

Landscape Selection Process

Key Altitudinal, Latitudinal and Coastal Corridors for response to Climate Change

**A report by
The Department of Environment and Climate Change.**

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1 Introduction

This project was conducted on behalf of the Northern Rivers Catchment Management Authority (NRCMA) to help identify land areas for strategic conservation efforts to aid adaptation to the potential adverse effects of climate change for wildlife.

2 Scope

A short timeframe and limited budgetary resources meant that the scope of the project was severely limited. The outputs are a first cut of land areas that are significant for the movement of wildlife that may be vulnerable to the adverse effects of climate change and other threatening processes. The outputs are based on using the best available desktop data at the time.

3 Study Area

The Study area is the Northern Rivers Catchment Management Authority (NRCMA) boundary and generally extends from the Queensland Border to the Manning Catchment and west to the Tablelands as show in Map 1, Appendix B.

4 Background

In the last few years an ever increasing volume of literature, reflecting the increasing research, on climate change has been produced. Despite this, projections regarding effects on biodiversity are of a much generalised nature. The range of predictions regarding the changes to weather patterns and the resulting effects on biodiversity are constantly being revised as new information becomes available.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) predicts that at current levels of greenhouse gas (GHG) emissions Australia will experience annual average temperature increases of 0.4-2.0 ° C by the year 2030 and 1-6 ° C by 2070. Average rainfall for the southeast Australia, in which the study area lies, is projected to decline along with increased erosion and inundation of the coastline as rainfall becomes more intense but less frequent. Higher average temperatures will cause higher evaporation and increase the incidence and intensity of bushfires (CSIRO, 2005).

As temperature and rainfall are major factors dictating the distribution of plants and animals it is expected that there will be direct and indirect effects on species and ecosystems across Australia.

The National Biodiversity and Climate Change Action Plan 2004-2007 (NRMMC, 2004) provides a national overview of the impact of climate change and provides strategies and actions to mitigate impacts of climate change on biodiversity based on knowledge compiled in 2004.

It Identifies ecosystems and species which may be particularly vulnerable to the effects of climate change. These include species and ecosystems which are: - already considered vulnerable, those in high altitude environments, restricted to small

geographic areas, vulnerable to invasive species, dependent on flowering and fruiting, low-lying coastal areas, freshwater wetlands or vulnerable to increased drought and fire.

In the study area it is expected that existing climatic conditions will shift, southwards or upwards in altitude, with associated species and ecosystems adapting or becoming extinct. For specialised species that exist in restricted habitats, such as the Broad-toothed Rat, *ex situ* conservation measures which are beyond the scope of this project will be required.

The identification of broad landscape corridors for adaptation to climate change is beginning to gain some attention in the scientific and government areas. The establishment and announcement of the large 'Alps to Atherton Corridor' has established a greater interest and awareness for biodiversity management in relation to the emerging threatening processes from climatic change predictions.

It is now apparent that recognised threatening processes arising from habitat fragmentation such as habitat isolation, habitat degradation, edge effects, predator/prey ratios to name a few, are now compounded by the increased needs for adaptation of wildlife to the potential pressures and threats presented by climate change. The impact of climate change scenarios on biodiversity are briefly investigated in this report. These investigations of the current ideas and principles surrounding climate change have been integrated to establish a set of working principles and criteria which formed the basis for the design and development of the project outputs.

This project works from within a theoretical framework that landscape connectivity will play a major role in both the alleviation of climate change effects and the adaptation to a changing climate for wildlife ecological processes. This hopefully will be achieved by increasing gene flow between different populations of species to maximise their chances of exploiting changed conditions. This approach is consistent with actions identified for "the protection of habitat for terrestrial and marine species or ecosystems vulnerable to climate change" (NRMMC, 2004).

5 Rationale and Principles of Design

From the discussions above the following principles have been used for the basis of the design and delineation of broad wildlife corridors for adaptation to climate change pressures.

The overall rationale is to provide connectivity of similar habitats along climatic gradients and links between threatened landscapes to refugial areas.

The following principles of design were integrated into the analysis and decision making for corridor delineation.

- Reduction in edge effects on reserves and existing vegetation.
- Linking threatened landscapes
- Linking formal protected areas
- Linking key habitats
- Incorporating habitat mosaics
- Buffering and/or expansion of protected areas and linking refugia.

6 Methods

6.1 Key Habitats and Corridors for forest fauna of north-east NSW (Scotts, 2003)

The Key Habitats and Corridors for forest fauna published by Scotts (2003) was considered the most suitable model on which to base the project methodology. This work and the associated data products provided a sound basis on which to establish preliminary design and development. It is the only broad-scale network of wildlife corridors and habitats which covers the whole of the study area. The methodology has been widely reviewed and accepted.

The objectives of this project were based on a broad delineation of existing corridors based on their significance for adaptation to climate change. Therefore supplementary data from, Scotts (2003) identifying specific fauna assemblages were evaluated and grouped together according to broad habitat requirements. This allowed for climatic gradients to be incorporated into the climate change corridors design. Table 1 illustrates the groupings that were made.

Climate Corridor Assemblages	Key Habitats and Corridors – Assemblages - Scotts, (2003)
1. Moist	(UNE) Moist Escarpment – Foothills
	(UNE) Wet Eastern Tablelands
	(UNE) Wet Escarpment
	(UNE) Northern Escarpment
	(LNE) Wet Eastern Tablelands
	(LNE) Mid North Coast Wet Escarpment
	(LNE) High Elevation
	(LNE) Moist Escarpment Foothills
	(TAB) Wet Eastern Tablelands
	(TAB) Wet Escarpment Eastern Tablelands
	(UNE) Eastern Tablelands
	(UNE) Dry Coastal-foothills
2. Dry	(LNE) Dry Valley
	(LNE) Dry Eastern Tablelands
	(LNE) Dry Coastal Foothills
	(TAB) Dry Eastern Tablelands
	(TAB) Southern New England Tablelands
	(TAB) Dry Western Tablelands
	(TAB) Dry Granite Tablelands
	(UNE) Coastal Complex
3. Coastal	(LNE) Coastal Complex
	(UNE) Dry Coastal Foothills
	(LNE) Dry Coastal Foothills
	(LNE) Dry Coastal Foothills

Table 1 Grouping of Scotts (2003) fauna assemblages into broad Climate Corridor Assemblages

Best available desktop data was integrated into the design and delineation of the climate change corridors were based on the best available desktop information and are listed below.

1. Best available vegetation mapping – NRCMA vegetation map – (Ecological, 2005).
2. Level three outputs from the Key Habitats and Corridors – Scotts, 2003. Level three outputs included information specific to each fauna assemblage such as; corridors, key habitats, habitat quality and habitat mapping.
3. SPOT5 satellite imagery (2005)
4. DECC databases, NSW Wildlife Atlas.
5. YETI flora records database.

6.2 Selection of “Species most at Risk” to Climate Change impacts

The fauna assemblage groups developed by Scotts (2003,) were examined for species which depend on landscapes which are predicted to be particularly vulnerable to climate change. The grouping of assemblages as dry, moist or coastal facilitated this approach. Reference species or groups were chosen which would be subject to the factors stated below.

The selection of species vulnerable to climate change included species which are already vulnerable due to climate change pressures such as a restricted distribution, limited dispersal ability, specialised habitat requirements, small populations and/or low genetic diversity. In particular species endemic to high mountain environments, freshwater wetlands and islands are highly vulnerable.

Other climate change pressures considered to impact on species at risk include

- Vulnerability to opportunistic pest species which are adapted to take advantage of a range of climatic conditions, such as the red fox.
- Increase in virulence of viruses and parasites due to higher temperatures.
- Changes in structure and composition of vegetation communities as a result of changes in rainfall and temperature regimes will affect species adapted to existing regimes. This will directly affect nectarivores, frugivores and species dependent on hollows and fissures in old growth forests for habitat.
- Rising sea levels will mean species dependent on mangroves, coastal wetlands and seagrass will be directly affected.
- It is also expected that bushfires will increase in their frequency, intensity and extent. This will particularly affect species adapted to wetlands and rainforest as many existing moist habitats become drier (NRMMC, 2004).

6.3 *Delineation of Climate Change Corridors for Dry, Moist and Coastal Assemblage fauna species*

6.3.1 *Moist and Dry Fauna Assemblages*

The grouping of these fauna assemblages allowed for a broader interpretation of the landscape in terms of major “adaptation” corridors for climate change.

This network of corridors was primarily delineated by using a visual assessment of the landscape based on the spatial mapping of fauna assemblage corridors as derived by Scotts (2003).

Table 1 lists the specific fauna assemblages that were grouped to best represent general climatic corridors significant for the three fauna assemblage groupings.

The initial design was then refined and analysed using more recent habitat quality models, vegetation mapping and visual checking using SPOT5 satellite imagery. This stage of the project refined the boundaries of the broad corridors.

The corridor network design included known refugial areas, such as large wetlands and permanent water holes. These areas may not have been identified by Scotts (2003) as the focus for his work was primarily on forest fauna. These areas are of particular importance as they have survived past environmental changes.

A process of expert review was carried out on the first output from the process. This process used further analysis of digital map layers which formed the basis of design for proposed corridors such as:-

- Spatial Corridor layers (Scotts, 2003)
- Fauna assemblage habitat models (Scotts, 2003)
- Analysis of vegetation patterns from the NRCMA vegetation map (Ecological, 2005.)
- Recent fauna and flora records from NSW Wildlife Atlas throughout and adjoining the study area.

The expert review process identified reference species that were specifically associated with each corridor. These species were based on the relative vulnerability of the fauna species to the adverse effects of climate change. In some cases two reference species were selected as significant for a particular corridor. The species nominated for each corridor will be species of particular conservation significance for that corridor, or section of corridor, in terms of vulnerability to climate change.

Species nominated as reference species may not be so vulnerable in other parts of their range; however the population has been assessed to have some vulnerability to the threatening processes presented by climatic change predictions due to other existing threatening processes. It is not intended that conservation efforts should be structured solely for the benefit of the nominated reference species at the expense of other conservation values.

6.3.2 Coastal Complex Fauna Assemblages

The coastal corridor complex was established through three main phases. The first phase used Corridors mapping from Scotts (2003) specifically for the coastal complex fauna assemblages. Extant vegetation was linked however gaps were included such as cleared areas and agricultural land that fit into a context of a coastal corridor.

The second phase included the additions of coastal wetlands and waterbodies. The third phase added links to the hinterland corridors to provide for overall connectivity between the three main climate change assemblages that were mapped.

7 Results and Discussion

Table 2 lists the species or groups selected as reference species for each corridor for the dry, moist and coastal complex assemblages.

Reference Species or Group	Climate Change Factor	Habitat at Risk
Albert's Lyrebird	restricted distribution	rainforest
Barred Cuckoo-shrike	frugivore	coastal, rainforest
Black-striped Wallaby	restricted distribution	rainforest
Brush-tailed Phascogale	nectarivore	old growth forests
Brush-tailed Rock-wallaby	specialised habitat, increased predators	high altitude
Coastal Shorebirds	migratory	coastal
Eastern Blossom Bat	nectarivore	coastal
Eastern Pygmy Possum	nectarivore	coastal in part of range, old growth forests
Emu	restricted distribution	coastal
Fleay's Barred Frog	restricted distribution, disease	rainforest
Giant Barred Frog	restricted distribution, disease	riparian
Giant Dragon-fly	specialised habitat	wetlands
Grass Owl	restricted distribution	coastal
Grey-headed Flying-fox	nectarivore, frugivore	rainforests
Ground parrot	restricted distribution, increased predators	coastal
Hastings River Mouse	restricted distribution, fire	high altitude
Koala	parasites, fire	coastal
Little Bentwing-bat	specialised breeding habitat, old growth forests	various
Long-nosed Potoroo	fire, increased predators	coastal
Loveridge's Frog	restricted distribution, fire	rainforests
Pouched Frog	restricted distribution, fire	rainforests
Rose-crowned Fruit-Dove	frugivore	rainforests
Shorebirds	migratory	coastal
Sooty Owl	specialised habitat	rainforests
Sphagnum Frog	specialised habitat	rainforests
Squirrel Glider	nectarivore	old growth forests
Stuttering Frog	restricted distribution, fire	high altitude
Waders	migratory	wetlands
Wallum Frogs	specialised wallum habitat	coastal
Wetland Waterbirds	migratory, fire, predators	wetlands
Wompoo Fruit-Dove	frugivore	rainforests
Woodland Birds	Declining nationally, nectarivores, increased predators	various
Yellow-bellied Glider	nectarivore	Old growth forests

Table 2: References “Species at risk” Chosen to Represent Corridors

7.1 Moist Faunal Assemblage Group

The analysis identified 30 major corridors in the NRCMA study area for the moist forest fauna assemblage which are summarised in table 3 below.

Corridor Name	CC Reference Species 1	CC Reference Species 2	HCV Status
Alstonville Plateau Link	Rose-crowned Fruit-dove	Pouched Frog	HCV Linkage
Billinudgel - Wollumbin	Wompoo Fruit Dove		HCV Linkage
Birriwal Bulga - Werrikimbe Connector	Yellow-bellied Glider	Sooty Owl	
Bongil Bongil - Bindarri	Koala	Yellow-bellied Glider	
Border - Tonnumbar Connector - East	Wompoo Fruit-dove	Yellow-bellied Glider	HCV Linkage
Border - Toonumbar Connector - West	Wompoo Fruit-dove	Yellow-bellied Glider	HCV Linkage
Border - Upper Clarence Connector - East	Albert's Lyrebird		
Border - Upper Clarence West connector	Wompoo Fruit-dove		
Border- Wollumbin Connector	Alberts Lyrebird	Wompoo Fruit Dove	HCV Linkage
Byron - Tweed Range	Alberts Lyrebird	Loveridge's Frog	HCV Linkage
Coffs Coast - Escarpment	Rose-crowned Fruit Dove	Giant Barred Frog	HCV Linkage
Coffs Coast - Escarpment - Upper Clarence	Giant Barred Frog	Sooty Owl	HCV Linkage
Corindi Connector	Yellow-bellied Glider	Grey-headed Flying Fox	
Dorrigo Connector	Giant Barred Frog	Sooty Owl	
Dunoon - Hanging Rock Creek Connector	Rose-crowned Fruit-dove	Pouched Frog	
Iluka - Richmond Range	Grey-headed Flying Fox	Black-striped Wallaby	HCV Linkage
Lower Bucca Connector	Grey-headed Flying-fox		
Macksville - Dunggir	Sooty Owl	Sphagnum Frog	
Mid North Coast Escarpment - Barrington	Giant Barred Frog	Sooty Owl	HCV Linkage
Mt Clunie Connector	Alberts Lyrebird	Wompoo Fruit-dove	
Nambucca - Missabotti	Yellow-bellied Glider	Wompoo Fruit Dove	HCV Linkage
Nightcap - Nimbin Connector	Rose-crowned Fruit-dove	Pouched Frog	HCV Linkage
Oyster Creek - Escarpment	Giant Barred Frog	Little Bent-wing Bat"	
Port Macquarie - Bulga Plateau	Sooty Owl	Yellow-bellied Glider	HCV Linkage
Sherwood Connector	Yellow-bellied Glider	Grey-headed Flying Fox	
Tweed/Border Ranges to Mount Clunie	Fleay's Barred Frog	Albert's Lyrebird	HCV Linkage
Urunga - Escarpment	Rose-crowned Fruit Dove	Giant - Barred Frog	
Yabba - Tooloom Creek - Connector	Rose-crowned Fruit-dove		
Yamba - Nymboida	Yellow-bellied Glider	Grey-headed Flying Fox	
Yarrahappinni - Escarpment	Grey-headed Flying Fox	Wompoo Fruit Dove	HCV Linkage

Table 3 List of Moist assemblage fauna climate change corridors and assigned reference species.

Quantitative analysis showed there were significantly more mapped key habitats within the "Reserve Buffers" and "Reserve Buffers and Linkages" features. Table 4 below shows the proportion of key habitats and old growth forest mapped within each corridor feature. The relative proportion of vegetated area for each corridor feature shows a clear trend. This kind of pattern will aid in qualifying and quantifying the nature of conservation actions required in corridor features to achieve the objectives of landscape connectivity and ecological viability. The patterns can be interpreted to

estimate resources or develop proposals and actions across specific areas of the landscape.

Corridor Features	Area Ha	Vegetated HA	% Vegetated	% Key Habitats	% Old Growth
Protect and Enhance	54409	43685	80	28	19
Reserve Buffers	307620	281005	91	51	22
Reserve Buffers and Linkages	1335370	1241743	93	73	39
Stepping Stone Linkages	92490	44646	48	16	6
Valley Floor Linkages	48597	26058	54	21	5

Table 4 Relative proportions of vegetation and HCV values within corridor features for moist assemblage fauna species.

These types of analysis demonstrate some general patterns for each corridor feature which can be surmised to estimate resources for particular conservation actions or to develop proposals and actions for each corridor features.

7.2 Dry Faunal Assemblage Group

20 corridors were identified for the dry corridor network and are summarised below in table 5.

The corridors designated HCV Linkages highlight the areas where good populations of dry assemblage species should be already utilising the corridor based on the presence of areas of key habitat.

Corridor Name	CC Reference Species 1	CC Reference Species 2	HCV Status
Apsley River-McDonald River	Woodland Birds	Koala	
Cairncross	Koala	Grey-headed Flying-fox	
Carrai Plateau	Hastings River Mouse		
Carrai Plateau-Macleay Lowlands	Little Bent-wing-bat	Brush-tailed Phascogale	HCV Linkage
Clarence Valley-Tablelands	Woodland Birds	Brush-tailed Phascogale	
Coastal Range	Emu		
Commissioners Waters	Woodland Birds	Koala	
Ewingar-Mt Pikapene	Woodland Birds	Brush-tailed Rock-wallaby	
Garra-Cathedral Rocks	Woodland Birds	Squirrel Glider	
Garra-Mt Duval	Woodland Birds	Koala	
Great Eastern Tablelands Corridor	Woodland Birds	Brush-tailed Rock-wallaby	HCV Linkage
Hillgrove-Garra	Woodland Birds	Squirrel Glider	
Macleay River-Collombatti	Brush-tailed Phascogale		HCV Linkage
Mann River	Woodland Birds	Brush-tailed Rock-wallaby	HCV Linkage
Mann River -Severn River	Woodland Birds	Koala	HCV Linkage
Richmond Range-Bungawalbyn	Woodland Birds	Squirrel Glider	
Rocky River Valley	Brush-tailed Rock-wallaby	Stuttering Frog	
Timbarra Plateau	Hastings River Mouse	Giant Dragon-fly	HCV Linkage
Warra-Henry River	Eastern Pygmy Possum		HCV Linkage
Warra-New England Range	Woodland Birds	Squirrel Glider	

Table 5 List of Dry assemblage fauna climate change corridors and assigned reference species.

Table 6 highlights the areas of lower conservation value which require most effort to achieve connectivity. The floodplains and tablelands would have once been areas of high biodiversity but have suffered most from broad scale clearing

Corridor Features	Area (ha)	Vegetated (Ha)	% Vegetated	% Key Habitats	% Old Growth
Linkage across Floodplain	121023	77596	64	8	14
Linkage onto Tablelands	66723	43112	65	47	21
Protect and Enhance Existing	159324	146028	92	25	45
Reserve Buffers and Linkages	1202026	1032285	86	27	43
Stepping Stone Remnants	18762	6301	34	3	3
Valley Floor Linkages	157762	134801	85	17	44

Table 6 Relative proportions of vegetation and HCV values within corridor features for moist assemblage fauna species.

7.3 Coastal Complex Faunal Assemblage Group

The analysis identified 18 major corridor sections in the NRCMA study area for the coastal complex forest fauna assemblage which are summarised in table 7 below along with the attribution of HCV linkage. HCV linkages were selected based on the following rule set. Corridors with either

1. More than 30% key habitats mapped within corridor.
2. More than 20% HCV wetlands mapped within corridor.

Corridor Name	Reference Species 1	Reference Species 2	HCV Status
Ballina	Grey-headed Flying-fox	Rose-crowned Fruit Dove	HCV Linkage
Ballina-Broadwater	Waders	Shorebirds	HCV Linkage
Bellinger - Nambucca	Grey-headed Flying-fox	Coastal Shorebirds	
Broadwater - Bungawalbin	Koala	Emu	HCV Linkage
Brunswick - Chincogan	Grey-headed Flying-fox	Alberts Lyrebird	HCV Linkage
Byron - Lennox	Ground parrot	Wallum Frogs	HCV Linkage
Coffs Coast	Grey-headed Flying-fox	Koala	
Crescent Head - Hastings	Grass Owl	Ground Parrot	HCV Linkage
Cudgen	Eastern Blossom Bat	Wallum Frogs	
Hastings - Camden Haven	Koala	Barred Cuckoo-shrike	HCV Linkage
Lower Clarence	Wetland Waterbirds	Emu	HCV Linkage
Macleay - Crescent Head	Wetland Waterbirds	Squirrel Glider	HCV Linkage
Nambucca - Macleay	Eastern Blossom Bat	Grey-headed Flying-fox	HCV Linkage
Taree Coast	Eastern Blossom Bat	Koala	HCV Linkage
Tweed - Cobaki	Long-nosed Potoroo	Wallum Frogs	
Tyagarah - Byron	Long-nosed Potoroo	Wallum Frogs	HCV Linkage
Uralba-Tuckean Swamp	Alberts Lyrebird	Koala	
Yuraygir	Emu	Ground Parrot	

Table 7 List of Dry assemblage fauna climate change corridors and assigned reference species.

Corridor Features	Total Area - Ha	Vegetated Ha	% Key Habitats	vegetated %
Coastal Connector	327540	230035	29	70
Linkage across Floodplain	37151	8870	6	24
Major Wetland Area	35981	27006	47	75

Table 8 Relative proportions of vegetation and HCV values within corridor features for moist assemblage fauna species.

8 FINAL OUTPUTS

8.1 *Separate digital spatial data layers for each fauna assemblage including moist, dry and coastal assemblages. Data structured in an Arcview GIS format.*

The layer delineates a key climatic gradient corridors network to provide for moist, dry and coastal faunal assemblage groups to respond to climate change pressures.

8.2 *Corridor names*

Corridors were identified and attributed with names based on location, landscape features or protected areas in close proximity. This was established to facilitate community identification with the mapped corridors.

8.3 *High Conservation Value Linkages*

The Corridors networks were analysed and tagged as HCV linkages if part of its extent contained significant areas of HCV habitat. This provides a quick reference for corridors which already support significant populations of species vulnerable to climate change. The selection of these HCV linkages varied for the three faunal assemblage groups. In moist and dry corridor assemblages, corridors containing over 30% key habitats were tagged as HCV Linkages.

8.4 *Corridor Features*

A visual analysis of the SPOT5 satellite imagery and vegetation mapping data revealed various features within the corridors that will assist in strategic planning for conservation actions. These are described below.

8.4.1 *Protect and Enhance*

The characteristics of this corridor feature are predominantly high levels of vegetated land, presence of high conservation value forest and a level of continuity with adjacent areas of vegetation or reserves or other public land. The priorities in these areas would generally be focused on the protection of the existing high conservation value features, or some enhancement of existing vegetation through plantings, weed management and removal threatening processes.

8.4.2 *Reserve Buffers and Linkages*

These corridor features are predominantly delineated around or linking existing formal reserves and some other public lands. The areas are predominantly vegetated and contain large areas of key habitats and other high conservation value features such as old growth forest, wetlands, rainforest and forest that have been subject to less disturbance and fragmentation.

8.4.3 Stepping Stone Consolidation

These areas are classically fragmented and contain remnant vegetation that may be subject to edge effects. The areas are somewhat compromised in terms of viability for acting as wildlife corridors for species which will not disperse large distances over open areas but can be utilised by other species, especially bats and birds. In some instances they are more effective than narrow linear corridors which are dominated by edge loving species and thus represent important priority areas that require consolidation, maintenance and protection. The priorities in these areas would include;

- strategic re-establishment of vegetation,
- rehabilitation - weed management, feral animal removal
- protection of existing remnants
- nest boxes.
- Stepping Stone areas enhance landscape connectivity and will provide good connectivity for a subset of more mobile species such as bats, birds and insects.

8.4.4 Linkage across Floodplain

The cleared floodplains of the study area represent major barriers to dispersal for many species. It is recognised that considerable resources would be required to complete these links however their importance should not be ignored. The higher productivity, access and permanent water of the major river systems will make these areas a high priority for conservation activities to address climate change. These have been refugia in past droughts and should be a high priority for future conservation efforts. Projected increased salinity in these areas may mean land becomes available for conservation as farming becomes unviable.

8.4.5 Linkage onto Tablelands

These areas are delineated as the most effective in improving connectivity for this highly threatened high altitude landscape. The extensive clearing and fragmentation of this area along with the projected higher temperatures and evaporation mean that many species and ecosystems already at risk further west may only survive along the tablelands/escarpment ecotone. Improving the connectivity along this predominately east to west gradient should be seen as a high priority.

8.4.6 Valley Floor Linkages

These are typically areas that link vegetation across the more productive, and thus heavily cleared alluvial flats and riparian areas. These areas are usually more fragmented and in poorer condition, however contain a high level of importance in terms of, productivity, connectivity and wildlife movement. Conservation actions would predominantly be associated with re-vegetation in strategic “stepping stone” locations and configurations.

8.5 Coastal Corridor Features

The coastal corridor has been developed using different methodology in delineating features. The geomorphology found within the long narrow coastal strip does not easily ready itself to splitting into discrete features similar to the dry and moist corridors. It also has its own unique set of climate change pressures and existing threatening processes. Sea level rises are expected to have a devastating effect on low level estuarine and freshwater wetland environments. Corridor features were categorised as a “Linkage across Floodplains” (as described above), “Major Wetland areas” or Coastal connector”.

8.5.1 Major Wetland Areas

These areas which may be inundated with salt water and change the make of wetland communities dramatically. Cleared areas immediately adjacent to areas currently supporting wetland ecosystems should be targeted as they will be increasingly important as sea level rises.

8.5.2 Coastal Connectors

Areas which are a mosaic of reserves, public lands forming stepping stone linkages of semi cleared ridges, small wetlands, and riparian strips. These will require a combination of the strategies outlined for other features

8.6 Database of quantitative statistical information including:-

Statistical information regarding each corridor section is built into the attribute table and can be analysed to evaluate conservation actions and funding requirements. The following information is included:

- Vegetation area (All fauna groups)
- Old growth area (All fauna groups)
- Key habitat area (All fauna groups)
- Coastal Wetland area (Coastal group)
- Rainforest area (Moist and Coastal group)

The area of these conservation features, in hectares and as a percentage of corridor area. This information is built into the attribute layers of the GIS spatial database.

9 Priority Actions and Criteria

Conservation actions and proposals may be determined by themes such as the reference species attribution, reserve system connectivity, stepping stone consolidation or key habitat protection. Themes can relate to certain incentives or priorities as new science is publicised on climate change predictions and associated priorities for wildlife and biodiversity in general.

The data will facilitate the assessment of various conservation proposals in terms of climate change priorities for fauna. The data illustrates the value of the proposals within the context of broader landscape wildlife corridors and their features.

During the project the project team explored various ideas on how to rank proposals and evaluate the importance of proposals in relation to each other. It was found that this level of evaluation was highly complex and that proposals should be assessed on their relative merits and considered contribution to the corridors network. After much discussion and assessment of the available tools for such an evaluation of proposals (incentives etc) the following criteria were developed, based on the outputs of this project and reference to existing high conservation value data mapped from previous conservation assessment processes such as Key Habitats and Corridors for forest fauna (Scotts, 2003). The following criteria should be used as a guide to evaluate and rank the relative priorities of incentive proposals.

9.1 Criteria for assessment of proposals

Characteristics of proposal location in order of relative importance;

Proposal assessment: Is the proposal

1. Within a broad corridor for climate change.
2. Within major regional wildlife corridor (Scotts, D 2003)
3. Within sub-regional wildlife corridor (Scotts, D 2003).
4. Adjacent to an existing incentives proposal or PVP agreement that protects similar values.
5. Likely to generate increased community uptake in surrounding areas.
6. Within a HCV corridor (ie corridors with more than 30% key habitat area)
7. A buffer to; existing HCV Corridor; Formal Reserve network; existing protection agreement such as VCA, covenants; wetland

10 Limitations

10.1 Isolated vulnerable Habitats

It may not be possible to connect some vulnerable habitats, such as isolated wetlands due to geographic or geological conditions or islands by vegetative corridors. In these instances localised threatening process should be minimised and other conservation strategies explored.

10.2 Floodplain remnants and linkages

In some areas opportunities to establish Floodplain Stepping Stones may arise which are outside delineated corridors. If this occurs in heavily cleared areas it would be prudent to revegetate these areas if no other property is available in the area.

10.3 Riparian corridors

Riparian areas are natural corridors for many species and should be considered a priority to maintain and enhance. Riparian Corridors were not specifically delineated by Scotts (2003) as they are already clearly defined in the landscape.

Although riparian corridors are not extensively mapped in the project outputs, it is essential that these areas receive protection, re-habilitation and even expansion to help complement an overall landscape connectivity approach to climate change. Lindenmayer and Fisher, 2006 state that 'Riparian corridors or stream buffers are a particular type of corridor that can often be particularly effective at maintaining habitat connectivity (Kirchner et al. 2003; Hilty and Merenlender 2004). They provide habitat for large numbers of terrestrial and aquatic fauna and flora (Loyn et al. 1980; Naiman et al. 1993; Spackman and Hughes 1995). In addition, populations of several groups of species are more fecund in riparian areas (Sederquist and Mac Nally 2000), thereby providing more offspring to disperse to the less productive parts of the landscape.'

In terms of connectivity, however, Lindenmayer and Fisher, 2006 go on to state that 'while riparian areas are useful for some terrestrial taxa, physical linkages outside the riparian zone are required to maintain landscape connectivity for other taxa (McGarigal and McComb 1992; Claridge and Lindenmayer 1994).

In terms of our recommendations for further corridor and landscape connectivity work, riparian corridors should feature strongly in any mapping of floodplain 'stepping stones' as an essential supplement to the existing broad corridors networks presented by this project.

11 Caveats

Lindenmayer and Fischer 2006 discuss some of the apparent disadvantages with wildlife corridors which should be considered. The discussion states that 'corridors may facilitate the spread of genes that break up co adapted gene complexes in naturally isolated population (Knopf, 1992). They may also exacerbate the spread of weeds, pest animals, diseases, and fires (Forney and Gilpin 1989). Corridors may be dominated by negative edge effects (Sisk and Margules 1993).

These disadvantages should be considered in the allocation of resources for conservation actions. Any re-establishment or rehabilitation of vegetation should also include strategic follow up actions and resources to reduce the impacts of weeds and edge effects and allow for the area to grow spatially and structurally.

The design of this project is based on climate change projections at the lower end of the predicted changes. This is dependent on a steady reduction in carbon emissions occurring within the next 10-15 years and annual temperatures across the study area not rising by more than 2 degrees C. If emissions are not drastically reduced and temperatures rise by 3-6 degrees C then the measures outlined in this report will be ineffectual.

12 Recommendations for Further work

- This project provides for the basis broad scale network of vegetated corridors, along climatic gradients linking with the Alps to Atherton continental scale corridor, to assist threatened wildlife populations adjust as projected ecological changes due to climate change occur.
- Further work to delineate stepping stone corridors across and between the most threatened landscapes such as floodplains, wetlands, lowland forest areas and low lying coastal landscapes needs to be established as a major incentive to mitigate the increasing pressures of habitat fragmentation on fauna assemblages that rely on these landscapes and their habitat for survival.
- Further refinement is needed to define the corridor network at a local rather than regional scale to increase the effectiveness of the mapping for planning on ground conservation works at a property scale. Setting reference species at this level will further improve the effectiveness of the corridors.
- Further research is needed to better understand the effects of climate change on biodiversity in the study region.
- Systematic fauna surveys are needed to determine the value of corridor linkages to different faunal assemblages.
- Research is needed on the population dynamics of vulnerable species in the study area to help improve strategies to maximise gene flow in a way which is of benefit to the species or population. This will assist in determining the effectiveness of different patch sizes for different species,

- Good baseline population data, such as current range and distribution, is lacking for much study area. Collecting this data should be a priority so that changes caused by climate change can be recognised. Migratory species are particularly important as changes in their arrival and departure times may signal the onset of dramatic changes.
- An effective monitoring programme is needed to ensure that by increasing connectivity in a designated corridor it is mitigating the pressures of climate change not exacerbating them.

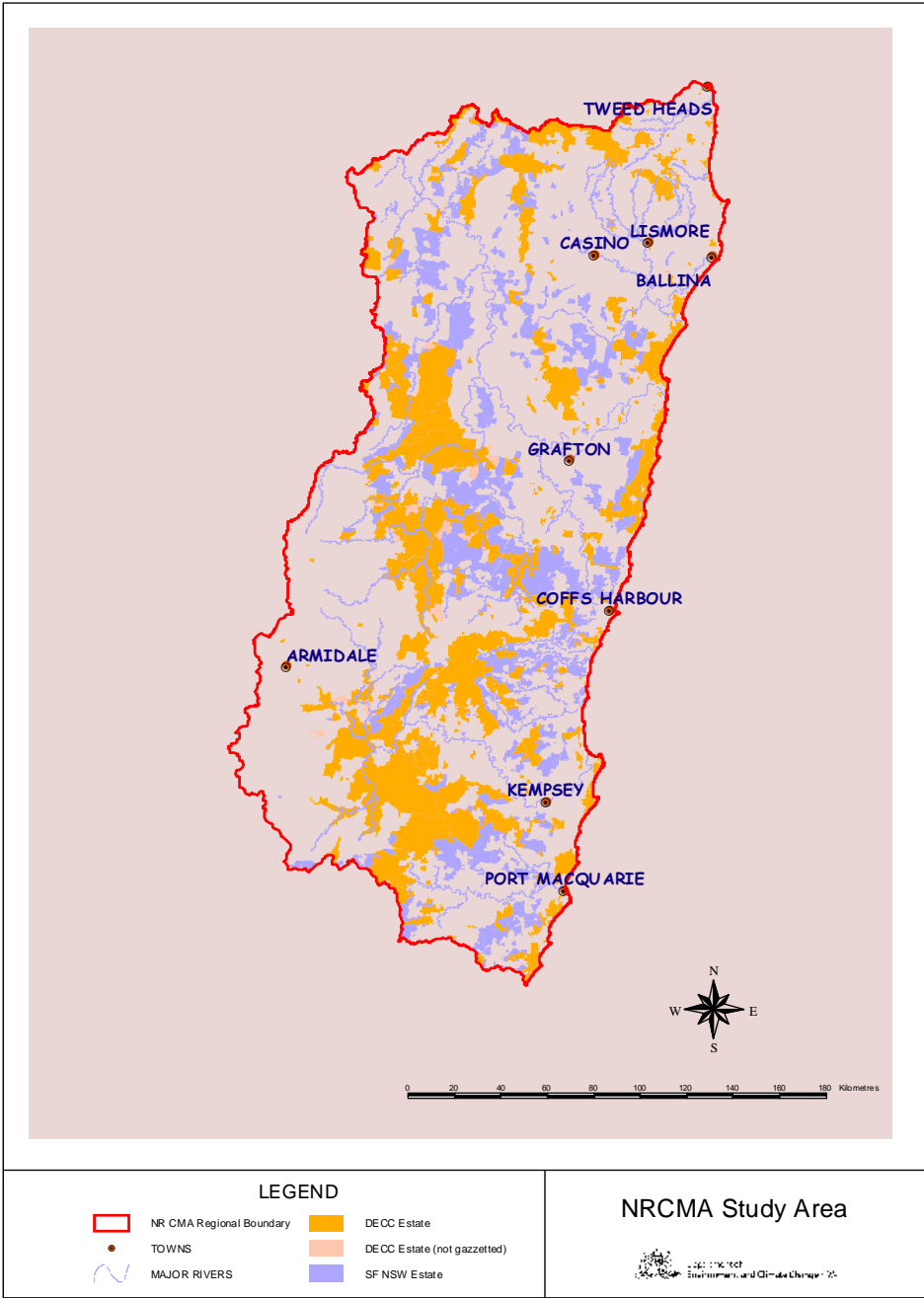
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APPENDIX A



MAP 1: Map of the Study Area for Climate change Corridors project over the Northern Rivers Catchment Management Authority jurisdiction.

APPENDIX B: Example map of All Corridors

