems, forests, and savanna have been unsustainably utilized and degraded elsewhere in Australia and the world.

The marine environment is similarly characterized. The high level of protection afforded by the present zoning of the adjacent section of the Great Barrier Reef World Heritage Area is complementary of the high natural integrity onshore. The Gulf coast waters, though not similarly protected, exhibit a high order of natural integrity. This natural integrity is very conducive to the long term maintenance of all the identified extant natural processes, especially the *in situ* processes. The high order of natural integrity also extends into the forests and water of the immediately adjoining Wet Tropics World Heritage Area and Great Barrier Reef World Heritage Area respectively. Indeed, the same can be said of some adjacent sections, both savanna and wet forest, of the island of New Guinea to the north.

Of special significance is what is effectively a continuous corridor of land and water of high natural integrity from the Wet Tropics Bioregion to the tip of Cape York Peninsula and similarly from the adjacent southern shore of New Guinea into the hinterlands of New Guinea. The biological bridge between Australia and New Guinea, whilst partially drowned by the waters of Torres Strait in very recent geological times, is still otherwise intact and has not been seriously or significantly truncated by modern technological society. All of the other analogous sites in the tropical regions of the world where part of a continent has been severed by post-glacial sea-level rise (e.g. Sri Lanka/India, Sumatra/Asia) have been grossly modified by later human development or destruction of the natural environment.

It is the combination of regional scale connectivity and high natural integrity of the lands and waters of Cape York Peninsula which is the critical contribution to scoring highly against Criterion 6.0. Retention of the global and regional significance of this value is therefore critically dependent on the maintenance of the connectivity of lands of high natural integrity in the Cape York Peninsula landscape and their respective connectivity to the hinterlands of New Guinea and the Wet Tropics region. The Gulf Coast connectivity is also potentially important.

Maintaining the extant natural processes as a package of interconnected systems within the context of Cape York Peninsula's high natural integrity (together with the adjacent and contiguous parts of New Guinea and the Wet Tropics), represents the optimum strategy for protecting the identified globally and regionally important values.

CRITERION 7.0 CONTRIBUTION TO KNOWLEDGE

Examples of geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena, the study of which has, or is continuing to, contribute significantly to an understanding of natural history beyond that place.

Subcriteria:

7.1 Geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes or phenomena - significant contribution to understanding of natural history.

7.2 Geomorphic or physiographic features, ecosystems, plant and animal communities or natural processes - significant contribution to direct educational value.

CRITERION 8.0 AESTHETICS

Superlative natural phenomena or areas of exceptional natural beauty or aesthetic importance.

Subcriteria:

8.1 Natural phenomena - superlative

8.2 Natural beauty - exceptional

Cape York Peninsula already makes a direct contribution to knowledge and has important characteristics which will ensure that it continues to make an important contribution to knowledge of natural history beyond the Peninsula proper. The most important features of Cape York Peninsula which support assessment of its global significance for *Contribution to Knowledge* are:

- The largest continuous tract of core tropical savanna biome remaining with a high degree of natural integrity
- A relative safe environment for visitation
- Ready access to key features for much of the year
- Most of the land is under some form of government tenure (Aboriginal land, national park, pastoral lease), providing the base for sound, long term management necessary for developing research and education programs
- A long record of natural history research (including the comprehensive CYPLUS program) provides a firm foundation for future research and studies
- Relative proximity to major research facilities in Cairns through James Cook University and the CRC for Tropical Rainforest Ecology and Management
- The research challenge presented by extensive and diverse areas of high natural integrity, including many features where little or no research has yet been conducted
- Global significance as a base-line landscape to monitor impacts in tropical environments of future climate.

The finding of this study is that a sound case can be made for Cape York Peninsula meeting Criterion 7.0 (*Contribution to Knowledge*), principally on the basis of it contributing significantly to an understanding of natural history beyond that place, e.g. in relation to understanding regional historical biogeography and tropical savanna global change response. The strength of the case became increasingly evident during the course of this study and can no doubt withstand further examination and scrutiny.

In the study we drew the distinction between *Aesthetic Potential* and *Realised Aesthetic Value* (the latter being based on user/visitor experience). In terms of the former, Cape York Peninsula contains various superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance, including:

- 1800km long coastal foreshore, a high proportion of which is of exceptional natural visual integrity
- Long, sandy beaches of exceptional natural beauty particular on the east coast
- Visually distinct eastern foreshore headlands
- The high level of natural integrity of the adjacent waters of the Great Barrier Reef World Heritage Area
- Accessible viewpoints that provide elevated vistas of the extensive natural wooded\ landscapes, e.g. Grassy Hill at Cooktown
- Prominent, distinct and unique landscape features, e.g. Black Mountain, Cape Melville, Iron Range
- Micro landscape features, especially closed forest, gallery forest, water features, tower karst caves
- Shelburne Bay dunefields
- Cape Flattery dunefields
- Iron Range rainforests
- Jardine and Wenlock River catchments
- The Quinkan landscape near Laura
- The beach barrier system and associated Pleistocene Carpentaria foreshore dune north and north east of the Mitchell River
- The Princess Charlotte chenier system.

Cape York Peninsula is a recognized landscape entity, has a high and diverse aesthetic potential revolving around the 'wild' natural landscape, and an already well defined and valued visitor experience. Further tasks include mapping potential aesthetic value and overlaying indicative experiential information.

Our findings from assessment against Criterion 8.0, (Aesthetics), are that Cape York Peninsula in *toto* has a high aesthetic potential and that many of the elements of an outstanding aesthetic experience are evident. Cape York Peninsula therefore qualifies as an area of exceptional natural beauty and aesthetic importance. These values are significant at least at the national level and with further analysis part or the entire Peninsula may prove to be significant at the global level.

A number of specific landscape features readily qualify as being superlative natural phenomenon. There is also a strong case for considering Cape York Peninsula in as being a superlative natural phenomenon of significance at the continental, regional and global levels.

8.6 SUMMARY

Application of all eight natural heritage criteria revealed that Cape York Peninsula contains significant natural heritage values in all categories. The criteria and sub-criteria were met to a greater or lesser degree, but the net result is that with only minor exceptions of existing development, the whole of the region contains important natural heritage values. Many of the identified values were found to be significant at the regional and global level.

The geology and geomorphology of Cape York Peninsula exhibits features of scientific significance representing major stages in Earth's geological history including global climate and sea-level changes, the history of cyclonic activities, mountain building processes, landscape formation, and past hydrological and land links between Australia and New Guinea. Some of these values are of regional and global significance. Geodiversity features of significance include the chenier ridges of Prince Charlotte Bay, and Shellburne Bay and Cape Flattery dune fields.

Cape York Peninsula contains many outstanding examples of major stages in Earth's biological evolutionary history, including relic Gondwanic plant species, and evidence of the historical biogeography of northern Australia and New Guinea. Significant biodiversity elements include endemic species and vegetation types, and an interlocking mosaic of *Eucalyptus*, rainforest, and other habitat types.

The high level of natural integrity (e.g. in terms of hydroecological processes), of this comparatively large tract of land in the seasonally dry tropics is of global significance. The exceptional value of the natural integrity of Cape York Peninsula is accompanied by a comparable level of natural integrity of the adjacent waters of the Great Barrier Reef World Heritage Area. The situation is comparable for much of the Carpentaria coast.

That the east flowing catchments and associated coastline of Cape York Peninsula is the only major tract of the mainland which is undeveloped and of high natural integrity adjacent to the Great Barrier Reef World Heritage Area is of natural heritage significance. The high order of natural integrity of the eastern fall and coastline and the current restrictive zoning of the adjacent waters is complementary and provides a significant mutual enhancement of the heritage significance of the two areas. The high natural integrity of the combination of the terrestrial and marine environments adjacent to Cape York Peninsula is of national, regional and global significance.

The combination of the high order of naturalness (natural integrity), the large scale of the landscape and the great biophysical diversity of Cape York Peninsula is, subject to appropriate management, conducive to the on-going maintenance of the extant natural processes which have largely shaped the landscape and ecology of the region.

Cape York Peninsula contains features which are conducive to scientific research and educational activities with the potential to contribute in an important way to our knowledge of natural history in general. Cape York Peninsula contains many features which have contributed to and will continue to contribute to an understanding of the physical and ecological evolution of the sub-continent of New Guinea and the special role of Cape York Peninsula in that process. At the global level, its large scale and high integrity contribute to its significance as a place for research and education.

Cape York Peninsula contains many features and places which are of potential and recognized aesthetic value, evidenced by a well developed nature based tourism industry. Some landscape components such as gallery forests along watercourses have generic aesthetic value and some particular places such as Black Mountain and Melville Range exhibit highly distinctive aesthetic values of national, regional and global significance.

Note that some of the values identified in this study could be easily overlooked if the global and regional contexts were not considered. A natural heritage assessment limited to such specific categories as rare and threatened species, or limited only to the context of Cape York Peninsula, would fail to recognize the global significance of its natural integrity.

For a variety of reasons, it was considered inappropriate to try and produce a map of the identified natural heritage values. There are values that cannot be mapped without greater definition and verification on the ground. Some values are not amenable to mapping as they are of a very spatially expansive nature being associated with, for example, entire catchments. In other cases, the list of heritage features were incomplete and only indicative of the total distribution of those values. Most importantly, we argued that to have mapped the identified natural heritage values in any precise form had the potential to be counter-productive by encouraging adoption of reductionist planning and management regimes when the core message is the need for an holistic approach.

Our view is that apart from some specific developed localities such as townships, military infrastructure and mines, the whole of Cape York Peninsula needs to be planned and managed on the assumption that one or more of the regionally and globally significant values is present. This does not mean that each and every hectare explicitly contains one or more of those values, but rather that each hectare which has not been permanently alienated by development has a context which is nationally, regionally and globally significant and ideally should be managed in accordance with that context.

8.7 THE FUTURE OF NATURAL HERITAGE VALUES IN CAPE YORK PENINSULA

During the study, the authors became aware of a number of activities and proposed developments which may constitute threats to the natural heritage values of Cape York Peninsula:

• Piecemeal Decision Making

One of the most critical and insidious threats to the natural heritage values identified here is a piecemeal or reductionist approach to decision making on Cape York Peninsula. In particular, the accumulated impact of decisions at the local and property level, especially those that are not readily reversible, represents a threat to the long term conservation of the area's natural heritage values. This form of threat is sometimes referred to as the tyranny of small decisions. The remedy to such threats is on-going, information-based regional planning to provide the context and framework for smaller scaled decisions in this special part of the Australian continent.

• Gas Pipeline

The proposed gas pipeline from Papua New Guinea to Gladstone in Queensland will run the length of Cape York Peninsula, mostly following the main Cape access road but in the south diverging further west. The pipeline has the potential to have major impacts, both directly and indirectly, on some of the identified heritage values of Cape York Peninsula.

• Weipa Bauxite mining

A distinctive vegetation community is the tall Eucalyptus woodland associated with bauxite derived soils in the northwest of Cape York Peninsula. In the longer term, the strip mining of bauxite will impact seriously on the conservation status of the woodland community.

• Clearing
All clearing has the potential to detrimentally impact on a range of identified values. It is neither possible nor appropriate to assess the heritage significance of a site at the local or property level alone. Rather, it is necessary to consider all clearing developments in the context of the global, regional and national natural heritage values of Cape York Peninsula.

• Grazing and associated activities
Grazing of cattle is a relatively recent landuse on Cape York Peninsula, but has already resulted in detrimental impacts on the natural environment. Much of the grazing has been conducted on an open range basis. However the impact of grazing is far from uniform; while large areas have been subject to limited impact, sensitive riparian zones and wetlands have been heavily impacted. The introduction of fencing has potential for both positive and negative effects. If the net result is increased stocking with continued access to sensitive areas, the detrimental impacts will be at least correspondingly increased.

• Feral Animals and Weeds
Apart from feral pigs, Cape York Peninsula is outstanding in the low incidence of problem feral animals and weeds. Not withstanding, Cape York Peninsula is very vulnerable to escalation of feral and weed impacts and control would be extremely difficult throughout much of the region. Irrespective of future landuse options, the natural heritage values demand on-going monitoring and control of exotic species of plants and animals. Pigs cause high impact in stream and flood environments and are highly disruptive to those environments. Long term eradication or strategic control must remain a management objective if the natural heritage values are to be maintained.

•Fire Regime
There is ongoing debate about the role of prescribed burning in the management of Cape York Peninsula. Fire regimes experienced at a location can be changed to modify vegetation patterns to meet a land use objective, for example, to benefit grazing or to promote the habitat of a rare and endangered animal species. The use of fire as a management tool by indigenous peoples is not contested. However it is unclear how extensively they controlled fire regimes across the landscapes compared with the influence of prevailing environmental conditions. Decisions on whether fire regimes should be manipulated at a given location should not be based on the assumption that fire regimes are spatially homogenous across Cape York Peninsula or are driven by human activity.

The study highlighted the strong web of ecological and hydrological connections across much of Cape York Peninsula. For example, clearing in groundwater recharge areas can impact downstream biological communities. This connectivity of surface/sub-surface and biological/geophysical processes necessitates a very conservative approach to assessing the potential impact of any clearing and development proposals. Maintaining the natural integrity of Cape York Peninsula's hydroecological processes should be a paramount management goal.

It would be inappropriate to attempt to directly translate the findings of this study to the property level of planning. The findings of this study in respect of natural heritage are so fundamentally different to the CYPLUS value base that it is now appropriate to review the Cape York Peninsula process commencing with a review of Government level policy on the area. From that must flow policy and policy guidelines for implementation at all levels of activity, both macro and at the individual property or site level.

This report does not propose that there should be no development on Cape York Peninsula. In any case that is beyond our brief. However, it is essential that all proposed activities be approached in the context of the newly identified values which were not previously recognized or appreciated.

8.8 CONCLUDING COMMENTS

We conclude that Cape York Peninsula of Tropical North Queensland has characteristics and features that are globally, regionally, and nationally significant in respect of all eight natural heritage criteria.

While the spatial distribution of some of these values can be readily mapped, many values could not be for a variety of reasons. Mapping the locations of values where data are incomplete and only indicative lists can be compiled is misleading. Critically, many of the values are of a geographically diffuse nature, and involve catchment-wide, extensive and overlapping distributions. A sense of the difficulties involved can be gained by reconsidering three related examples. Figure 5.16 shows the distribution of vegetation types unique to Cape York Peninsula. Figure 5.19 illustrates the location of wetland, gallery forest, and other vegetation types associated with surface and near surface water dry season refugia. Figure 3.2 highlights the environmental domain classification together with the major catchment boundaries.

Given the diffuse and widespread pattern of natural heritage values across Cape York Peninsula, the interconnectedness of the landscape's ecology, and the gaps in knowledge at a property scale, a conservative approach to protecting and managing the whole region is essential. Why follow the convention of spatially delineating each of the values, and then creating a 'Swiss cheese' land use pattern with all the negative environmental consequences evident in southern Australia? The time has come to recognize the opportunity and benefits of an integrated approach to land use and land management on Cape York Peninsula. There are lessons to be learn from indigenous land use which did not involve large scale clearing and was based on more integrated notions of the relationship between nature and society. Cape York Peninsula presents a unique opportunity to work with instead of against nature.

The challenge for the people of Queensland and Australia is to forge a direction for the future development of Cape York Peninsula that does not repeat the mistakes of other parts of the nation or elsewhere in the seasonally dry topics of the world. Patterns of development are needed that protect the integrity of natural processes, and that are environmentally and socially responsible. Given the national and global significance of this area, anything less will be an historic tragedy.

It is rare that a community has the opportunity to make its mark in history. Usually communities are simply swept up in the currents of their times, and are unable to set a new course. In considering the future of Cape York Peninsula, we have the opportunity to choose a new path of development, different from that previously followed elsewhere in Australia. Indeed, throughout the world, communities, nations and their governments struggle in their attempts to redirect the path of economic development in order to promote a more sustainable way of living. Is it possible to generate economic wealth in ways that are environmentally and socially responsible? Can development occur that protects rather than destroys nature, and respects rather than degrades indigenous rights and values? These are the fundamental questions of our time, and are of global as well as national significance.

The study region represents one of the last opportunities on Earth, in a tropical, humid/arid season environment, to fully implement the precautionary principle in planning any new developments. Sensitive management that enhances and maintains natural values is likely to yield significant benefits in a future world deprived of vast natural vistas, pristine rivers and beaches, and healthy plant and animal ecological communities. We have the knowledge but do we have the determination to succeed?

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