6.1 l EIS and SEIS Cassowary reports Vol I, II, III & WP 3 L Moore

CASSOWARY ASSESSMENT OF THE
'ELLA BAY INTEGRATED RESORT PROJECT'
NORTH QUEENSLAND
6 – 14 NOVEMBER 2006

VOLUME I – CASSOWARY FIELD SURVEY

VOLUME II – IMPACTS AND MITIGATION

VOLUME III – POPULATION VIABILITY ANALYSIS

Report prepared
for
John Holland Services Pty Ltd

L.A. MOORE
'Cloudhill'
63 Wooleys Road,
Millaa Millaa 4886
Queensland, Australia
Phone +61 7 4097 2107
Email: cloudhill@bigpond.com; lesmoore3@bigpond.com

NOTICE TO USERS OF THIS REPORT

Signature: L. A. Moore Date:

CASSOWARY ASSESSMENT
Ella Bay

Table Of Contents

VOLUME I – CASSOWARY FIELD SURVEY

VOLUME II – IMPACTS AND MITIGATION

VOLUME III – POPULATION VIABILITY ANALYSIS (PVA)

List of Tables

Boxes

List of Figures

List of Plates

APPENDICES

VOLUME I

CASSOWARY FIELD SURVEY

CASSOWARY SURVEY OF ELLA BAY, INNISFAIL

1. INTRODUCTION

This report has been prepared for John Holland Services Pty Ltd (John Holland) for the purpose of providing information concerning the threatened southern cassowary *Casuarius casuarius johnsonii*, listed as Endangered under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. The scope of the cassowary assessment is that area subject to the Ella Bay Integrated Resort Project, Innisfail and the study has been based on the Terms of Reference (TOR) for an Environmental Impact Statement (The Coordinator-General, December 2005). In addition, the Ella Bay Road and the forest surrounding Flying Fish Point were also surveyed for cassowaries, and these areas are included in this report.

1.1 STUDY SCOPE

The Ella Bay cassowary field survey and subsequent analyses encompasses the local cassowary population and includes all cassowaries that inhabit or pass through the project site or adjacent, nearby areas. With regard to the requirements of threatened species and communities listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, this report addresses the following matters:

- *the presence of any listed species or community and its associated habitat;*
- *the potential direct and indirect impacts of the proposal;*
- *and mitigation measures proposed* (TOR 2005).

The detailed components of the TOR dealt with in this study comprise:

1. *Surveys of the key cassowary habitats to be impacted (by both direct and indirect impacts) to determine presence/absence of cassowaries, abundance, age classes and breeding potential.*

2. *For each of the different areas to be impacted, an analysis of its values in terms of: population density (e.g., does it have high population density that is considered important); level of protection (tenure); its role in connectivity, including the importance of the areas being connected; provision of known, likely or supplementary resources for food, water, breeding and shelter; use as a refugial area; likely genetic importance; any other values that are identified.*

3. *Maps of Cassowary habitat types following EPA 2004 that have been ground truthed with vegetation surveys.*

4. *Identification of any sites that are part of a conservation initiative endorsed by the Recovery Plan (QPWS 2001).*

5. *For each of the different areas to be impacted, an analysis of its values, and the expected impact on these values, in terms of: population density (e.g., does it have high population density that is considered important); level of protection (tenure); its role in connectivity, including the importance of the areas being connected; provision of known, likely or supplementary resources for food, water, breeding and shelter; use as a refugial area; likely genetic importance; any other values that are identified. Some of these will require checking with local authorities as above.*

6. *Consideration of all potential impacts - direct and indirect impacts, on and off site – which may include but are not limited to habitat loss, fragmentation, roads and traffic, dogs, human interaction, disease and habitat degradation.*

7. *An analysis of possible mitigation measures that could be used and those proposed to be used.*

8. *PVA at the local population level. This should include a clear indication of the sources and reliability of the relevant life history parameters used. Where possible, the parameters should include data that has been researched from the local population. It should include a discussion of the limitations of the results.*

(TOR - The Coordinator-General, December 2005).

Figure 1

Location of Ella Bay Study Area

1.2 REPORT STRUCTURE

This report comprises three discrete volumes.

Volume 1 presents the methodology and results of an eight-day field survey of cassowaries at Ella Bay and Flying Fish Point, 9 km northeast of Innisfail.

Volume II comprises an impact assessment and mitigation strategy for the proposed Ella Bay Integrated Resort Project and Little Cove, and includes the Ella Bay Road which will be used to access the proposed resort.

Volume III presents a preliminary population viability analysis (PVA) of the Ella Bay cassowary population, with specific evaluation of all known factors and their potential interactions on the cassowaries using and surrounding the proposed Ella Bay Integrated Resort Project.

1.3 CONSERVATION STATUS OF THE SOUTHERN CASSOWARY

In Australia, the southern cassowary *Casuarius casuarius johnsonii* is classified as 'Endangered' under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. The southern (Wet Tropics) population is classified as 'Endangered' under the *Queensland Nature Conservation Act 1992*, while the northern (Cape York) populations are classified as 'Vulnerable'. The primary causes of the species' decline in the Wet Tropics include habitat clearing and fragmentation due to development, road death, disease, dog attacks and hunting.

1.4 CASSOWARY SURVEY STUDY AREA

The total study area comprises:

- Ella Bay Property and Little Cove;
- Ella Bay Road and Flying Fish Point;
- Ella Bay National Park.

1.4.1 Ella Bay Property and Little Cove

This study is focused primarily Lot 30 on Crown Plan N157629 and Lot 337 on NR53, herein referred to as the Ella Bay Property (Figure 2). The site is located approximately 110 kilometres south of Cairns and approximately nine kilometres to the northeast of Innisfail within the Wet Tropics Bioregion (Figure 1). The site adjoins the extensive swampland and rainforests of the Ella Bay National Park to the north, south and west with a small boundary section adjoining freehold land in the far southwest corner of the property (3D - BAAM 2006). The total study area includes the Ella Bay National Park in the southern and western sections of the Ella Bay Swamp to the north, and parts of the Seymour Range to the west and south.

A detailed site description of the Ella Bay Property is given in Section 2 of the Vegetation Survey Report (3D - BAAM 2006).

1.4.2 Ella Bay Road and Flying Fish Point

This area includes the entire length of the Ella Bay Road and sections of the Ella Bay National Park extending from Mount Maria south to the Flying Fish Point township, and is treated separately from the Ella Bay Property in this report (Figure 2).

1.5 POST-CYCLONE SURVEYING CONDITIONS

Field surveying for cassowaries in the study area was made difficult by large quantities of debris deposited on the ground by Cyclone Larry, which passed directly over the Innisfail area on 20 March 2006. The total canopy loss that occurred on the ridges resulted in some sections of these areas being inaccessible for ground surveying. Moreover, it was evident that much of the highly disturbed areas was not accessible to foraging cassowaries, due to tree-fall debris covered by an impenetrable growth of *Calamus* and other creepers. Typical examples of cyclone damage on ridgelines and foothills are shown in Plates 1 - 3. Due to a lack of recent rain and the drying effect caused by a lack of tree canopy, the soil was dry and generally unsuitable for recording footprint impressions.

Figure 2

Cassowary study area Ella Bay – Flying Fish Point

Plate 1. Eastern face of Seymour Range showing severe wind damage on ridgeline and foothills caused by Cyclone Larry on 20 March 2006. The majority of this area has yet to recover its canopy.

Plate 2. View showing the damaged condition of much of the exposed ridgelines and upper slopes of Little Cove development area. This forest type has been subject to repeated cyclone disturbance and is characterised by *Acacia celsa* and *A. mangium*.

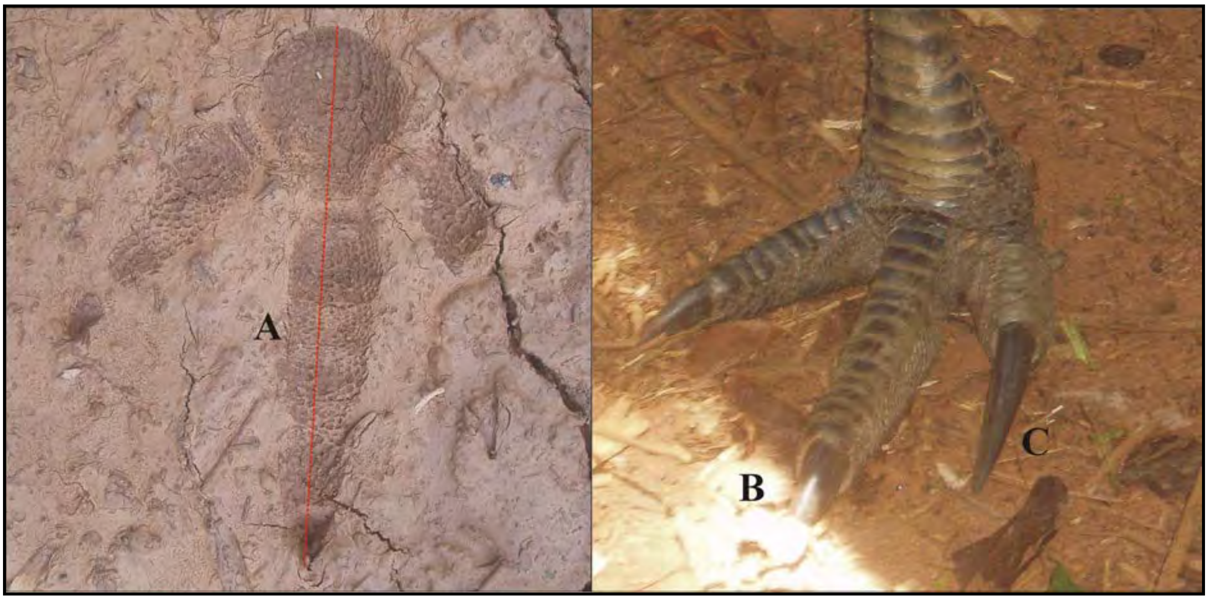
Plate 3. Cyclone damaged mesophyll vine forest showing a canopy loss of approximately 80% and heavy regrowth of *Calamus australis* and *Merremia peltate.* The remaining emergents predominantly comprise *Alstonia scholaris* and *Archontophoenix alexandrae*. Due to an almost impenetrable sub-canopy, movement through these areas by cassowaries was difficult and often impossible.

2. SURVEYING METHODOLOGY

The development of genetic techniques to identify individual cassowaries from cassowary dung has been underway since 1997. At the time of this project, however, this survey technique was not available and is a methodology unable to provide the ecological or home range data necessary to evaluate effects on individual animals. As such, the cassowary field surveying techniques used in this study are those developed and tested by the author over numerous surveys carried out between 1988 and 2003 (Crome and Moore 1988, 1990, 1993a,b, Moore and Crome 1992, Moore 1995, 1996a-i, 1997, 1998a-c, 1999a-i, 2000a, b, 2003, 2006 a-c). This methodology is designed to provide a rapid estimate of the presence and abundance of cassowaries and their current use of habitat, and is not intended to be statistically rigorous. A long-term scientific study (including DNA studies) would be required to obtain statistical validity.

Figure 3

Diagnostic features of cassowary footprint



Cassowary footprint illustrating the diagnostic features and measurement point. A = Measurement taken in millimetres from heel to end of central toe; B = Central toe with distinct claw tip; C = Inner toe or stiletto (indicates right foot).

The field methodology used was a combination of detailed mapping of cassowary sign and the direct observation of located cassowaries. The primary objective was to accurately locate, measure and map all cassowary sign i.e., footprints, bird sightings, droppings and vocalisations. All observations were noted and plotted onto a field map. When possible, photographs are taken of each located cassowary.

Although temporary or seasonal food shortage may result in a lack of droppings with which to determine the presence or absence of cassowaries, given suitable weather and soil conditions moving birds will always leave footprints and their presence in an area can be established. Thus, particular effort was made to locate and measure footprints, and subsequently locate the bird responsible for making them. The distance between the heel and tip of the large central toe can be accurately measured on most footprints, and the variation in foot size may often be sufficient to separate individual birds from their neighbours (Moore, 2003). Figure 3 shows a typical cassowary footprint and illustrates the diagnostic features and measurement point. Unfortunately, due to extensive canopy loss (40% - 80% loss: Fell and Stanton), the forest floor had been exposed to direct sunlight and the soil being too dry to retain footprints. In addition, very little fruit was available to cassowaries over large portions of the study area, so droppings were scarce. As a result, most footprints in this survey were located in soil disturbed by pig and megapode activity, or along streamlines and in swamps. In summary, due to the scarcity of indirect sign, resident cassowaries were often located without scat or footprint evidence of their presence.

2.1 FIELD OBSERVATIONS

Similar individual recognition methodology was employed as that used in a previous study of mating systems in free-living emus (Coddington and Cockburn, 1995). In their study of 42 adult and nine juvenile emus, it was concluded that individual identifications could be reliably made using the pattern of the worn area on the sides of the head and neck, colour, shape and size of body, and any other distinctive features such as skin flaps, scars, or distinctive feather patches. The sex of their animals was determined using copulatory position, a visible penis when defecating, whether seen in company with chicks, and the disappearance of one member of a pair to start incubation.

Cassowary sightings comprise individual birds and family groups. Adults and older subadult cassowaries are often individually identifiable using visible physical characteristics. These features may include: footprint measurement, size and shape of the casque ('helmet'); presence or absence of markings on exposed surfaces e.g. blotches on the casque; visible scars on legs, neck, head, beak; the length and shape of the wattles, the size and sex of the bird; the presence or absence of chicks; and the number and relative ages and size of any chicks accompanying the male parent. Unaccompanied males (no chicks) were identifiable by their relatively small size (in comparison to adult females), and the presence of a distinctive "drooped tail" to their ventral profile. Adult females are generally clearly larger and present a horizontal line to their ventral profile, lacking the "tail" of the male (Moore, 2003, 2006). Photographs of all birds are taken when possible to build an 'identikit' database with which to separate individual birds.

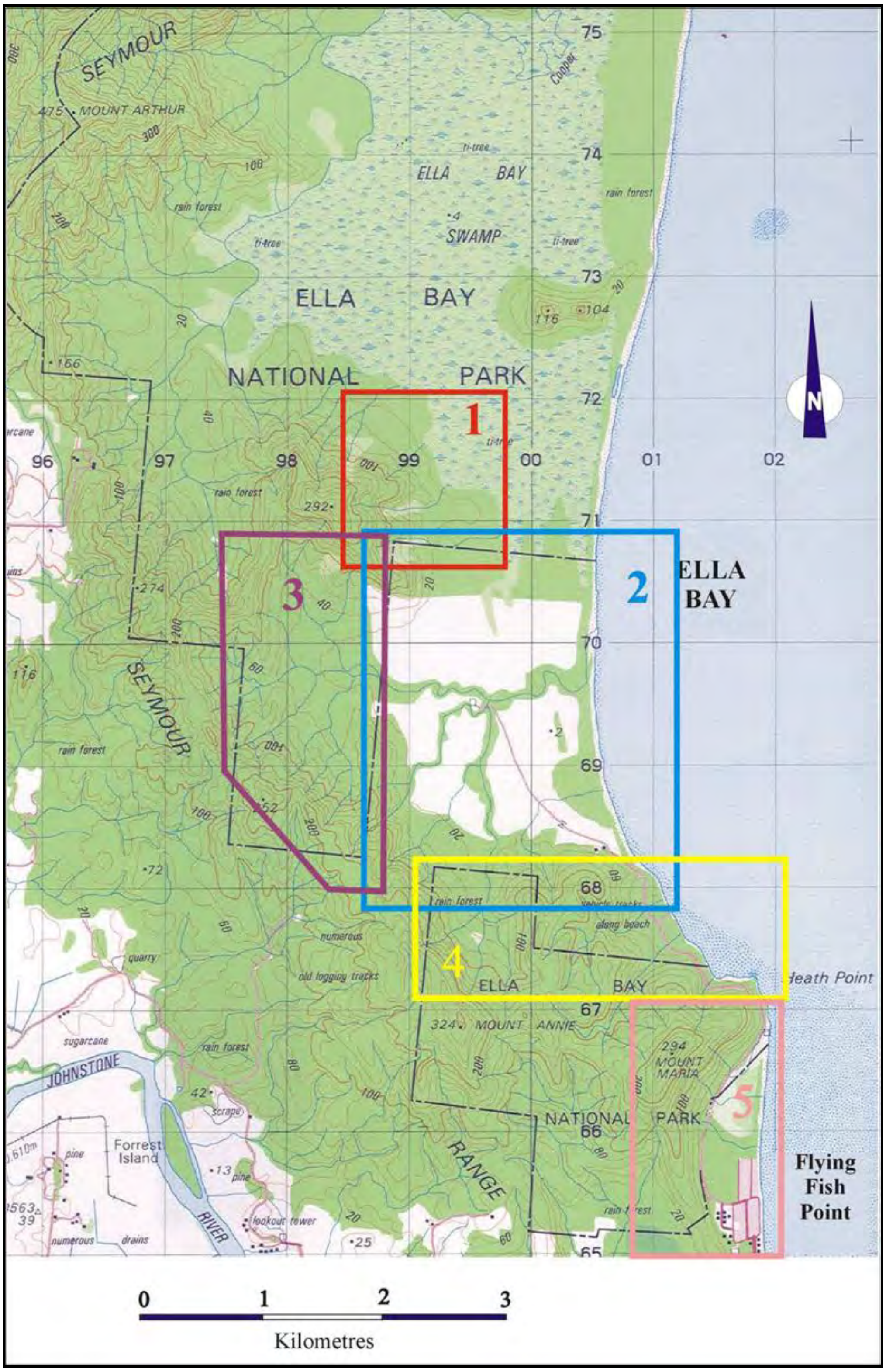
2.2 GROUND SURVEY AND MAPPING

To provide coverage of the study area, five Search Areas were defined using an aerial map superimposed with the Ella Bay Property boundaries and a 1:50 000 topographic map. The survey area extended into the Ella Bay National Park for approximately one kilometre (Figure 2). The boundaries of existing vegetation units as mapped by Stanton and Fell (BAAM 2006), were marked onto field maps and the placement of approximate search trails were based on clearly recognisable features such as ridgelines, creeks, and existing tracks and roads. All data recorded in the field were plotted onto the field maps and subsequently transferred to an aerial base map for interpretation.

Using the Search Area maps in conjunction with compass bearings and landscape features, daily field searches were conducted on foot. When possible, a GPS was used to locate waypoints, and digital photographs of habitat within each Search Area were taken to aid in the assessment of cassowary habitat quality. The approximate location of individual Search Areas is shown on Figure 4.

Figure 4

Cassowary Search Areas and Total Study Area



3. RESULTS OF ELLA BAY CASSOWARY ASSESSMENT

This chapter presents the results of the Ella Bay Property and Little Cove cassowary assessment.

3.1 CASSOWARIES OF ELLA BAY AND LITTLE COVE

Approximately 9.5 km^2 were surveyed on foot over the eight days of the Ella Bay cassowary study. The total search effort resulted in the location of 72 cassowary signs comprising sightings, measured footprints, partial footprints, and droppings. A breakdown of the located sign is presented in Table 1. The locations of all field observations and cassowary sightings are presented on Figure 5. As it is a complex data set, the Legend for Figure 5 is presented separately for ease of interpretation.

Table 1

Breakdown of located cassowary sign

Sightings*	Footprint (measured)	Partial footprints	Droppings	Total Sign
19	22	13	18	72

*includes multiple sightings of individual birds

Three cassowaries comprising two adult males and one adult female were utilising the Ella Bay Property during the field survey (Figure 4). All birds were photographed and are readily separated on differing physical characteristics. Individual cassowary information for each located bird is presented in Section 3.2. The adult female cassowary was located within the Ella Bay National Park approximately one kilometer to the north of the Ella Bay Property in mesophyll vine forest. It is considered to have the bulk of its home range in this area. Of the remaining two cassowaries, one adult male was using the entire vegetated area of the Ella Bay Property and Little Cove development area, while a second young adult male was recorded in Little Cove and the National Park to the west. The areas of activity for all three birds i.e., the polygon that represents all recorded field sign, are presented in Figure 6.

Figure 5 - Legend

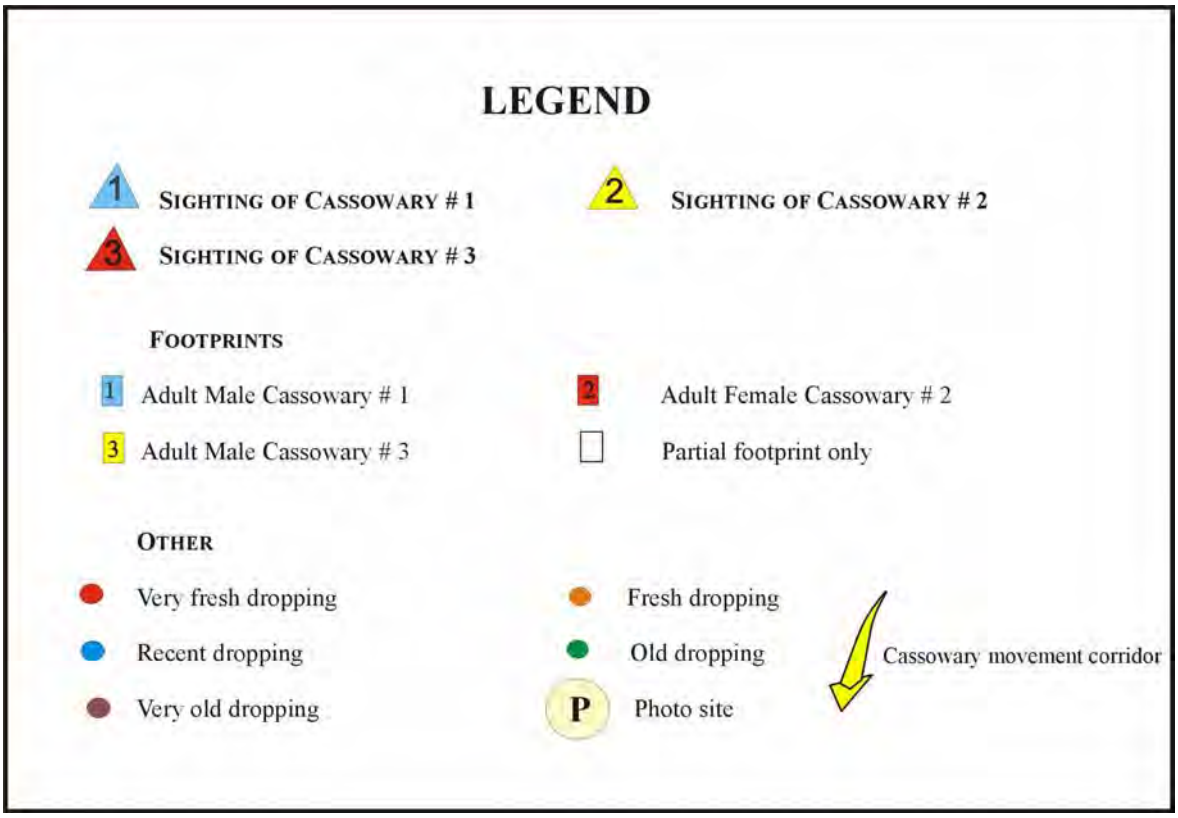


Figure 5

Cassowary Field Observations – Ella Bay Property and Little Cove

6 - 14 November 2006

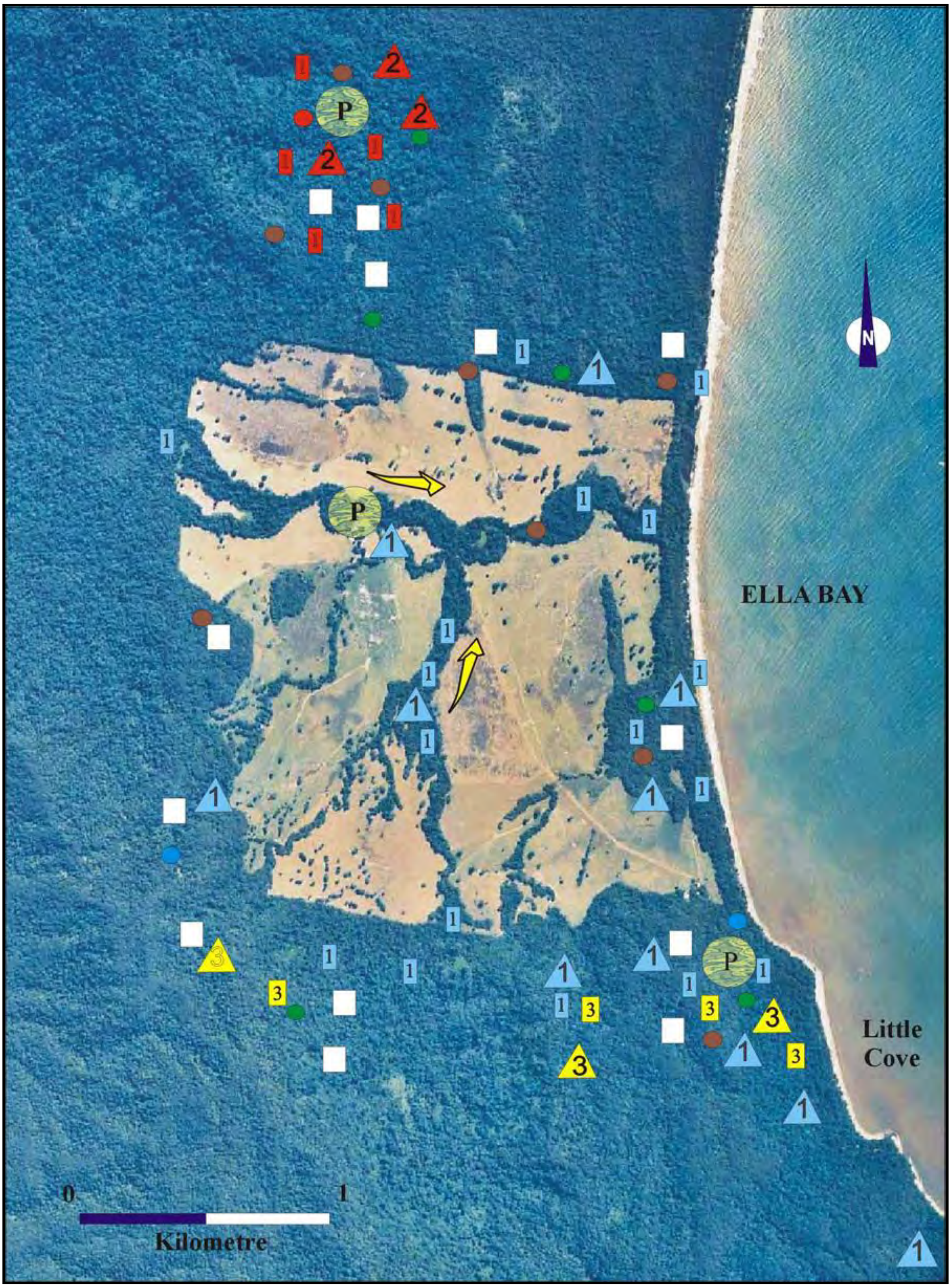
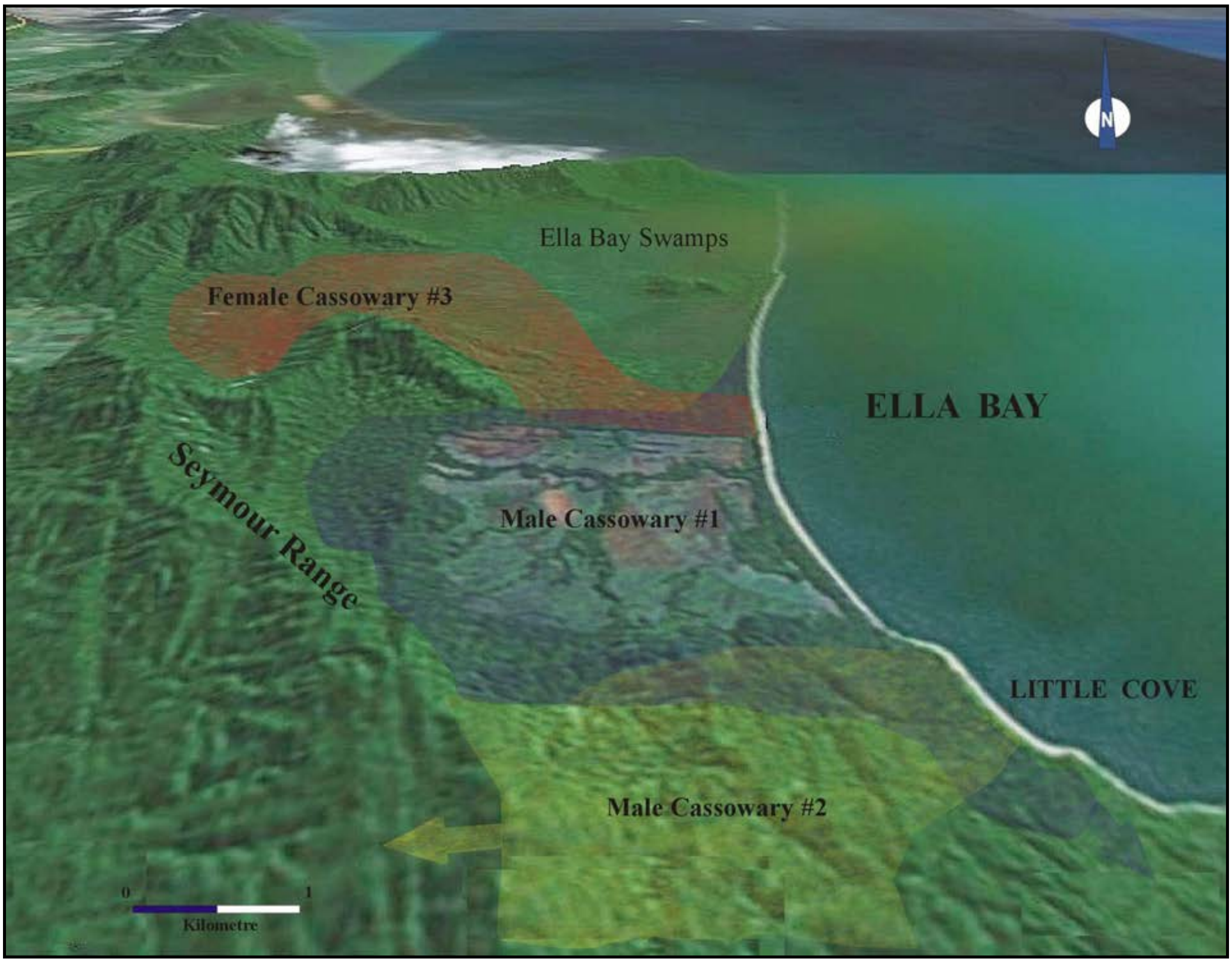


Figure 6

Areas of Activity of Ella Bay Property and Little Cove cassowaries

6 – 14 November 2006



3.1.1 Cassowary population size and density estimates

Only three cassowaries were identified in the Ella Bay Property and Little Cove study area. There were no indications, by either sightings or footprints, of the presence of juvenile or young subadult cassowaries in this part of the study area. It is concluded that the majority of the dependent chicks and young subadults in the study area died during or following the cyclone.

In a previous study (Moore 2003, 2006), it was concluded that depending on the resolution required and the environmental parameters of the subject site, a sample plot between 5-15km^2 was necessary to reflect true cassowary density. In this project, the Ella Bay Property and Little Cove study area comprised 9.5 km^2 of standing vegetation in total, and as a result is large enough to give an accurate cassowary density. The estimated cassowary density of the Ella Bay Property and Little Cove was therefore one adult per 3.2 km^2 (9.5 km^2 / 3 adults).

As illustrated in Table 2, estimated cassowary density is considerably lower in this area than that estimated in a similar field survey conducted on the western side of the Seymour Range earlier in 2006 (post-cyclone): 0.32 bird / 1 km^2 in this survey of the eastern side of the range compared 0.98 bird / 1 km^2 on the west side of the range i.e., one third the density. It is considered that the difference in cassowary densities is due to the level of cyclonic wind disturbance along the eastern face of Seymour Range compared with that on the western face of the range. In contrast, the presence of areas of relatively intact habitat and the survival of the majority of potential cassowary food trees along parts of the western face of Seymour Range suggest it may act as a **cyclone refuge** for cassowaries.

In the context used in this report, a cyclone refuge is: an area whose natural topographic complexity and landscape attributes e.g., landforms (main protective ridges to the east with western facing ridges, gullies, and streams), varying elevation, aspects, slope, vegetation and possibly soil type, contributes to the predictable retention of native habitat, or a significant reduction in habitat damage in cyclone events. Such areas provide both a refuge from the worst impacts of a cyclone, and a source from which surviving individuals (cassowaries and biodiversity generally), can recolonise the surrounding more damaged areas.

The cassowary densities from a pre-cyclone study of the Mission Beach cassowaries have been included in Table 2 for comparison with the Seymour Range post-cyclone studies.

Table 2

Comparison of cassowary densities

Age and Status	Area densities (bird/km²)			Population densities (km²/bird)		
	Ella Bay[1]	**West Seymour Range[1]**	**Mission Beach[2]**	**Ella Bay[1]**	**West Seymour Range[1]**	**Mission Beach[2]**
Adults and subadults	**0.32**	0.98	0.78	**3.16**	1.02	1.29
Known Adults	**0.32**	0.65	0.48	**3.16**	1.54	2.09
Known adult males	**0.22**	0.33	0.28	**4.75**	3.07	3.63
Known adult females	**0.11**	0.33	0.19	**9.5**	3.07	5.35
Known subadults	**0**	0.32	0.28	**0**	3.07	3.63

[1] Post-cyclone

[2] Pre-cyclone

3.1.2 Distribution and behaviour

The weather during the survey period was hot and clear, with little or no breeze. In response to the oppressive conditions, which were exacerbated by the lack of tree canopy, cassowaries were moving only in the cool of the mornings and late afternoons. During the heat of the day, birds rested in dense, more sheltered areas of *Calamus* and debris thickets. Due to significant wind damage and the presence of dense ground debris from Cyclone Larry, access for cassowaries to much of the eastern foothills of Seymour Range is difficult or impossible. Similarly, tree fall on the surrounding ridges has resulted in a dense layer comprising tree debris, vine forest regrowth and *Calamus australis*. As such, cassowary usage of much of the survey area was restricted to small pads through an almost impenetrable sub-canopy cover of *Calamus australis* and *Merremia peltate* vegetation. Although not often visible in this thick vegetation, birds could be tracked by the sound of their panting (Plate 4).

Plate 4. Photograph of Cassowary #4 panting heavily while sheltering in a *Calamus* thicket along the Seymour Range foothills. The temperature in the forest at this time was 38^0 C and there was no air movement. Audible panting could be heard from most birds at greater than 15 metres distance.

3.2 ELLA BAY PROPERTY AND LITTLE COVE - INDIVIDUAL CASSOWARY INFORMATION

The survey of this area identified three adult cassowaries. The field data relating to these individuals is summarised below with comments where appropriate, and illustrated in

Figure 6 as individual areas of activity. Photographs of identified cassowaries and representative photographs of the habitat they used during the survey are also presented.

3.2.1 Adult Male Cassowary # 1 – Footprint = 193 mm (Plates 5 – 7)

The following data and comments are presented for this bird:

- Observed multiple times on 6, 7, 8, 9 and 10 November 2006;
- Previously photographed moving along Jungle Perch Creek during the fauna survey in mid-October(BAAM 2006);
- Distribution of footprints indicate primary usage of the Ella Bay Property and Little Cove subdivision;
- Also sighted just north of Heath Point on 8 November 2006;
- Hand-fed on the outskirts of Flying Fish Point immediately post cyclone (identified from photographs);
- Field observations indicate that this bird is probably the resident breeding male of the Ella Bay Property and Little Cove;
- Observed using Road Crossing #1 (Figure 10) on four occasions.

Plate 5. Cassowary #1 sighted in Little Cove subdivision on 7 November 2006. Note the prominent casque and noticeable "tail", the former character indicating an old bird and the latter indicating an adult male.

Plate 6. Cassowary #1 photographed moving down a west to east riparian corridor within the Ella Bay Property. The western half of this creek is steep-sided and the bird has to move along the narrow vegetation line using the cleared edge to access the foreshore vegetation (Photo: M. Sanders BAAM).

Plate 7. Another view of Cassowary #1 showing the distinct tail and long equal length wattles (Photo: M. Sanders BAAM).

Plate 8. View of 'Jungle Perch Creek' from the south showing extensive cyclone damage and emergent feather palms and vine towers. The western half of the creek is not accessible to cassowaries and Cassowary #1 walks along the cleared edge of the narrow riparian strip.

Plate 9. West end of 'Jungle Perch Creek' showing degraded mesophyll vine forest and narrow riparian strip. The creek at this point is flanked by banks 2-4 metres high and has significant debris piles in the waterway.

Plate 10. Interior of Jungle Perch Creek in the lower reaches. Note the complete lack of canopy and the log dams created by cyclone debris.

3.2.2 Young Adult Male Cassowary # 2 - Footprint = 190 mm (Plate 11)

The following data and comments are presented for this bird:

- Observed on 8, 10, and 11 November 2006
- Photographed on 10 November 2006 within the Ella Bay National Park west of Little Cove;
- Using parts of Little Cove during the survey but most activity centred on less damaged sections of forest along creeks within the Ella Bay National Park;
- Observed using Crossing Point # 1 (Figure 10) on two occasions.

Plate 11. Enlarged and enhanced distance photograph of Cassowary #2 located foraging within the Little Cove subdivision. Note the relatively small and unmarked casque, indicating a younger adult. The presence of a clear "tail" identified the bird as an adult male.

Plate 12. Habitat used by Cassowary #2 west of Little Cove subdivision. Note the dense sub-canopy vegetation dominated by *Calamus australis*.

Plate 13. Vegetated stream used by Cassowary #2 to move through National Park west of Little Cove. Note the open damaged forest visible in the background.

Plate 14. Recovering mango tree in the Little Cove subdivision. Prior to the cyclone, this area had numerous mango trees and when in fruit these were regularly visited by cassowaries and flying foxes. Although damaged extensively, most of the known mango trees appear to have survived the cyclone.

3.2.3 Adult Female Cassowary # 3 - Footprint = 204 mm (Plate 15)

The following data and comments are presented for this bird:

- Sighted on 12 November 2006 drinking at a small pool in disturbed mesophyll vine forest approximately one kilometre north of the Ella Bay Property;
- Observed again on 13 and 14 November 2006;
- Followed for six hours on 14 November and sighted on a number of occasions;
- Photographed on 14 November 2006;
- Bulk of home range likely to be west of the Ella Bay Swamps.

Plate 15. Cassowary # 3 located sheltering in a small area of undisturbed mesophyll vine forest just west of Ella Bay Swamp. Note the diagnostic unequal-sized wattles and tall but straight, slightly notched casque, clearly separating it from both Cassowary #1 and Cassowary #2. Although not distinguishable in the photograph, the horizontal ventral profile indicates this is a female cassowary

Plate 16. Swamp-edge habitat and drinking site being used by Cassowary #3 during the field survey. A number of resting sites were located amongst the dense *Calamus* growth indicating regular and prolonged use of the area. Note the dense sub-canopy.

Plate 17. Cyclone-damaged mesophyll vine forest with feather palms in the activity area of Cassowary #3.

Plate 18. View of cyclone-damaged mesophyll vine forest adjoining Ella Bay Swamp. Cassowary #3 avoided these open debris areas, which were hot and difficult to negotiate.

3.3 CURRENT FOOD RESOURCES

Although few fruits were visible on the trees, a number of cassowary food species were recorded in droppings. Food items recorded in droppings included:

- Foxtail Palm *Wodyetia bifurcata* (exploited garden plants)
- Wait-a-while *Calamus australis*
- Currywood *Polyathalia michaelii*
- Zamia Palm *Lepidozamia hopei*
- Blue Quandong *Elaeocarpus angustifolius*
- *Ficus* sp
- *Cryptocarya* sp.
- Bracket fungi

All located droppings were collected and a complete identification of food items will be undertaken as part of an on-going study into the post-cyclone recovery of rainforest at Mission Beach and Innisfail.

4.0 CASSOWARY HABITAT TYPES AT ELLA BAY PROPERTY

The distribution of cassowary habitat in the Wet Tropics bioregion was mapped by the Environmental Protection Agency (EPA) in 2004. A brief summary of the habitat types used by EPA for categorising cassowary habitat in this mapping project are summarised in Box 1, with full descriptions presented in Appendix A.

BOX 1

HABITAT CATEGORIES - ENVIRONMENTAL PROTECTION AGENCY (2004)

Essential habitat:

Regional ecosystems where there is an *accurate and verified* record of a cassowary and is *known* be preferentially used by cassowaries for breeding, feeding and general activity.

General habitat:

Regional ecosystems where there is an accurate and verified record of a cassowary, but is not known to be preferentially used as habitat.

Rehabilitating habitat:

Non-remnant regional ecosystems that consist of rehabilitating and regrowing vegetation that provide shelter and supplementary feeding and breeding resources. If allowed to return to a remnant state, these regional ecosystems would be likely to be categorised as either essential or general cassowary habitat, depending on how it satisfies the definition criteria.

Unknown:

Mapped vegetation polygons where the regional ecosystem type is unknown at present.

Cleared:

Regional ecosystems cleared of native vegetation, and therefore not considered cassowary habitat.

Cultivated:

Regional ecosystems representing agricultural and forestry plantations.

Other vegetation:

Remnant regional ecosystems that are either too small or too distant to satisfy the patch analysis rules, or are considered geographically and climatically unsuitable, despite being essential or general cassowary habitat types.

A number of cassowary habitat types recognised by EPA occur within the subject site. An analysis of their relative values, role in connectivity, provision of known, likely or supplementary resources for food, water, breeding and shelter is presented below.

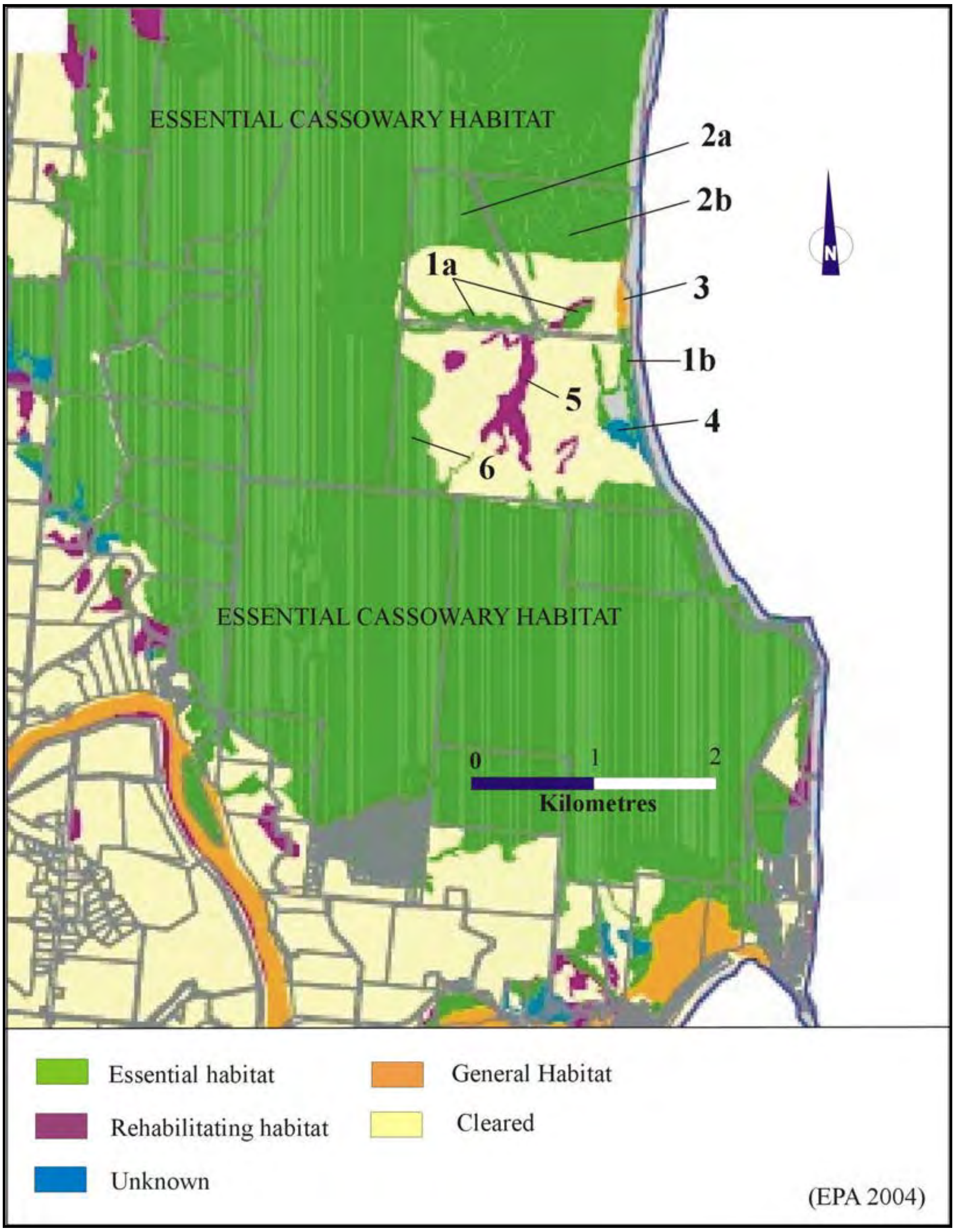
4.1 STATUS OF CASSOWARY HABITAT AT ELLA BAY PROPERTY

While cassowaries are essentially a species of rainforest habitats, they are not confined to such (Crome and Moore 1990) and move widely through the landscape. Birds are encountered in mangroves, paperbark woodland, and various eucalypt open forests and woodlands adjacent to tracts of rainforest. However, Hopkins and Graham (cited in Werren 1993) concluded these communities produced less than 5% of the total amount of food available to cassowaries within the vegetation mosaic each month. This and other studies (Crome and Moore 1990, 1993; Bentrupperbaumer 1998; Moore 1992 – 2006) have shown that although cassowaries can use a range of habitats, it is unlikely that populations or even individual birds can be maintained in non-rainforest habitats permanently. This is primarily due to the lower plant diversity in these communities being unable to supply the fruit that cassowaries need year round (Crome and Moore 1990).

The recognised cassowary habitat types within the Ella Bay Property are shown on Figure 12. An assessment of the direct and indirect impacts on cassowary habitat within the subject site, and an analysis of possible mitigation strategies is addressed in Volume II of this report (Impact Assessment and Mitigation Strategies), with the numbered habitat locations described below.

Figure 7

Cassowary habitat types at the Ella Bay Property (*sensu* EPA 2004) (numbers reflect locations discussed in text)



4.1.1 Location 1a

During the field survey this degraded riparian strip was used by the resident male cassowary, Cassowary #1. However, due to the narrowness of the remaining vegetation and its degraded and cyclone damaged condition, the importance of this corridor to the maintenance of cassowaries at Ella Bay has been reduced significantly. In addition, the stream banks in the western section of Location 1a are precipitous, and filled with cyclone debris. As such, the cassowary is forced to walk along the cleared edge rather than using the creek-side vegetation (Plates 6 and 7). Currently the riparian strip serves as a movement corridor facilitating access to pond apple infestations that occur on the disturbed swamplands and stream edges in the central and foreshore areas of the property (refer to Locations 3 and 4 on Figure 7). This exotic food source is currently of increased importance to the cassowary following the dearth of native fruit following the cyclone, but its contribution to the ecology of the birds at Ella Bay is dubious. Moreover, the implementation of a proposed weed control program at the Ella Bay Property will eliminate this exotic species and thus remove the motivation for birds to forage in the swamplands and foreshore areas.

The presence of significant numbers of the favoured cassowary food tree blue quandong *Elaeocarpus angustifolius*, in the central reaches of this creek, however, would provide an important food resource for cassowaries.

4.1.2 Location 1b

The foreshore vegetation of the Ella Bay Property comprises a highly disturbed non-rainforest mix of open forest woodland with broad-leaved paperbark *Melaleuca quinquinerva* woodland (Plate 19) on sand; coastal foredune complex with coastal she-oak *Casuarina equisetifolia*; and a shrubland of exotic species including lantana *Lantana camara*, Pond Apple *Annona glabra*, and giant bramble *Rubus alcerifolius (*BAAM 2006*)*. These latter three weed species have prolonged fruiting periods, and being readily eaten by cassowaries, have the potential of spreading throughout the landscape in the droppings of cassowaries and other birds and mammals.

This area has been mapped as '*Essential Cassowary Habitat*' (EPA 2004) but is considered to be more accurately categorised as '*General Habitat'* i.e., cassowaries have been recorded here but it is not preferred cassowary habitat. Plate 19 shows an example of the *Melaleuca* dominated open forest/woodland that occurs in much of this area.

Plate 19. Disturbed open forest/woodland with *Melaleuca quinquenervia* lining the foreshore at the Ella Bay Property. There are no native cassowary food trees in this vegetation association apart from exotic weeds.

4.1.3 Location 2a

This area comprises disturbed simple-complex mesophyll to notophyll vine forest on moderately to poorly drained metamorphics (BAAM 2006). Although severely impacted by Cyclone Larry, this habitat currently provides important food and water resources for cassowaries (Cassowary #1 and Cassowary #3) and is an important buffer for the sensitive Ella Bay Swamp wetlands. As such, its designation as '*Essential Cassowary Habitat*' is warranted and acceptable solutions to allow preservation of this essential habitat must be met, if consent to develop is to be granted.

4.1.4 Location 2b

This area comprises a mosaic of open eucalypt forest with a vine forest sub-canopy, and feather palm dominated mesophyll vine forest. The area was significantly damaged by

Cyclone Larry but is an important habitat for cassowaries. As such, its designation as '*Essential Cassowary Habitat*' is warranted and acceptable solutions to allow preservation of this essential habitat must be met, if consent to develop is to be granted.

4.1.5 Location 3.

This area is a highly disturbed association of non-rainforest habitats comprising open eucalypt and secondary shrubland/closed shrubland with *Hibiscus tilaceous, Lantana camara* and *Annona glabra* (BAAM 2006). Although cassowaries are known to visit this area, the only reliable food source is the introduced pond apple *Annona glabr*a. The implementation of a proposed weed control program at the Ella Bay Property will eliminate this exotic species and remove the motivation for birds to forage in this habitat. This location is mapped as '*General Habitat*' (EPA 2004), but should be reclassified as '*Other Vegetation'*.

4.1.6 Location 4.

The habitat of this area is currently classified as 'Unknown' (EPA 2004). The vegetation comprises an exotic shrubland dominated by a dense infestation of pond apple *Annona glabra* and is not natural or suitable cassowary habitat. As such, the location should be reclassified as '*Other vegetation'*.

4.1.7 Location 5.

This location is classified as '*Rehabilitating Habitat*' (EPA 2004), and is the second of two highly degraded natural drainage lines that traverse the cleared area of the property. Although at times flowing strongly, at the time of the field survey it comprised a network of small pools and was primarily used for shade by numerous agile wallabies *Macropus agilis* and horses. On one occasion Cassowary #1 was sighted moving down this drainage line and into Jungle Perch Creek to the north. However, it does not currently provide much in the way of food resources or breeding alternatives for cassowaries as it is narrow in width, and much of its length comprises secondary regrowth forest with little sub-canopy. If allowed to return to a remnant state, however, this corridor would be likely to be categorised as general cassowary habitat and as such should retain its current habitat status.

4.1.8 Location 6.

This area comprises disturbed notophyll to mesophyll vine forest on the foothills of the Seymour Range. Although severely impacted by Cyclone Larry, this habitat currently provides important food and water resources for cassowaries (Cassowary #1 and Cassowary #2) and its designation as '*Essential Cassowary Habitat*' is therefore warranted. As such, acceptable solutions to allow preservation of this essential habitat must be met, if consent to develop is to be granted.

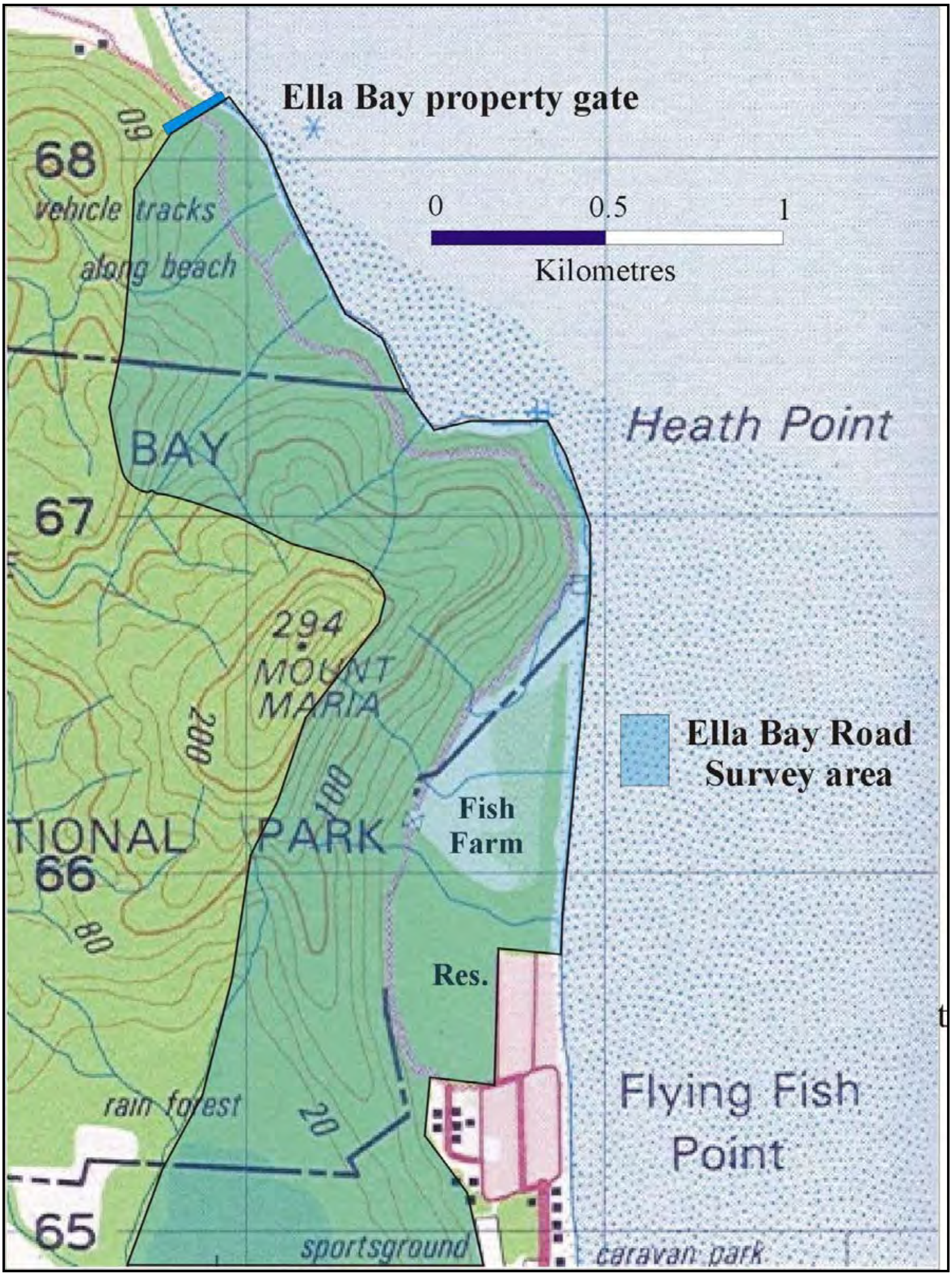
5.0 CASSOWARIES OF ELLA BAY ROAD AND FLYING FISH POINT

The area adjoining the Ella Bay Road was surveyed separately to obtain the information required to conduct an impact assessment of the threats to cassowaries associated with increased usage and potential upgrade of the Ella Bay Road. The study area extended from the Ella Bay Property gate in the north, to the Flying Fish Point-Innisfail Road in the south (Figure 8). The habitat surveyed comprised the eastern footslopes and adjacent ridges of the Seymour Range, although access to some sections of the area was limited due to the highly disturbed nature of the vegetation following Cyclone Larry. The approximate boundaries of the search area are shown in Figure 8.

Cassowaries using the forest along the Ella Bay Road were located and identified, and their use of the available habitat assessed. Road crossing points i.e., where cassowaries traditionally cross the road(s), were identified and described.

Figure 8

Ella Bay Road Survey Area



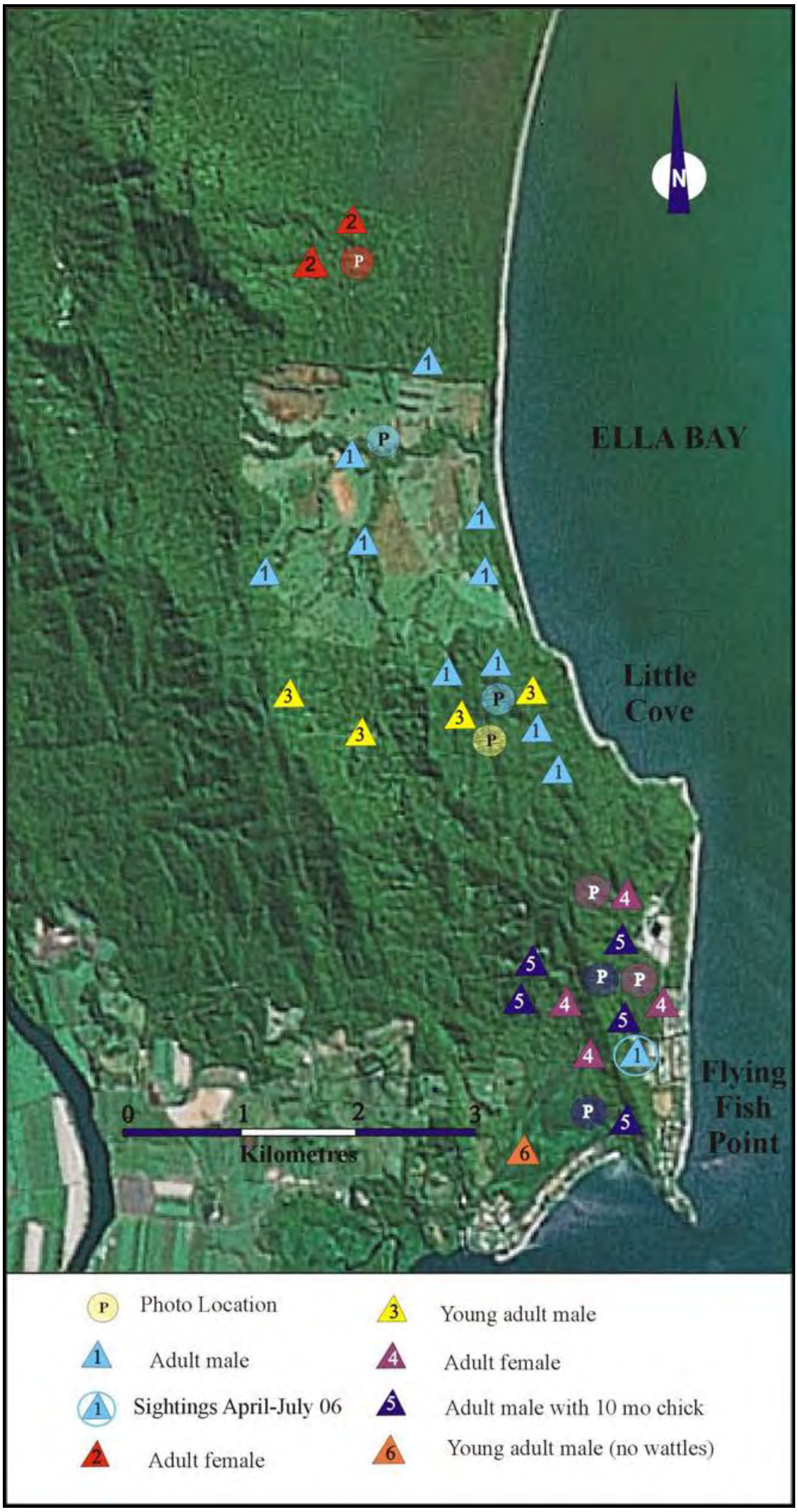
5.1 RESULTS OF ELLA BAY ROAD CASSOWARY ASSESSMENT

Three adult cassowaries and one chick were identified in the Ella Bay Road survey area. These comprised one adult female (Cassowary #4), an adult male with a nine-month old chick (Cassowary #5), and a young adult male (Cassowary #6). All three adult cassowaries are readily separated on physical characteristics and a number of photographs were obtained of Cassowary #4 and Cassowary #5. Although not photographed, Cassowary #6 is a very distinct individual due to its extremely small wattles. As this area was not surveyed as intensely as the Ella Bay Property and cassowary use was influenced by the presence of nearby QPWS feeding stations, population densities have not been calculated.

Cassowary #5, and provided access to the Ella Bay Road at a number of possible road crossing points. The locations for these cassowary road crossings are shown on Figure 10 (refer 5.1.3 Road Crossings). A third, less-used pad was located west of the ridgeline running from the fish farm south to Flying Fish Point. This ridge pad was primarily used by female Cassowary #4 during the survey. The combined locations of all individual cassowary sightings i.e., Ella Bay Property, Little Cove and Ella Bay Road are shown on Figure 9.

Cassowary movement through the Seymour Range foothills area was primarily undertaken on two rough pads running parallel to the Ella Bay Road through a very thick sub-canopy of lianes, regrowth and tree debris. Both pads connected with the feeding station on the outskirts of Flying Fish Point. These movement pads were used by Cassowary #4 and 9.

Figure 9
Cassowary sightings 6 – 14 November 2006



5.2 INDIVIDUAL CASSOWARY INFORMATION - ELLA BAY ROAD

5.2.1 Adult Female Cassowary #4 - No footprint measurement (Plates 20-23)

The following data and comments are presented for this bird:

- Observed on 7, 8, 10, 12, 14 November
- Sighted crossing at Road Crossing #2 on two occasions, Road Crossing #3 (Figure 10) on one occasion;
- Regularly observed foraging along foothills and ridge opposite fish farm;
- Observed at a feeding station on the outskirts of Flying Fish Point on 8 November 2006;
- Visibly affected by heat with loud panting and frequent rests in shady thickets.

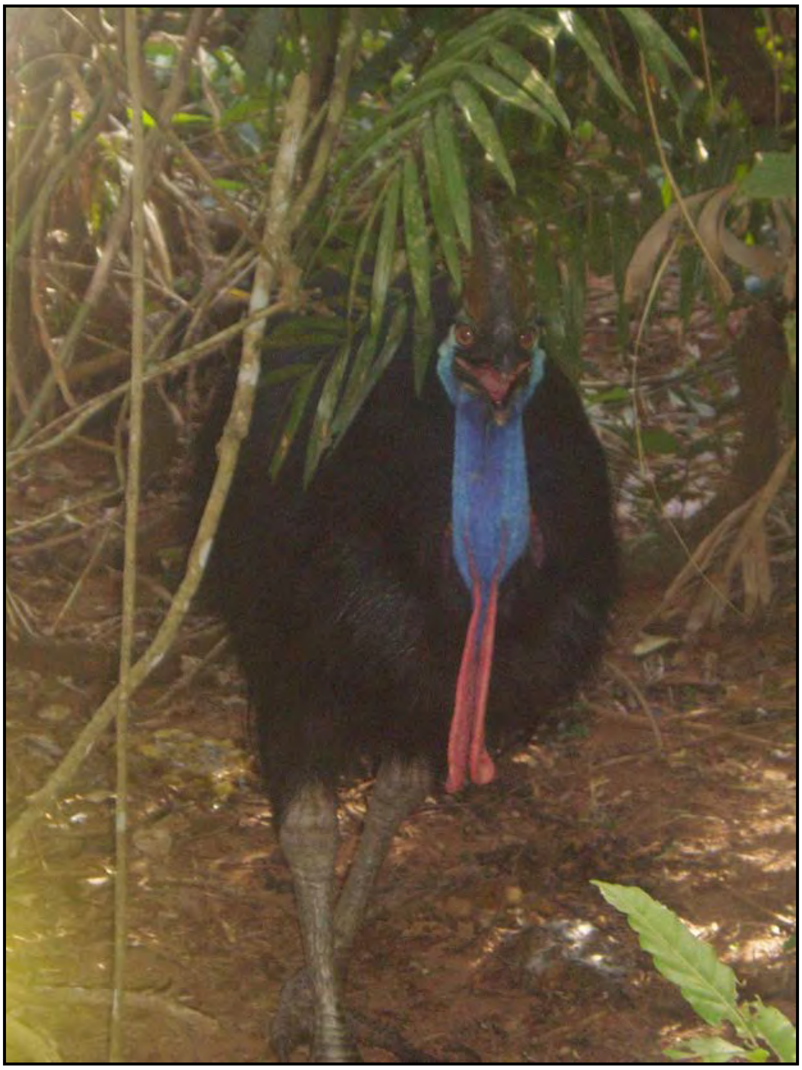


Plate 20. Cassowary #4 was first located resting in a *Calamus* thicket west of Ella Bay Road, opposite the fish farm. Note the panting behaviour of the bird, the sounds of which made tracking possible through the thick sub-canopy of lianes and debris.

Plate 21. Close-up of head and casque of Cassowary #4 showing clear diagnostic characters

Plate 22. Note the horizontal ventral profile of Cassowary #4, indicative of a female cassowary; and the large casque indicating an older bird. The open nature of the forest at this point is evident.

Plate 23. Cassowary #4 in typical cyclone damaged habitat west of Ella Bay Road.

5.2.2 Adult Male Cassowary #5 - No footprint measurement (Plates 24-25)

The following data and comments are presented for this bird:

- Observed on 9, 10, 11, 12, 13 November;
- Sighted crossing the road at Crossing #3 on 10 November 2006 0730hrs, and at Crossing #2 (Figure 10) at 1715 hrs;
- Observed foraging in the National Park to the west of Flying Fish Point and also along foothills opposite the fish farm;
- Observed at a QPWS feeding station on the outskirts of Flying Fish Point on 10 November 2006 with a 9 month old chick (cyclone survivor);
- Chased away from feeder by Cassowary #4 on a number of occasions;
- Male and chick had been fed by locals post-cyclone until feeding station was established.

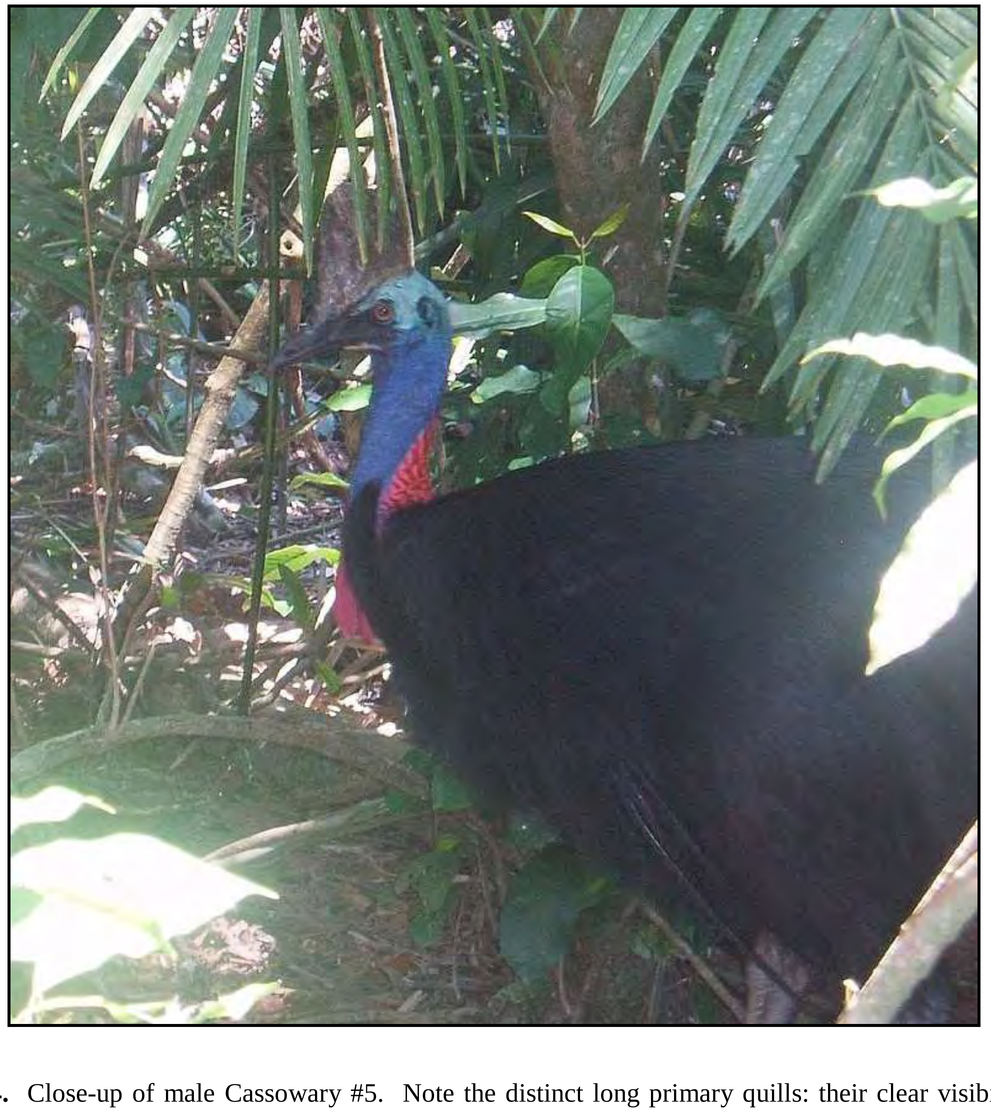


Plate 24. Close-up of male Cassowary #5. Note the distinct long primary quills: their clear visibility is a 'threat display', and indicates the male's agitation at the proximity of the photographer.

Plate 25. First sighting of adult male Cassowary #5. Note the distinctive tall but un-bent casque and moderate-length wattles.

Plate 26. Nine-month old chick of male Cassowary #5. This is one of the few surviving coastal chicks in the Mission Beach-Innisfail area following Cyclone Larry, and its growth has been stunted due to an inadequate diet. The remaining dependent young in this area either died in the cyclone or were abandoned by their male parents, subsequently succumbing to starvation, road death or dog attack.

5.2.3 Adult Male Cassowary #6 - No photo or footprint measurement

The following data and comments are presented for this bird:

- Observed briefly on 14 November in a mosaic of swamp and mesophyll vine forest north of the Flying Fish Point to Innisfail Road;
- No photographs were taken of this bird;
- Sighted as a likely adult male but with no wattles visible – on closer view the bird was noted as having very small wattles only a few inches long;
- Nick-named ‘necktie’;
- Locals know of this bird and have noted its lack of wattles.

5.3 ELLA BAY ROAD CASSOWARY CROSSING POINTS

Three active cassowary road-crossing points and two likely road-crossing areas were identified along the Ella Bay Road. The locations of these cassowary road crossing points are shown on Figure 10. The cassowaries making use of these crossings were identified and the crossing points photographed and described. A fourth road crossing point is sign-posted immediately south of Flying Fish Point on the Innisfail to Flying Fish Point Road. This latter crossing point allows access to the mangroves for cassowaries and is apparently used on a regular basis. It was not monitored in this survey.

Figure 10

Cassowary Road Crossing Points 6 – 14 November 2006

The proposed Ella Bay Integrated Resort Development will necessitate the construction of a road capable of handling a significantly increased traffic flow. Alternative locations for this upgraded road and appropriate road management strategies to protect crossing cassowaries will be addressed in Volume II of this report (Impact Assessment and Mitigation Strategies).

5.3.1 Individual Road Crossing Points

Road Crossing Point #1

Crossing #1 is located at a small creek 0.6 kilometres south of the Ella Bay Property gate and was utilised by two adult cassowaries: adult male Cassowary #1 and adult male Cassowary #2. Both these cassowaries used a vehicle track through the Little Cove subdivision to cross the creek via the road. A small disused vehicle track on the southern side of the creek was then used to access the forest west of the Ella Bay Road.

Plate 27. View of Cassowary Crossing #1 from the south. The main crossing point area is located at the bend in the road and is encircled in red. Cassowaries use a vehicle track through Little Cove subdivision on the north side of the creek to access this crossing point

Plate 28. View of disused vehicle track at Cassowary Road Crossing Point #1. The creek is to the right of the photo. Both birds were observed using the Ella Bay Road to cross the creek and access this small track.

Road Crossing Point #2

This Crossing Point was utilised by two adult cassowaries: adult female Cassowary #4; and adult male Cassowary #5 (accompanied by its chick). The road crossing occurs along a section of winding road and, due to the terrain, has a number of potential road crossing points. During this survey cassowaries were observed crossing west across the Ella Bay Road from the reserve located east of the road. Birds were also recorded foraging along the foothills west of the road and depending on vegetation access, could cross the road at many locations.

Road Crossing Point #3

This Crossing Point was utilised by two adult cassowaries: adult female Cassowary #4; and adult male Cassowary #5 (accompanied by its chick). The birds may cross the road in either direction and at any point along this section of the Ella Bay Road. Road crossings were frequent during the survey due to the presence of a feeding station nearby.

Plate 29. View of Cassowary Road Crossing Point #2 from the north.

Plate 30. View of Cassowary Crossing Point #3 from the north. The northern outskirt of Flying Fish Point is visible in the centre background.

6. CASSOWARY AREAS OF ACTIVITY BASED ON FIELD DATA

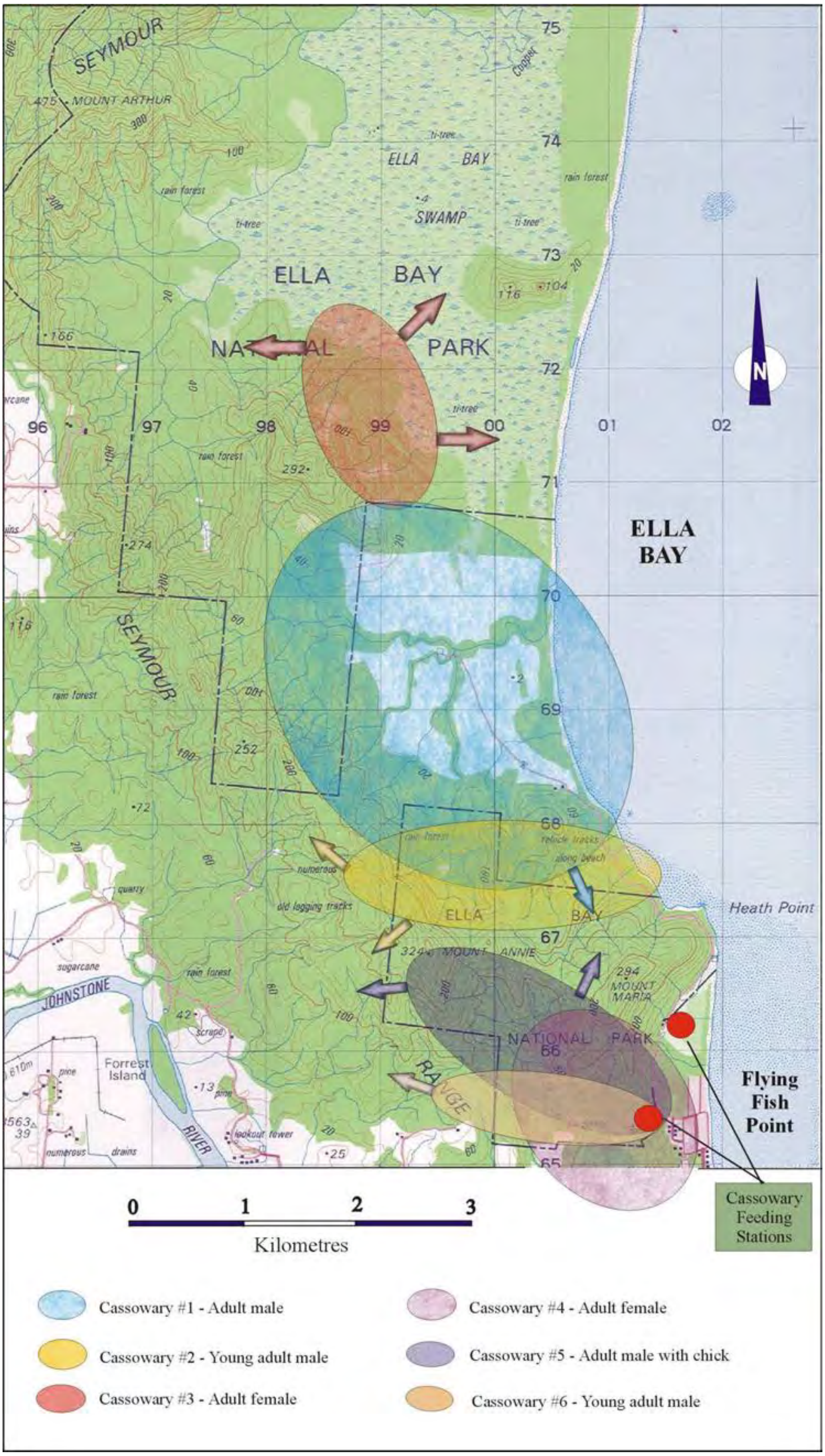
Cassowary home ranges vary over time depending on environmental conditions and patterns of food abundance. Thus, the total extent of any bird's home range (i.e., that area used over a number of years) can only be determined by long-term field studies and are subject to continual change and adjustment. The short duration of this cassowary survey does not provide sufficient field or contextual data i.e., long-term surveys of the surrounding off-site habitat, to develop such home range estimates. However, the area of activity for each identified cassowary based on the entire set of field data is achievable, and these representations are presented in Figure 11. Although coarse, these activity polygons provide a base from which to identify and evaluate the potential threatening processes, and to assess the importance of the study area to the local cassowary population.

7. CONCLUSION

A total of six adult cassowaries and one nine-month old chick were identified in the field survey. It is probable that this adult number approximates the original adult cassowary population that was present in the study area pre-cyclone. Their continued presence in what is now significantly damaged habitat with minimal food resources, reflects both the species' strong site fidelity and their ability to withstand periods of food shortage. It is clear, however, that without the support of Flying Fish Point residents many of these birds would have succumbed to starvation post-cyclone. Although eight months have passed since the cyclone, the cassowaries at Flying Fish Point are still heavily dependent on the food provided in the local feed stations. In addition, all birds observed in the survey showed considerable signs of heat stress due to the lack of a forest canopy, and much of their day was spent avoiding the strong sun in dense thickets of *Calamus* and cyclone debris.

Figure 11

Areas of Activity Based on Field Data 6 – 14 November 2006



VOLUME II

IMPACT ASSESSMENT

AND

MITIGATION STRATEGIES

8.0 IMPACTS ON THE SOUTHERN CASSOWARY POPULATION

8.1 INTRODUCTION

The impact assessment and mitigation strategies included in this report cover the Ella Bay Property, the surrounding Ella Bay National Park, the Ella Bay Road and the forest surrounding Flying Fish Point. The study has been based on the Terms of Reference (TOR) provided for the environmental impact statement (Coordinator-General, 2005).

8.2 STUDY SCOPE

The terms of reference (TOR) requires that this report address "*the presence of any listed* [EPBC Act] *species or community and its associated habitat.'* As such this report includes *'all known cassowary that inhabit or pass through the project site or adjacent, nearby areas'*. Specifically the TOR requires that this assessment of impacts and mitigation strategies present:

1. *"Consideration of all potential impacts - direct and indirect impacts, on and off site – which may include but are not limited to habitat loss, fragmentation, roads and traffic, dogs, human interaction, disease and habitat degradation.*

2. *An analysis of possible mitigation measures that could be used and those proposed to be used."*

8.3 IMPACTS OF DEVELOPMENT OPTIONS

As a basis for assessing the impact of development on the Ella Bay Property, the following development options have been analysed:

Option A: The Integrated Resort Master Plan (P3 and J. H. Holland Services).
Option B: The 'no-change' option i.e., the property remains a pastoral concern.

It is considered that the possibility of returning the entire property to its natural vegetated state is not realistic or feasible. Therefore, it has not been included as a landuse option in this impact assessment.

Potential impacts considered here can be separated into three distinct groupings:

- Direct impacts
- Indirect impacts
- Cumulative impacts

8.3.1 Option A - Impacts and threatening processes

Direct impacts

The potential direct impacts of developing a resort within the Ella Bay Property include:

- Loss of 'essential' and 'general' cassowary habitat within the development footprint;
- Loss of safe access to retained remnants of cassowary habitat within the development;
- Interactions with people including habituation due to feeding;
- Interactions with domestic animals including dogs; and
- Collision with vehicles.

Indirect impacts

These impacts are sometimes more difficult to pin down but certainly include:

- a reduced carrying capacity from loss of habitat leading to pressures on reproductive productivity and recruitment;
- barriers to traditional movement corridors leading to disruption of social breeding systems;
- increased human activity and noise resulting in animals withdrawing from adjacent forest;
- increased risk of road death to cassowaries occupying adjacent or nearby habitat due to increased traffic flows;
- negative interactions between humans and cassowaries resulting from the attraction of cassowaries into urban areas created by the planting of domestic and native

fruiting trees, and the presence of standing water in backyard pools or ponds (cassowaries have to drink two to three times per day);

- disturbance from night lighting along streets and in residences; and
- potential transmission of disease from domestic animals to cassowaries e.g., poultry, dogs, and cats.

Cumulative impacts

This causal pathway approach recognises that although individual actions may be insignificant by themselves, the *aggregate* of these effects have a significant effect. For the subject site, these are considered to include:

- increased likelihood of further subdivision on the remaining freehold lots in the area;
- increased pressure on surrounding remnant vegetation and population linkages; and
- increased traffic flow to and from the development.

8.3.2 Option A: Mitigation strategies inherent in design

The mitigation proposals listed below have been identified in discussions with the developers and an ecological appraisal of the Ella Bay Master Plan (Figure 12). They underpin and are integral to the assessment of the magnitude and significance of impacts as outlined in Table 4. If these mitigation proposals are amended in any way, it may invalidate the impact assessment as included in Tables 4 and 5.

1. All lost or compromised habitat will be compensated for by revegetation and remnant enhancement, with the aim of increasing the total amount of essential cassowary habitat above what currently exists at the site.
2. All declared weed species currently exploited by cassowaries i.e., pond apple *Annona glabra,* will be removed from the property in a weed-control program.
3. Approved cassowary and people-proof fencing will be erected to prevent interactions between the cassowary(s) and the Integrated Resort (refer to Section 9.0: Mitigation Strategies).
4. All pedestrian walkways through cassowary corridors will be elevated above the forest floor to separate cassowaries and people, and to provide unhindered cassowary use of the creek and associated vegetation.

5. Such pedestrian walkways will be strategically located to minimise any disturbance to the normal behaviour of the cassowary(s).
6. The pedestrian ‘walkovers’ may serve as a focal point for ecological interpretation, particularly that of the endangered cassowary.
7. A strict dog control program will be enforced.
8. There will be limited vehicle use within the grounds of the Integrated Resort.

8.3.3 Option B: Impacts and threatening processes

The following impacts, both positive and negative, have been identified and used to assess the potential impacts of the continued management of the Ella Bay Property as a viable cattle-grazing property. They underpin the assessment of magnitude and significance of impacts as outlined in Table 5.

Direct impacts

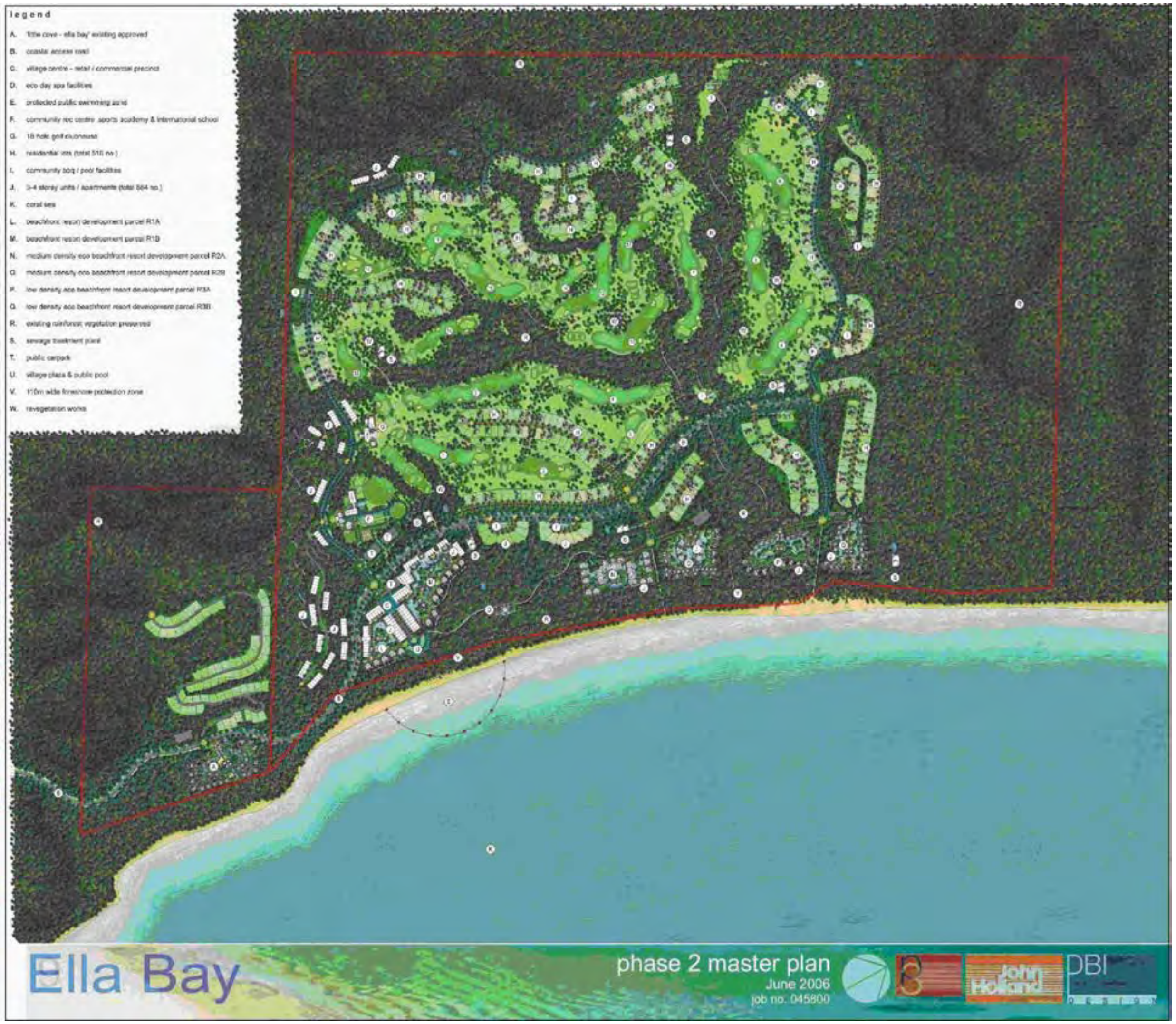
- Continued degradation of all remnant vegetation within the boundaries of the cattle grazing property due to uncontrolled access by cattle.
- Incremental loss of ‘Essential’ and ‘General’ cassowary habitat (*sensu* EPA 2004) within and adjoining the property due to cattle grazing and on-going farm management practices.
- Continued exploitation and dispersal of declared weed species present on the property by cassowaries.
- Continued light traffic on Ella Bay Road and road remains unsealed.

8.3.4 Option B: Mitigation strategies

Grazing is the as-of-right use of this property. There are no statutory requirements for the landowner to revegetate or fence riparian corridors or cassowary habitat to reduce cattle access. While pond apple (*Annona glabra*) is listed as a Class 2 pest in Queensland (landowners are required to remove it from their land) it has not been removed and is unlikely to be controlled with the current property management practises. Enforcement action by the responsible state agency is a possible mitigation strategy.

Figure 12

Phase – 2: Ella Bay Integrated Resort



8.4. ANALYSIS OF IMPACTS

To provide a transparent assessment of the potential impacts on the cassowary population of the two development scenarios for the Ella Bay Property, an analysis of the Significance (i.e., the value or worth assigned to a particular effect or impact); and the Magnitude (i.e., the degree or scale of the impact) of each effect has been applied to the subject site. The overall score is gained by multiplying the Significance by the Magnitude. These terms may need further clarification and thus, brief definitions are given below:

Significance: Also referred to as 'Importance', reflects the effect of the change that may take place (Wood, 1995). In this instance, the main elements used in assessing significance of impacts will be scientific and professional judgement, the extent of disturbance to the valued ecological system or species, and the level of public concern.

Magnitude: Refers to the estimation of the degree, extensiveness, and scale of the interaction, and varies according to the extent of the action and the significance of the environmental effects involved (loc. cit.)

While the Significance criteria are self-explanatory, an explanation is given below for the terms used to represent the predicted Magnitude of an affect. These are:

Some change: Denotes occasional exposure to an effect which significantly alters normal cassowary behaviour, and which results in a persistent low risk to individual birds or the population.

Moderate change: Denotes regular exposure to an effect that results in a moderate risk to individual birds or the population.

Large change: Denotes a constant exposure to an effect which places an individual cassowary or the population to high to extreme risk on a daily basis.

It is important to note that the criteria used in weighting the Magnitude scores are not empirical, but instead are based on professional judgements built on approximately twenty years research experience of cassowaries in north Queensland. The guideline criteria are given in Table 3.

The results of the impact assessment analysis for the Ella Bay Integrated Resort Master Plan development option are presented in Table 4, with the results of the continuing pastoral landuse option presented in Table 5. Those impacts considered extreme i.e., scores from -24 to -48, are shaded in pink, while those that have a significant negative impact i.e., scores greater than ten, are shaded in light yellow. A comparison of the potential impacts of the two options is given in Table 6.

Table 3
Guideline Criteria

Significance		Magnitude	
No perceived negative impact	0	No perceived change	0
Impact on individual bird within subject site	-2	Some change	2
Impact on study area cassowary population	-4	Moderate change	4
Impact on Seymour Range cassowary population	-6	Large change	6
Impact on the Wet Tropics cassowary population	-8		

Table 4

Impact Assessment for Option A: Ella Bay Integrated Resort project

Development Impacts	Significance	Magnitude	Overall Score[2] (Max = -48)	% of Maximum Impact
Habitat loss on site	0	0	0	0
Habitat degradation (edge effect) and encroachment (e.g., off-property pathways and picnic spots)	-2	2	-4	8.3
Traffic flows	-6	6	-36	75.0
Road death	-6	6	-36	75.0
Dog attack	-4	6	-24	50.0
Movement barriers (fences/roads)	-2	6	-12	25.0
Negative interactions with humans[1]	-4	4	-16	33.3
Hand-feeding issues[1]	-4	6	-24	50.0
Disease	-4	4	-16	33.3
Usage of adjoining forest by people (disturbance & interactions)	-4	4	-16	33.3
Domestic fruit trees and water sources	-2	2	-4	8.3
Increased noise and activity	-2	4	-8	16.7
Night lighting adjoining forest area	-2	4	-8	16.7
Invasion of pathogens affecting habitat quality (e.g., *Phytopthora*)	-2	2	-4	8.3
Reduced population carrying capacity (K)	0	0	0	0
Reduced productivity and recruitment	0	0	0	0
Impact on adjoining WHA National Parks (weed invasion)	-2	2	-4	8.3
Total Effect			**-200**	**416.5**
Maximum Possible Total Effect			-816	1700
Change as Percentage of Maximum			**-24.5**	**24.5**

[1] Subsequent risk of relocation and disruption to local social breeding systems.
[2] Magnitude x Significance

8.4.1 Option A: Integrated Resort

Although all Overall Scores less than -8 (n = 8 of 17 identified impacts) indicate a considerable negative impact on cassowaries, those scores from -24 to -48 (n = 4) represent impacts judged to have "extreme" impacts on the viability of the cassowary population of the Ella Bay Property, and that of the Seymour Range cassowary population. These effects include road death (75%), increased traffic flows (75%), hand-feeding (50%), and dog attack (50%).

Other issues resulting from Option A that potentially impact on cassowaries at the Ella Bay Property result from an increase in long-term human activity of the area, and the problems associated with cassowary and human interactions. These include negative interactions with humans (33.3%); the potential for an increased use of the adjoining forests by residents and visitors (33.3%); disease (33.3%); and movement barriers (25%).

8.4.2 Option B: Continued pastoral activities

Although all Overall Scores less than -8 (n = 6 of 17 identified effects) indicate a considerable negative impact on cassowaries, those scores from -24 to -48 (n = 4) represent impacts judged to have "extreme" impacts on the viability of the cassowary population of the Ella Bay Property, and that of the Seymour Range cassowary population. These effects include habitat loss (75%); habitat degradation (75%); a potential reduction of adjacent World Heritage Area values (75%); and a reduced productivity and recruitment (50%).

The major issues resulting from Option B that potentially affect cassowaries at the Ella Bay Property result from the permanent decrease in cassowary habitat area and quality both on and adjoining the Ella Bay Property. Cattle grazing and agricultural management practices will continue to degrade the remnant vegetation along drainage lines and the foreshore. Similarly, the 300 metre-wide vegetated buffers of essential cassowary habitat (*sensu* EPA 2004) adjoining the Ella Bay National Park on the northern and western boundaries of the property, are at considerable risk of attenuation or removal. The ecological values of the adjacent World Heritage Area, therefore, may be significantly reduced by the concomitant influences of degrading habitat, edge effect and weed invasion.

Table 5

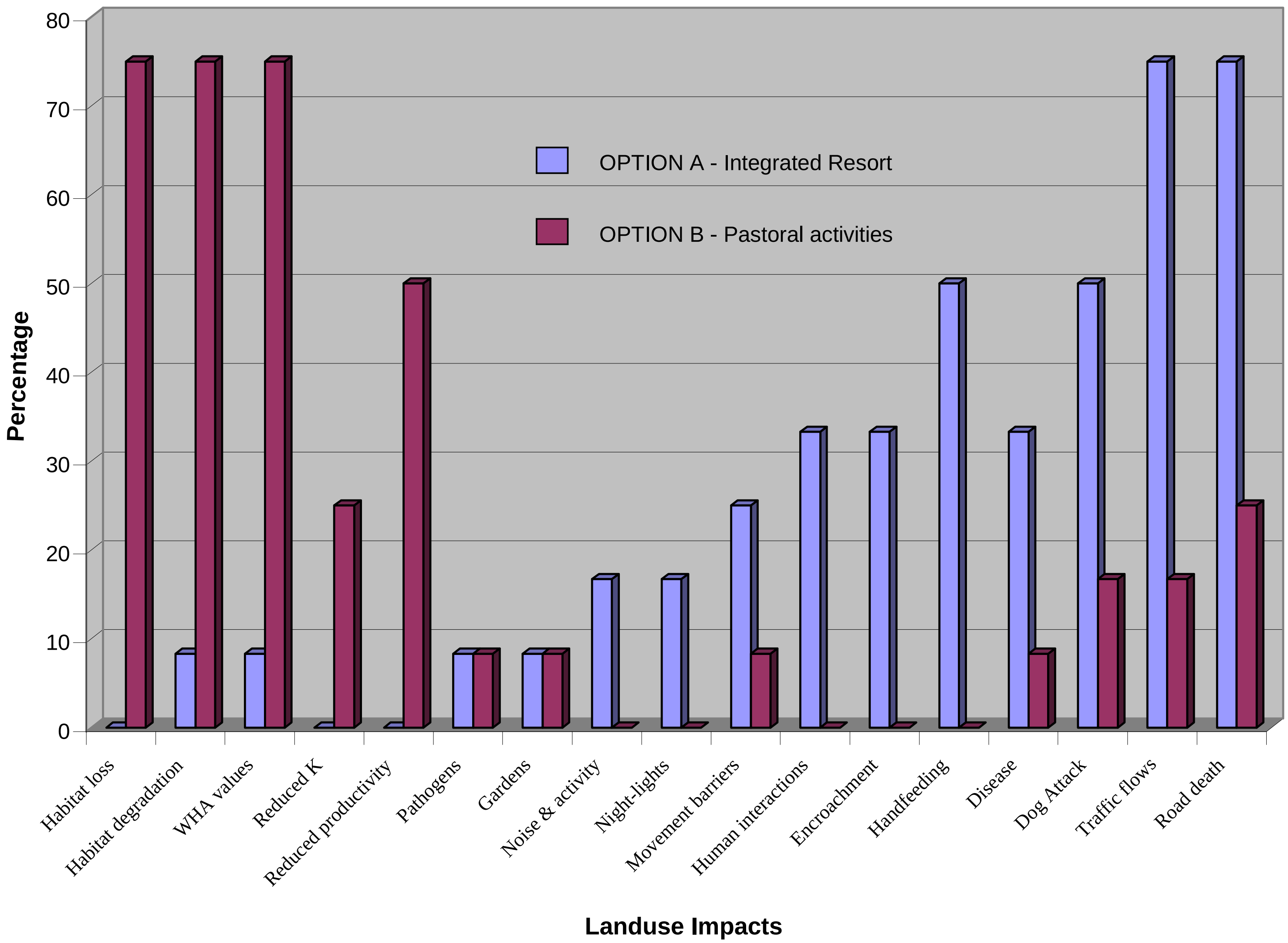
Impact Assessment for Option B: Continued pastoral landuse

Development Impacts	Significance	Magnitude	Overall Score [2] (Max = -48)	% of Maximum Impact
Habitat loss on site	-6	6	-36	75.0
Habitat degradation (edge effect) and encroachment	-6	6	-36	75.0
Traffic flows	-4	2	-8	16.7
Road death	-6	2	-12	25.0
Dog attack	-4	2	-8	16.7
Movement barriers (fences/roads)	-2	2	-4	8.3
Negative interactions with humans[1]	0	0	0	0
Hand-feeding issues[1]	0	0	0	0
Disease	-2	2	-4	8.3
Usage of adjoining forest by people (disturbance & interactions)	0	0	0	0
Domestic fruit trees and water sources	-2	2	-4	8.3
Increased noise and activity	0	0	0	0
Night lighting adjoining forest area	0	0	0	0
Invasion of pathogens affecting habitat quality (e.g., *Phytopthora*)	-2	2	-4	8.3
Reduced population carrying capacity (K)	-2	6	-12	25.0
Reduced productivity and recruitment	-4	6	-24	50.0
Impact on adjoining WHA National Parks	-6	6	-36	75.0
Total Effect			**-188**	**391.6**
Maximum Possible Total Effect			-816	1700
Change as Percentage of Maximum			**-23.0**	**23.0**

[1] Subsequent risk of relocation and disruption to local social breeding systems.
[2] Magnitude x Significance

Figure 13

Comparison of Environmental Impacts for Option A and Option B



8.5 COMPARISON AND DISCUSSION OF LANDUSE OPTIONS 'A' AND 'B'

Table 6 presents the comparative impacts resulting from the impact assessment analysis for two landuse options, 'OPTION A' the Integrated Resort, and 'OPTION B' continuing Pastoral Activities (Tables 4 and 5 respectively).

Table 6

A comparison of potential impacts of landuse options at Ella Bay Property

Development Option	% of Maximum impact
OPTION A: Resort Master Plan	24.5
OPTION B: Pastoral landuse	23.0

From Table 6 it can be seen that the generic potential for impact is more or less identical between the two activities i.e., 24.5% (Option A) compared to 23.0% (Option B). However, the nature of the specific impacts influencing the total outcomes differs markedly. Figure 13 illustrates the magnitude of each identified impact for each option. It can be seen that the major impacts associated with 'Option A', the integrated resort, relate to the threats posed by the increased traffic flow along Ella Bay Road, and people and wildlife management issues associated with a permanent human population using the Ella Bay Property.

In contrast, the major impacts associated with 'Option B', (continued pastoral landuse) involve the permanent loss or degradation of cassowary habitat within the site, and the potential devaluing of World Heritage Area values resulting from habitat degradation, edge effects, and the spread of declared weeds into the adjoining Ella Bay National Park.

In the case of 'Option A' (Integrated Resort), there are a number of possible mitigation strategies in addition to those which have been identified in the Master Plan (see 8.3.2) that can be applied to reduce the impacts identified in Table 4. The primary objective of these mitigation strategies should be to maintain or preferably reduce impacts in the area of road risk and human/wildlife management to that approximating those for the existing pastoral landuse.

Unfortunately, the impacts resulting from the continued use of the Ella Bay Property as a pastoral property are not as easily addressed (Table 5). As freehold ownership includes an ‘as of right’ entitlement to agricultural activities within the property, there are few, if any, mitigation strategies that are assured of being enacted outside the requirement for controlling pond apple. For example, there is no statutory obligation on the landowner to fence off the drainage lines or the remnant vegetation to prevent ongoing habitat degradation. In addition, while a permit is required to undertake further vegetation clearing, there is no obligation on the landowner to revegetate already cleared land or restore degraded habitat.

9.0 MITIGATION STRATEGIES

9.1 MITIGATION STRATEGIES FOR ELLA BAY PROPERTY

The primary objective of cassowary mitigation strategies at the Ella Bay Property is to facilitate the continuation of normal cassowary behaviour while minimising the possibility of adverse contact between cassowaries and humans. In the context of this impact assessment, ‘contact’ includes injury or death of cassowaries from collision with vehicles, and dog attack. As such, an approved cassowary management plan will need to be developed for the Ella Bay Property and the road connecting it with the Flying Fish Point township. This management plan should present the specific locations and types of mitigation to be used in detail, and include a long-term monitoring component. Those specific strategies that comprise the cassowary management plan are dependant on the final design of the Master Plan and the location and form of the Ella Bay Road upgrade, but should include the following elements:

9.1.1 Rehabilitating and augmenting cassowary habitat so there is no net loss

The distribution of cassowary habitat in the Wet Tropics bioregion was mapped by the Environmental Protection Agency (EPA) in 2004. The habitat types used by EPA for categorising cassowary habitat in this mapping project are summarised in Volume I, with full descriptions presented in Appendix A. The EPA habitat types, in order of their relative importance to cassowaries, are listed below:

1. Essential habitat;
2. General habitat;
3. Rehabilitating habitat;
4. Other vegetation;
5. Unknown;
6. Cleared;
7. Cultivated.

As indicated in the Ella Bay vegetation survey results (3D - BAAM 2006), the Ella Bay Property contains vegetation mapped as ‘Essential Habitat’, ‘General Habitat’, and ‘Rehabilitating Habitat’ for the endangered southern cassowary *Casuarius casuarius johnsonii* (EPA 2004). The recognised cassowary habitat types are shown in Section 4.1 Figure 7 of Volume I (Cassowary Survey), reproduced here as Box 2 for ease of reference. A summary of the relative values to the species of each numbered location is presented here along with possible mitigation strategies for each identified location.

Location 1a

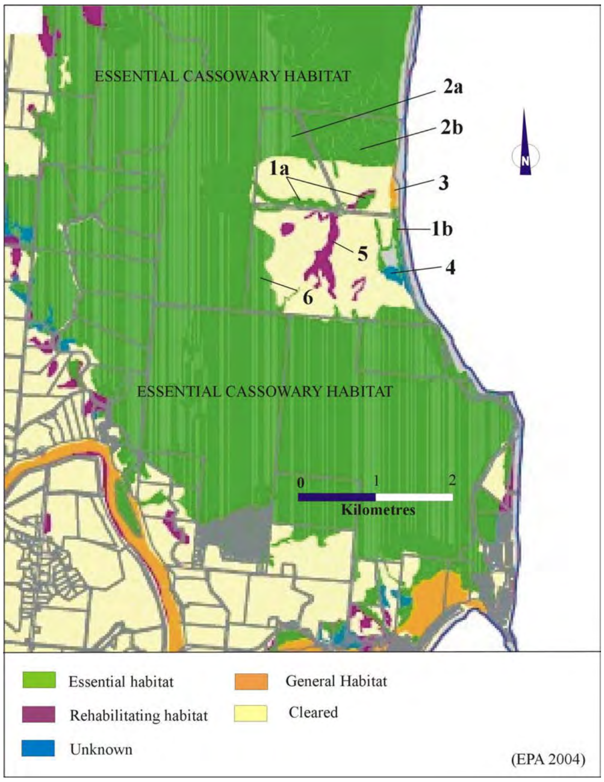
The vegetation along this narrow riparian strip is wind-disturbed and the stream banks are steep for much of the western half. The remaining vegetation in the eastern section of the stream is degraded mesophyll vine forest with infestations of pond apple *Annona glabra* and giant bramble *Rubus alceifolius.* The cassowary survey concluded that the resident adult male cassowary (Cassowary #1) made regular use of this riparian corridor, ostensibly to access the infestations of pond apple present within the lower sections of the stream and along the foreshore vegetation. Although this non-native food source will be removed in any future weed control program for the site, the corridor contains numerous potential cassowary food trees, the most common being blue quandong *Elaeocarpus angustifolius*. It also allows an alternative access route for cassowaries to forage in the feather palm dominated mesophyll forest to the north of the property.

Given the significance of this corridor to the local cassowary population, it will be necessary to ensure cassowaries have safe access to the area. In addition, the inclusion and revegetation of an additional movement corridor, shown as (B) on Figure 14, will facilitate cassowary movement into the Ella Bay Swamp, to the north of the Ella Bay Property. The structure and placement of the corridor is discussed further in Section 9.1.2, with its location and additional revegetation requirements shown on Figure 14.

BOX 2

Cassowary habitat types at the Ella Bay Property (*sensu* EPA 2004)

(Numbers reflect those discussed in text)



Location 1b

This area comprises *Melaleuca* dominated open forest/woodland, degraded in places by cattle grazing and weed infestations. It is considered that it holds little in the way of ecological benefits for cassowaries while potentially allowing adverse interactions between birds and visitors. As such, it is recommended that this area be closed off to cassowaries. Any cassowary habitat lost as a result should be compensated for by the inclusion and revegetation of a cassowary movement corridor linking the main east-west corridor to the Ella Bay Swamp forest block to the north of the Ella Bay Property ('B' on Figure 14).

Location 2a

This area currently provides habitat for two adult cassowaries (Cassowary #1 and Cassowary #3), and acts as an important buffer for the Ella Bay Swamp, listed as an '*Important Wetland in Australia* (WTMA 2005)'. Acceptable solutions to allow the preservation of the essential cassowary habitat in this area include cassowary-proof fencing, a restriction on use by residents and visitors to the resort, and a strict dog control program.

Location 2b

The management of this area is as recommended for Location 2a.

Location 3

This location contains no worthwhile habitat for cassowaries, being comprised of shrubland dominated by exotic and declared weed species. Weed control programs will remove these weeds, thus making it unattractive to cassowaries. As such, it is recommended that the area be closed off to cassowaries.

Location 4

This area comprises an exotic shrubland dominated by infestations of pond apple *Annona glabra* and is not natural or suitable cassowary habitat. In addition, as this non-native food source will be removed in any future weed control for the site, it is recommended that the area be closed off to cassowaries.

Location 5

This north-south drainage line does not currently provide much in the way of food resources for cassowaries, and for much of its length comprises secondary regrowth forest with little sub-canopy. If allowed to return to a remnant state, however, the corridor would be categorised as general cassowary habitat, and as such should retain its current habitat status as mapped by EPA (2004). In addition, it provides an alternative movement corridor for cassowaries in the south of the property allowing them to access the main east-west corridor, and thus to the National Park located west and north of the site.

Given the potential significance of this corridor to the local cassowary population, it will be necessary to ensure cassowaries have safe use of the site. The structure and placement of this corridor is discussed further below, with its location shown on Figure 14.

Location 6

The management of this area is as recommended for Locations 2a and 2b.

9.1.2 Retaining and creating connecting corridors of vegetation through the site

In the fauna assessment of the Ella Bay Property (BAAM 2006), it was recommended that a buffer zone of at least 50 metres be established and revegetated either side of the existing drainage lines to protect the habitat of the threatened mist frog *Litoria rheocola*. This 100 metre-wide corridor, in addition to the requirement for the construction of appropriate cassowary-proof fences lining the movement corridors, is considered an adequate minimum width for cassowaries.

Figure 14 shows the major cassowary movement corridors within the Ella Bay Property superimposed onto the Resort Master Plan. The location and extent of the cassowary-proof fences, the approximate locations of the Ring Road crossing points over the cassowary corridors, and the additional north corridor component (‘B’ on Figure 14), are also illustrated. The main east-west corridor does not allow cassowary access to that part of the foreshore represented by Locations 1b, 3 and 4 (Box 2), for reasons presented in Section 9.1.1. Any cassowary habitat lost by doing so, however, should be compensated for by increasing the revegetation planned to take place in the new northern corridor ‘B’ and throughout the remainder of the site, or be the subject of an ‘offset’ i.e., either the gifting to the protected estate of an agreed part of the subject site or the purchase and donation to the protected estate of alternative compensatory habitat elsewhere.

Figure 14

Cassowary corridors at Ella Bay Property

9.1.3 Cassowary-proof fence

A cassowary proof fence should surround the entire integrated resort along the existing vegetation line and extend into selected areas of revegetation where appropriate. The fence should be at least 1.8 metres in height to guarantee the exclusion of cassowaries and be constructed of natural material e.g., tea-tree or similar, on a backing structure of 50mm diamond-shape chain mesh fencing. The fence should be densely screened with plants so that birds cannot run into it by accident, or be attracted by people or food resources. Such a fence serves a dual purpose: separating birds from humans, while protecting and enhancing the adjoining cassowary habitat, in this instance the Ella Bay National Park. There should be a gap between the lower section of the fence and the ground of approximately 100 mm, to allow the passage of small mammals and reptiles, but yet not large enough to give access to small cassowary chicks.

9.1.4 Walking trails

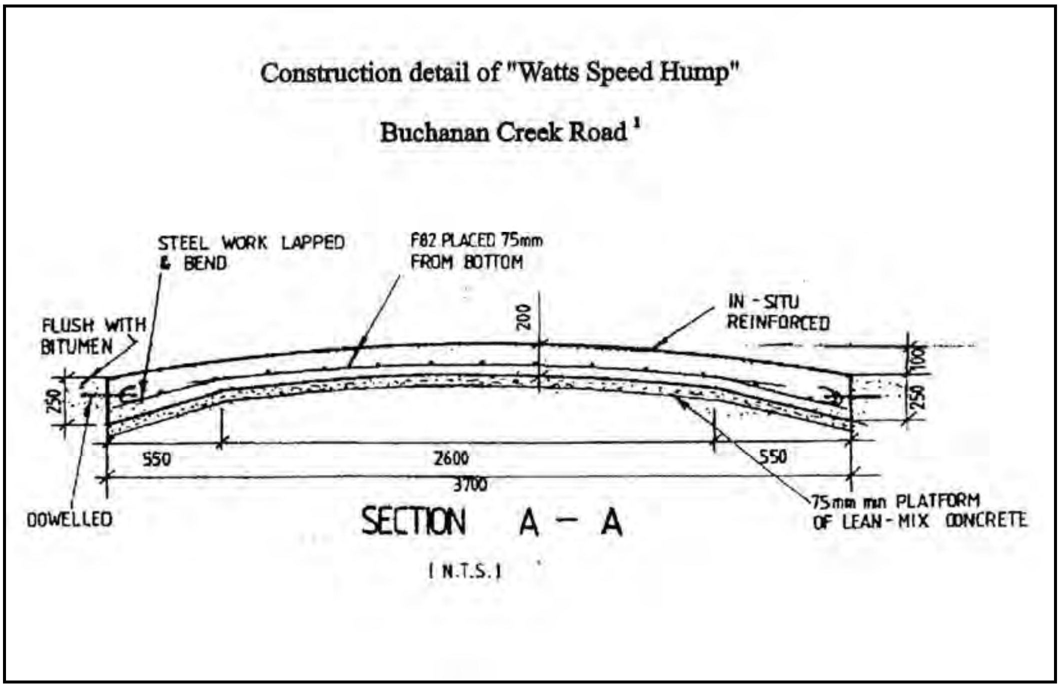
No walking trails should be located outside the cassowary-proof fence surrounding the development. All ground level walking trails and pedestrian paths inside the development should be located outside the cassowary movement corridors, or if located within the corridor, be raised approximately 2.5 metres above ground level to prevent interactions between cassowaries and people.

9.1.5 Roads

Road over-passes should be constructed on the ‘Ring Road’ to cross above sections of the cassowary corridors, or existing gullies and creeks. These over-passes are essential to facilitate the unhindered movement of cassowary and other fauna.

All roads within the resort should also be constructed following the QDMR guidelines referenced in Section 9.3.3. Where necessary, traffic calming devices should be located on the roads within the resort. An example of speed humps developed for the Daintree lowlands is shown in Figure 15 to illustrate one possible approach to reducing speed within the resort itself. There are many others.

Figure 15
Detail of "Watts Speed Hump"



9.1.6 Dog control

A rigorous dog control program should be implemented and monitored, as dogs attack and kill many cassowaries every year. It is recommended that the feasibility of Pet Fence Transmitters be evaluated for domestic pets within the development.

9.1.7 Landscaping

The planting of accessible native or domestic fruiting trees within the resort precincts should be restricted. Any planting of cassowary food trees within the development may attract cassowaries into the resort, with the accompanying risk of injury to both humans and birds. This strategy will also avoid issues with flying foxes concentrating within the resort.

9.1.8 Water sources

Apart from existing natural streams, no standing water e.g., ponds or fountains should be accessible to cassowaries in or around the development. Cassowaries have to drink a number of times per day and it is probable that in many areas the presence of water is as big an attraction to cassowaries as fruiting trees.

9.1.9 Weed control

The implementation and monitoring of a rigorous weed control to remove declared weeds, plus a garden-escapee education program for residents and resort management.

9.1.10 Lighting

To reduce the possibility of disturbance to cassowaries and other fauna using the adjoining areas, all external lighting within the development should be directed away from the surrounding rainforest vegetation.

9.1.11 Education programs

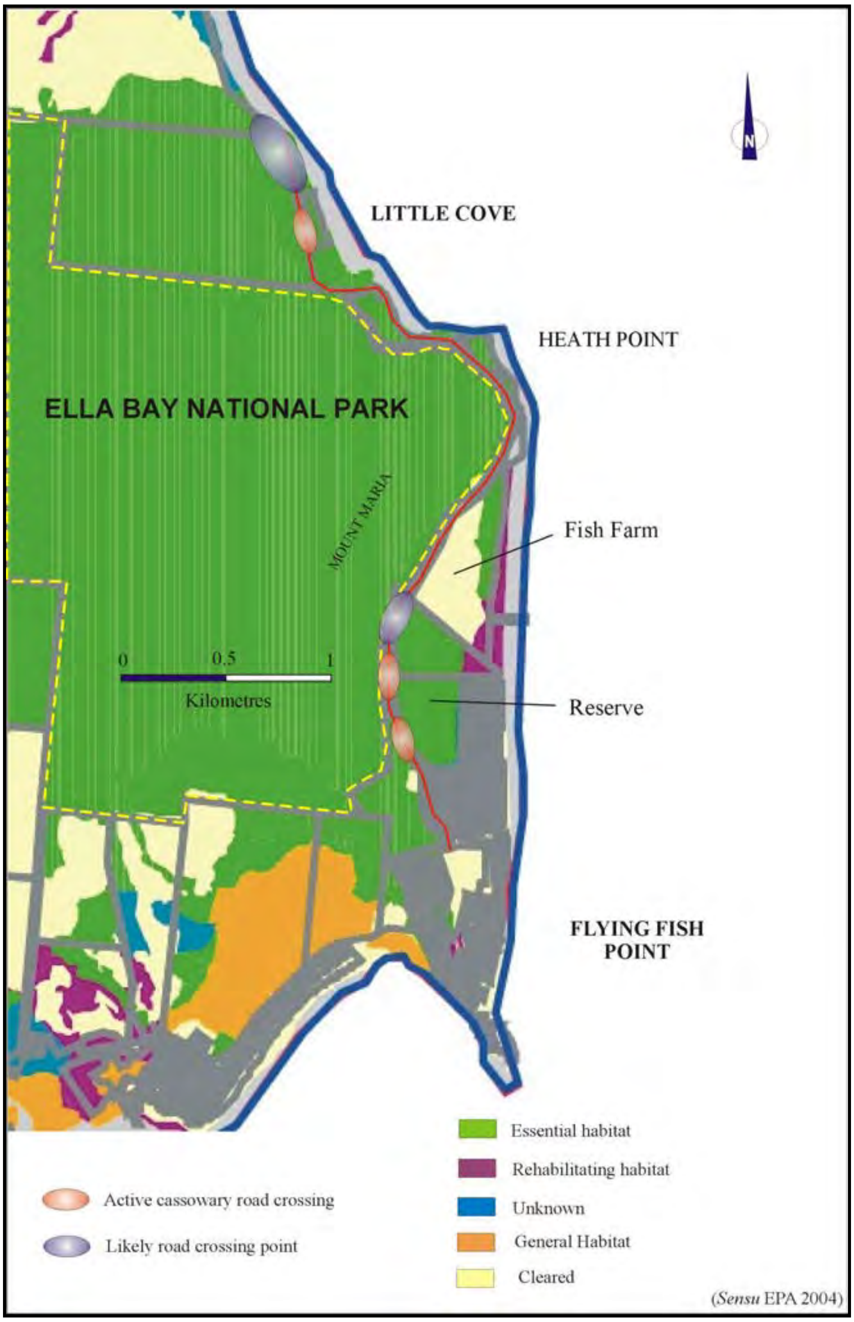
A Queensland Parks and Wildlife Service (QPWS) education program on the risks associated with hand feeding of cassowaries should be initiated. Human behaviour is not predictable in hand feeding situations, and naiveté of most people with wild animals will eventually promote an attack. Cassowaries can also ‘bully’ non-food items from adults and children if they are attracted to them e.g., toys, keys, jewellery, pens. This non-natural feeding behaviour can result in illness and death for the cassowary and possible trauma for humans who are confronted. In addition, experience has shown that people often feed harmful products to wild animals (e.g., in zoo situations), either deliberately or in ignorance e.g. plastics, contaminated food etc.

9.2 ALIGNMENT OF THE ELLA BAY ROAD

The vegetation and geology of the Ella Bay Road is described elsewhere in detail (3D: BAAM 2006b). This road connects the Ella Bay Property to Flying Fish Point, approximately 3.5 kilometres to the south. It is currently unsealed and for up to one kilometre of its length is cut into a steep and rocky coastal headland (Heath Point). To the north of Heath Point, the road drops into a number of well-vegetated flats and low ridges, and to the south into disturbed lowland rainforest bordering an aquaculture farm ('fish farm'). The entire length of the Ella Bay Road was surveyed for cassowaries from 6 to 14 November 2006 (Volume I of this report). The EPA cassowary habitat types adjoining the Ella Bay Road and Flying Fish Point are shown on Figure 16. The approximate locations for the cassowary road crossing points are also identified, along with names mentioned in the text.

Figure 16

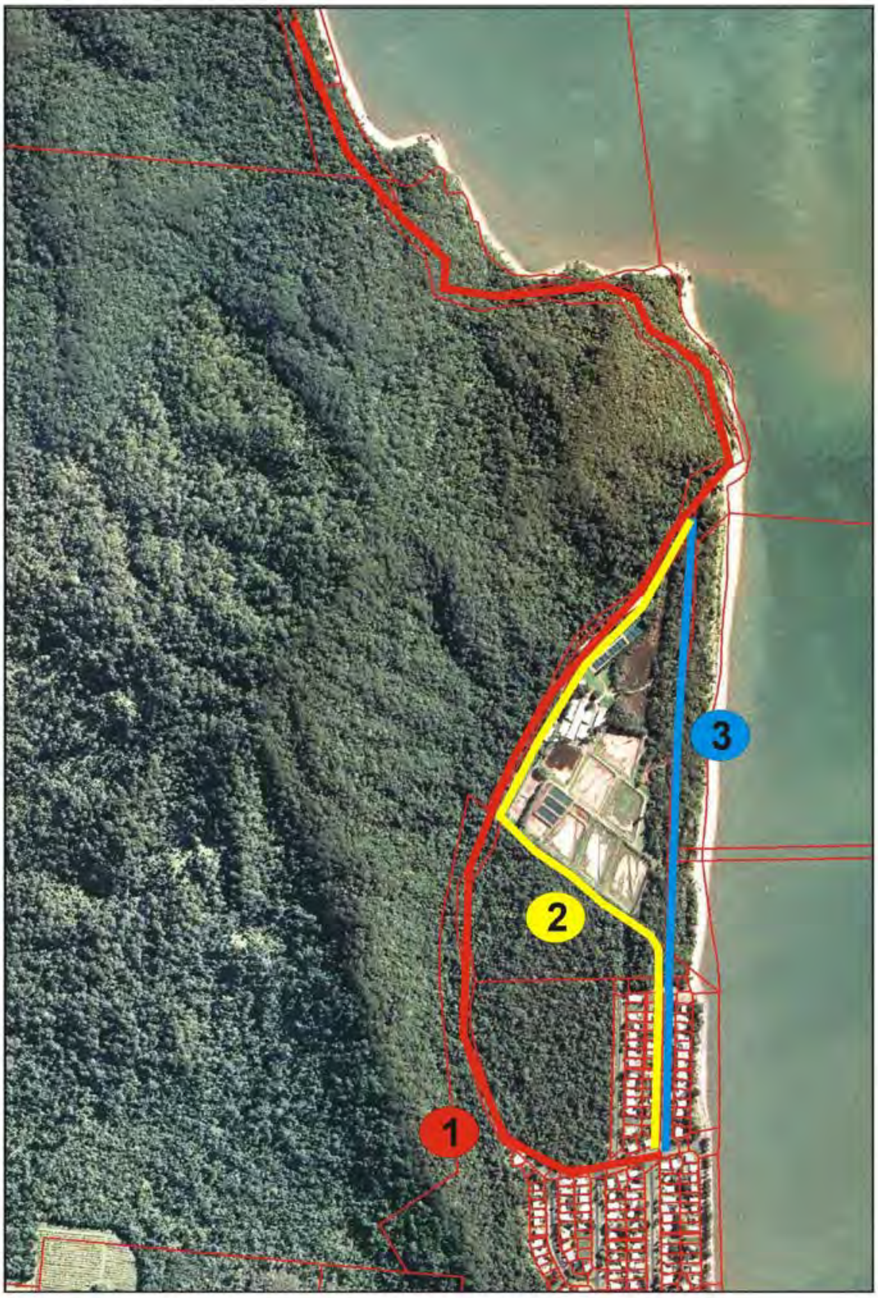
Cassowary habitat types along the Ella Bay Road (*sensu* EPA 2004)
(place names reflect locations discussed in text)



9.2.1 Ella Bay Road alignment options

In this assessment, three possible road alignment options are considered for their potential effect on cassowaries. This assessment does not include any other environmental considerations e.g., vegetation, geology, and coastal management issues. The approximate locations of the road options are shown below on Figure 17.

Figure 17
Ella Bay Road Alignment Options



9.2.2 Option 1 – Retain the existing alignment

This is considered the least preferable of the three possible road alignments. Currently there are two adult cassowaries and a chick that regularly cross the Ella Bay Road between Flying Fish Point and the fish farm to exploit the vegetation within the Reserve. This places them at risk of collision with vehicles, and that risk will increase significantly if the road is upgraded and traffic flow increases.

9.2.3 Option 2 – Fish Farm boundary

This option allows cassowaries to access the Reserve without having to cross the upgraded Ella Bay Road. In addition, it enables the Reserve to be incorporated into or managed with the adjoining National Park. However, there is still the possibility that birds may occur on the road near the fish farm. As such, there would be a need to incorporate a cassowary-proof fence along the new road if this option were adopted. Although not the preferred option, this placement significantly reduces the risk of road death for cassowaries.

9.2.4 Option 3 – Coastal alignment

This road placement is the preferred option in that it provides maximum protection for the resident cassowaries. The boundary fences of the fish farm could be extended to meet the new road, leaving only a small length of cassowary-proof fencing to ensure that cassowaries are not able to access the road at these points. As with Option 2, this road alignment enables the Reserve to be incorporated into or managed with the adjoining National Park.

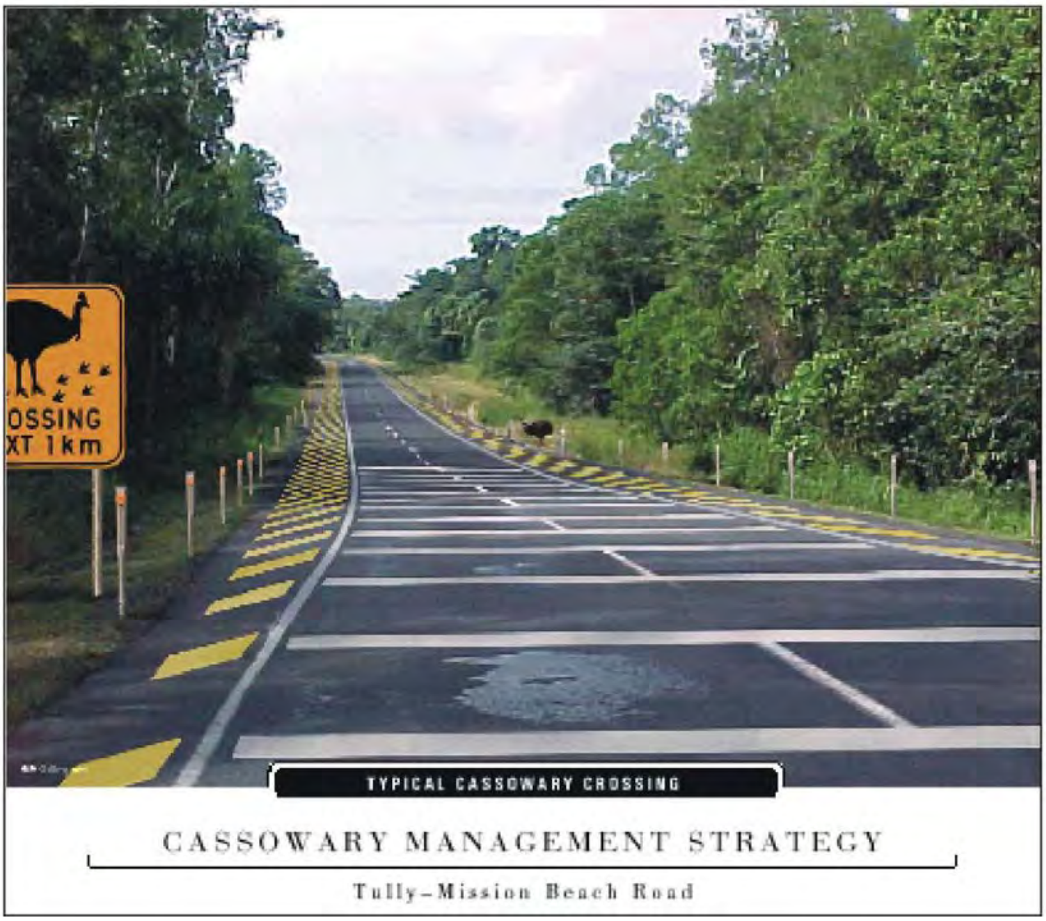
9.3 MITIGATION STRATEGIES FOR THE ELLA BAY ROAD CROSSINGS

9.3.1 Road management plan

A road management plan for known and likely cassowary crossing points on the Ella Bay Road should be developed and implemented. The points currently used by cassowaries to cross the Ella Bay Road have been identified and mapped; however, the exact placement of traffic calming points will be dependent on the final location and form of any road upgrade. An example of a Mission Beach road crossing indicating possible traffic calming suitable for use on the Ella Bay Road is illustrated in Figure 18, with generic measurements detailed in Appendix B (Moore 1998, 1999). This crossing has been designed to comply with Queensland Department of Main Roads standards.

Figure 18

Illustration of Standard Cassowary Road Crossing Design



9.3.2 'Wildlife Protection System' (WPS).

Another wildlife collision prevention strategy that may be suitable for the Ella Bay Road cassowary road crossings is a 'Wildlife Protection System' (WPS). This technology has been used extensively in Canada and is designed to alert approaching drivers with 'real time' information of the presence of wildlife on the road. The WPS uses infrared cameras to detect the presence of wildlife on or near the roadway. When the cameras detect wildlife, flashing lights at both ends of the road segment are triggered, thus allowing drivers to reduce speed and anticipate wildlife on the road.

9.3.3 Ella Bay Road upgrade

All upgrade works should be undertaken with reference to the best practice guidelines as presented in “Queensland Department of Main Roads: Roads in the Wet Tropics: Planning, Design, Construction, Maintenance and Operation Best Practice Manual (2000)”.

VOLUME III

POPULATION VIABILITY ANALYSIS

10. CASSOWARY POPULATION VIABILITY ANALYSIS (PVA)

10.1 BACKGROUND TO PVA

Population viability analysis (PVA) is the quantitative evaluation of all known factors and their interactions that act on populations and contribute to their risks of short and long-term decline or extinction (Boyce 1992). In PVA, extinction vulnerabilities of small populations (generally <500 individuals) are estimated using computer simulation modelling (Clark *et al* 1991; Lindenmayer *et al* 1993). The ready availability of generic computer packages for running PVA has increased its use and subsequent application in conservation planning and endangered species management over the past decade.

PVA requires a sophisticated understanding of the biology of the species in question e.g., an extensive knowledge of its population dynamics, genetics, and spatial and temporal dimensions of population change (Noon *et al* 1999). As software programs become more accessible e.g., VORTEX, RAMAS, ALEX, etc., this basic biological knowledge is a prerequisite for conducting a PVA.

10.1.1 Underlying principles of PVA

PVA uses simulation to assess the viability of a population (Possingham 1999). It began as an attempt to answer the question of how large must a population be for it to have a reasonable chance of survival (usually defined as 95%) for a reasonably long period of time (usually taken as 100 years - Soule 1993). However, it is unlikely that any modelling effort by itself can determine why a population is declining or why it has declined in the past (Caughley and Gunn 1994). The predictions made from PVA models should be considered, therefore, to be projections about what would be most likely to happen to the population ***if*** various hypotheses about the status of the population and threats were true (Miller and Lacy 1999). For population modelling to be successful in evaluating options for the management of threatened species therefore, it must be part of a larger process that incorporates other approaches, including the study of natural history, field observations and experiments, analysis of historical and current data, and long-term monitoring (Akcakaya *et al* 1999).

It is important to accept that the concepts of population extinction and loss of genetic diversity are based on probabilities rather than certainties. Thus the PVA results can only provide us with information on the probability of extinction given certain assumptions about the biology and status of the population. PVA does not predict the fate of a species - it is a probabilistic rather than a predictive tool which focuses on the factors most likely to limit the persistence of a species over time (Noon *et al* 1999). As a result, we are really not able to predict or guarantee exactly what will happen to these populations with any certainty (Shaffer 1987). It is unlikely therefore, that we will be able to create conservation strategies that will ensure the survival of any threatened population. A properly conducted PVA, however, should provide the information required to devise and implement management strategies that will decrease the likelihood of decline and extinction of a population over a given period of time (Soule 1986).

10.1.2 Opportunities for the use of PVA in conservation management

It is generally accepted that PVA is a useful tool provided adequate data exist and the models and assumptions are transparent and carefully assessed. It can also contribute significantly to an understanding of the population biology of a species, thus identifying any knowledge gaps in its life history (Keedwell 2004). For most species it is best suited for projecting population trends 10–50 years into the future to compare different management scenarios, but is less useful for predicting absolute measures of survival, such as probabilities of extinction. Moreover, the results of PVA are often used in the context of adaptive management i.e., to develop and estimate the relative risks of conservation strategies and inform decision and policy making for both endangered and non-endangered species (Clark *et al* 1991; Lindenmayer *et al* 1993; Boyce 1997; Rolls and Taylor 1997; Shaffer 1997).

10.1.3 Constraints and shortcomings of PVA

Although numerous studies have demonstrated that PVA can contribute significantly to conservation policy and the management of rare species (e.g., Clark *et al* 1991; Lacy 1993; Lindenmayer *et al* 1993; Possingham 1994; Ruggiero *et al* 1994), it can be easily used incorrectly, potentially to the detriment of the species being modelled (Keedwell 2004). Limitations of PVA include the difficulty of validating stochastic models, the frequent neglect of environmental trends and periodic fluctuations, the omission of risks that are hard to estimate, and the fact that alternative model structures often result in different predicted effects of management regimes (Caughley and Gunn 1996; Taylor 1995; Beissinger and Westphal 1998; Ludwig 1999).

Moreover, some studies have concluded that predictions of future population sizes and quasi-extinction events can only be accurate if the data used adequately captures the distribution of population growth rates (Coulson *et al 2001*). The recognised limitations and pitfalls in the use of PVA are considerably exacerbated for endangered species if the quantitative models used are built on poor demographic data (Lindenmayer *et al* 1993; Beissinger and Westphal 1998). Unfortunately, accurate population data are usually difficult to obtain for rare species. While a PVA can be tailored to suit the data available, often the parameters and structures of such models result in large uncertainties (Akcakaya 1999). Analytically comprehensive analyses of population trends and persistence probabilities require extensive ecological data (Beissinger and Westphal 1998), and any PVA will only be as good as the data on which it is based.

The amount of information required for an effective PVA is considerable, however, and in practice data are often not available for many important variables, particularly demographic variables such as population size, age structure, sex ratio, life history traits, habitat quality and availability (Reed *et al* 1998). It usually transpires therefore, that in the process of synthesising current information about a species, inadequacies in knowledge are often highlighted.

10.1.4 Scope of a PVA for the 'local' cassowary population at Ella Bay

Any scientific inquiry starts with a question, and population viability analysis is no exception. In the Terms of Reference for an Environmental Impact Statement for the EIS of Ella Bay Integrated Resort Project the following requirement is stated:

- '*PVA at the local population level. This should include a clear indication of the sources and reliability of the relevant life history parameters used. Where possible, the parameters should include data that has been researched from the local population. It should include a discussion of the limitations of the results*.'

The inherent question to be answered in such a PVA is whether the 'local' cassowary population is threatened by the resort project, and if so, why and how. To answer this it is necessary to first determine what is actually meant by the term 'local population level'. As PVA deals with populations of animals or plants, it is not valid to subject only those birds identified in and surrounding the Ella Bay Property to a PVA, as they interact with and are influenced by the remainder of the Seymour Range cassowary population. Indeed, it is crucial to have a sense of spatial and temporal relationship between cassowaries, their habitat, and demographic factors and risks. As such, Figure 19 presents that area (located within the red square), considered to represent the local cassowary population potentially influenced by any adverse impacts resulting from the Ella Bay Integrated Resort Project.

It can be seen on Figure 19 that there are two discrete subpopulations in this area, the Seymour Range and Mount Arthur cassowaries, and the Graham Range cassowaries, both tenuously connected by a narrow vegetated ridge and separated by the Bramston Beach Road. Given the location and scale of potential impacts as identified in Volume II of the cassowary assessment (Impacts and Mitigation), it is considered that the Seymour Range population is representative of the 'local' cassowary population. As there have been only two recent surveys conducted in the southern section of the Seymour Range i.e., ca 20 km^2 (Moore 2006 c & d), it will be necessary to estimate many of the model parameters using data from previous field studies at Mission Beach (Moore 1998 – 2007).

The type of parameters that need to be estimated will depend on the model structure, and the type of data available from the two Seymour Range surveys. If a parameter is not known or uncertain, then a range of numbers can be used for that parameter instead of a single number. This necessitates that the model must be run many times, with different combinations of the low and high values of each parameter to make sure that all uncertainty in parameter values is accounted for. This statistical approach provides a way to measure the sensitivity of results to each parameter.

Figure 19

PVA study area

NOTE

Box 3 below presents a preliminary structure for the remainder of the population viability analysis for the cassowaries of Ella Bay and Seymour Range. This PVA study is yet to be commissioned.

BOX 3

DRAFT PVA REPORT STRUCTURE

10.0 CASSOWARY POPULATION VIABILITY ANALYSIS (PVA)

10.2 POPULATION VIABILITY ANALYSIS PACKAGE

10.3 INPUT PARAMETERS FOR SIMULATIONS

- Age of first reproduction
- Age of reproductive senescence
- Maximum number of young per breeding cycle
- Female breeding numbers
- Male breeding pool
- Mortality
- Initial population size
- Carrying capacity
- Catastrophes
- Genetic drift and inbreeding depression
- Immigration/Supplementation
- Definition of extinction

10.4 SENSITIVITY ANALYSES

10.5 POPULATION SIMULATIONS

- Baseline models (with and without inbreeding)
- Adult mortality assessment
- Effect of immigration on persistence probabilities
- Effect of Integrated Resort Project on persistence probabilities
- Effect of continuing Pastoral Activities on persistence probabilities

11. PVA RESULTS

- Present simulation results from 10.5

12. DISCUSSION

- Analysis and interpretation of PVA Results from Chapter 11.

13. CONCLUSION

- Assessment of population viability analyses for all population simulations.

APPENDIX A

CASSOWARY HABITAT TYPES - ENVIRONMENTAL PROTECTION AGENCY (EPA) 2004

Essential[1] habitat:

Regional ecosystems where there is an *accurate and verified*[2] record of a cassowary and is *known*[3] be preferentially used by cassowaries for breeding, feeding and general activity. That is:

- Known to be used by cassowaries for breeding, either for nesting or by males with chicks with striped plumage or;
- Known to contain food resources that are used by cassowaries or;
- Known to be used by cassowaries, though it is unknown exactly whether this is for foraging and feeding, breeding, territorial movements, dispersal or some other aspect of its life history.

General[4] habitat:

Regional ecosystems where there is an accurate and verified record of a cassowary, but is not known to be preferentially used as habitat. That is:

- General habitat sometimes provides linking habitat that cassowaries use to traverse between regional ecosystems of essential habitat.
- The record is known to be a vagrant animal or;
- The regional ecosystem is known to support cassowaries infrequently never during times of food shortage elsewhere or;
- There is insufficient information known to determine if cassowaries regional ecosystem.

Rehabilitating habitat:

Non-remnant[5] regional ecosystems that consist of rehabilitating and regrowing vegetation that provide shelter and supplementary feeding and breeding resources. If allowed to return to a remnant state, these regional ecosystems would be likely to be categorised as either essential or general cassowary habitat, depending on how it satisfies the definition criteria. This includes regional ecosystems where there have been previous accurate and verified records, prior to disturbance. Rehabilitating habitat sometimes provides linking habitat that cassowaries use to traverse between regional ecosystems of essential habitat.

Unknown:

Mapped vegetation polygons where the regional ecosystem type is unknown at present. Once assigned a regional ecosystem, these units will be classified as one of the other cassowary habitat categories listed here. Until this is completed, a cassowary habitat category cannot be ascertained.

Cleared:

Regional ecosystems cleared of native vegetation, and therefore not considered cassowary habitat. Cleared habitat sometimes provides linking habitat that cassowaries use to traverse between regional ecosystems of essential habitat.

Cultivated:

Regional ecosystems representing agricultural and forestry plantations. Cultivated habitat sometimes provides linking habitat that cassowaries use to traverse between regional ecosystems of essential habitat.

Other vegetation:

Remnant regional ecosystems that are either too small or too distant to satisfy the patch analysis rules, or are considered geographically and climatically unsuitable, despite being essential or general cassowary habitat types.

Notes

[1] *Essential* habitat is defined as that necessary for the persistence of cassowary populations in perpetuity.

[2] *Accurate and verified* means there is a record of cassowary from a reputable organisation or individual that could be contacted and double-checked (see Appendix 1 for list), the record was obtained after 1980 and the record had a positional accuracy of at least 1km.

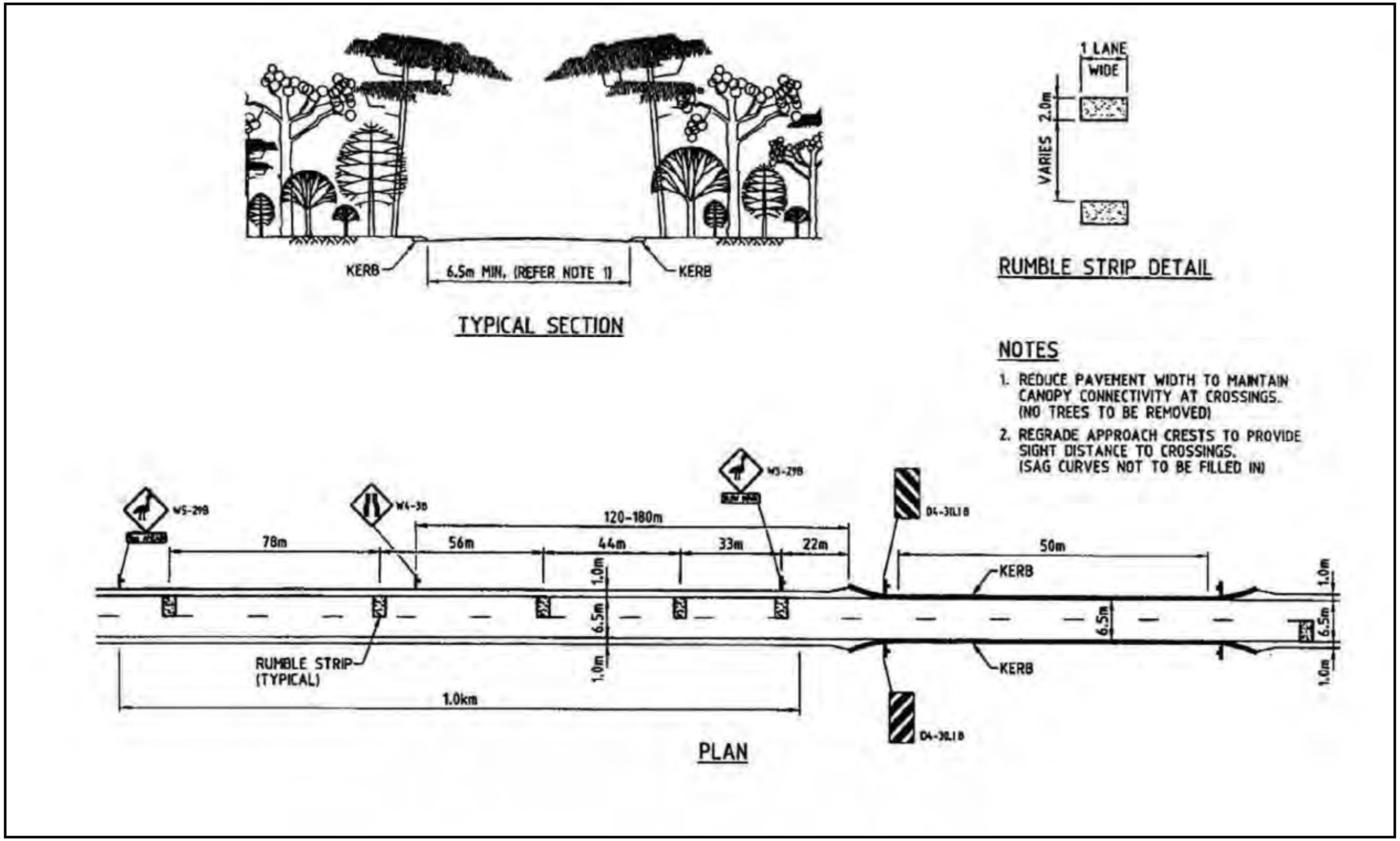
[3] *Known* means that the regional ecosystem has been reported in reputable research, scientific literature or via personal communication from cassowary experts as being significant habitat for cassowary for foraging, feeding, breeding or some other aspect of its life history.

[4] *General* habitat is defined as that occasionally used by cassowaries, but not considered essential for the persistence of cassowary populations in perpetuity.

[5] *Non-remnant* means all vegetation that fails to meet the structural and/or floristic characteristics of remnant regional ecosystems in the *Vegetation Management Act 1999*. This may include regrowth, heavily thinned or logged and significantly disturbed vegetation.

APPENDIX B

Detail of Standard Cassoway Road Crossing Point Design (Mission Beach 1998)



REFERENCES

Akçakaya, H. R., Burgman, M., Ginzburg, L., 1999. Applied Population Ecology. Sinauer Associates Inc. Massachusetts, USA

Bentrupperbäumer, J., 1998. Reciprocal Ecosystem Impact and Behavioural Interactions between Cassowaries, *Casuarius casuarius* and Humans, *Homo sapiens*. Ph.D. Thesis, James Cook University, Townsville Australia.

Coddington, C. L., Cockburn, A., 1995. The Mating System of Free-Living Emus *Australian Journal of Zoology* 43, 365 – 372.

Crome, F., H., J., and Moore L., A. (1993a). Cassowary populations and their conservation between the Daintree River and Cape Tribulation. Vol. 1 Summary. *A report to the Douglas Shire Council*.

Crome, F., H., J., and Moore L., A (1993b). Cassowary populations and their conservation between the Daintree River and Cape Tribulation. Vol. 2 Background, survey results and analysis. *A report to the Douglas Shire Council.*

Crome, F., H., J., and Moore L., A. (1992). Report on a survey of cassowary populations in the Whitfield Range, north Queensland. *Internal Research Report*. CSIRO 17/3/92.

Crome, F., H., J., and Moore L., A. (1990). Cassowaries in north-eastern Queensland: Report of a survey and a review and assessment of their status and conservation and management needs. *Austl Wildl. Res. 17:369-85.*

Crome, F., H., J., and Moore L., A. (1988). The southern cassowary in north Queensland - a pilot study.

Volume 1: *Introduction, distributional survey and effects of habitat disturbance.*

Volume 2: *The biology of the cassowary: An analysis of information in cassowaries from the literature, zoos, museums and a public survey.*

Volume 3: *Techniques. An assessment of counting, trapping and handling methods* *and husbandry*.

Volume 4: *Summary and Management options.*

Reports prepared for the Queensland National Parks and Wildlife Service and the Australian National Parks and Wildlife Service.

EPA (2004). Distribution of cassowary *Casuarius casuarius johnsonii* habitat in the Wet Tropics Bioregion, Queensland. Environmental Protection Agency, Townsville.

Moore, L.A. (2007 – in press). Population ecology of the Southern Cassowary *Casuarius casuarius johnsonii*, Mission Beach, north Queensland. *Journal of ornithology.*

Moore, L.A. (2007 in prep). Implications of environmental catastrophes and climate change for management of an endangered species: the Southern Cassowary *Casuarius casuarius johnsonii. Austral Ecology*

Moore, L.A. (2007 - at review). Connectivity and cassowary conservation: the disappearing coastal cassowaries of the Queensland Wet Tropics. *Pacific Biological Conservation.*

Moore, L.A. (2003). MSc: Ecology and population viability analysis of the Southern Cassowary (*Casuarius casuarius johnsonii*): Mission Beach, North Queensland. Masters of Science thesis, Department of Zoology and Tropical Ecology, James Cook University, Queensland.

Moore, L.A. (2001). A field survey of the cassowary population of Mission Beach, North Queensland: Population number, densities, distribution, demography, and implications for conservation and management. *Report for Community for Coastal and Cassowary Conservation* (C4), funded by the Wet Tropics Management Authority.

Moore L.A. (2000a). Surveying an Endangered Rainforest Species: Methods and Application. The Southern Cassowary *Casuarius casuarius johnsonii*. *Supplement to Masters of Science Thesis*, James Cook University, Townsville.

Moore, L.A. (2000b). Literature survey, bibliography and museum specimen lists for the Southern Cassowary *Casuarius casuarius johnsonii. Supplement to Masters of Science Thesis;* James Cook University, Townsville.

Moore, LA (1999a). Cassowary Management Plan. I. Daintree. *Report for Wet Tropics Management Authority.*

Moore, LA (1999b). Cassowary Management Plan. II. Kuranda (Cairns). *Report for Wet Tropics Management Authority.*

Moore, LA (1999c). Cassowary Management Plan. III. Innisfail. *Report for Wet Tropics Management Authority.*

Moore, LA (1999d). Assessment of cassowary populations at Mt Spec (Townsville) and the Cairns foothills. *Report for Wet Tropics Management Authority*.

Moore, LA. (1999e). Road Link Study - Southern Atherton Tablelands: A field survey to assess the major issues of road upgrades on selected Rare and Endangered fauna. *Report for Queensland Department of Main Roads.*

Moore LA. (1999f). Road Crossing Points and Management Strategies for Street Creek Cassowary #11. *Report for the Wet Tropics Management Authority*.

Moore LA. (1999g).Cassowary Road Crossing Strategy: Buchanan Creek Road, Daintree Lowlands. *Report for the Wet Tropics Management Authority.*

Moore LA. (1999h). Preliminary results of a field survey of cassowaries in the Innisfail Area, north Queensland. *A Report for the Wet Tropics Management Authority.*

Moore LA. (1999i). Road Crossing Strategies for cassowaries and other fauna: South Mission Beach Road, Mission Beach. *Report for Queensland Department of Main Roads*.

Moore, LA (1998a). Field survey of cassowaries in the Kuranda region (Cairns*)*. *Report for Wet Tropics Management Authority.*

Moore, LA (1998b). Draft cassowary management plan for Daintree lowlands bioregion*. Report for Wet Tropics Management Authority.*

Moore, LA (1998c). Cassowary Conservation Roads: A Management Strategy and Road Upgrade Assessment for El Arish and Tully-Mission Beach Roads, Mission Beach*. Report for Queensland Department of Main Roads.*

Moore, LA (1997). Environmental Impact Assessment Study of the Daintree Power Line Proposal – Fauna. *Report for Far North Queensland Electricity Authority*.

Moore, LA (1996a). Cassowary assessment studies for Lot 157 Fan Palm Road, Daintree: *Report for Daintree Rescue Program*, Queensland Department of Environment.

Moore, LA (1996b). Cassowary assessment studies for Lot 52 Cooper Creek, Daintree: *Report for Daintree Rescue Program*, Queensland Department of Environment.

Moore, LA (1996c). Cassowary assessment studies for Lots 1 & 2 Buchanan Creek Road, Daintree: *Report for Daintree Rescue Program*, Queensland Department of Environment.

Moore, LA (1996d). Cassowary assessment studies for Lots 86 & 87 Cape Tribulation Road, Daintree: *Report for Daintree Rescue Program*, Queensland Department of Environment.

Moore, LA (1996e). Cassowary assessment studies for Cooper Creek National Park, Daintree: *Report for Daintree rescue Program*, Queensland Department of Environment.

Moore, LA (1996f). Cassowary assessment studies for Lot 6 BK157145 (6V) Alexandra Range Central Cow Bay, Daintree: *Report for Daintree Rescue Program, Queensland Department of Environment.*

Moore, LA (1996g). Survey of cassowary road crossing points on Buchanan Creek Road, Cow Bay: *Report for Daintree Rescue Program*, Queensland Department of Environment.

Moore, LA (1996h). Part 1: Cassowary Monitoring Program, Daintree lowlands: *Report for Wet Tropics Management Authorit (WTMA).*

Moore, LA (1996i). Part 2: Cassowary Monitoring Program, Daintree lowlands: Report for Wet Tropics Management Authority.

Moore, LA. (1995a). Status of Cassowaries in proposed boardwalk area at Cow Bay, Daintree. *Consultancy report for Natural Resource Assessments, Cairns.*

Moore, LA and FHJ Crome. (1992). Report on a survey of cassowary populations in the Whitfield Range, north Queensland. *Internal Research Report*. CSIRO 17/3/92.

Mowat, G., Strobeck, C., (1999). Estimating Population Size of Grizzly Bears Using Hair Capture, DNA Fingerprinting, and Mark-Recapture Analysis. Ed. L. M. Darling: Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15 - 19 Feb.,1999. Volume Two.

Noon, B.R., R.H. Lamberson, M.S. Boyce, and L.L. Irwin. 1999. Population viability analysis: A primer on its principal technical concepts. In: Ecological Stewardship: A Common Reference for Ecosystem Management. K. Johnson et al. (eds). Elsevier Science Ltd., London

Reed, M., Murphy, D.D., Brussard, P., 1998. Efficacy of population viability analysis. Wildlife Society Bulletin 26, 244-251.

Wood, C. 1995 *Environmental Impact Assessment: A Comparative Review*. Longman, Harlow (UK), 337 p.

Ella Bay Integrated Resort Development

Table Of Contents

VOLUME III – POPULATION VIABILITY ANALYSIS (PVA)

List of Tables

Boxes

List of Figures

List of Plates

APPENDICES

VOLUME III

POPULATION VIABILITY ANALYSIS

10. CASSOWARY POPULATION VIABILITY ANALYSIS (PVA)

The impacts of the two landuse options at Ella Bay are discussed in detail in Volume II: Impact Assessment and Mitigation Strategies and comprise: Option A: developing the Ella Bay Integrated Resort (EBIR); Option B: continued pastoral use. The major impacts associated with Option A (EBIR) relate to the threats posed by increased traffic along Ella Bay Road and the concomitant flow-on impacts associated with a large permanent human population using the Ella Bay Property. There is a range of strategies available to mitigate the major impacts within the development footprint to that approximating those for existing pastoral landuse. They include cassowary-proof fencing, cassowary road management strategies for the Ella Bay access road, and strict dog control. Effective people management at the EBIR, however, is an area of mitigation that will need further examination.

While able to mitigate the on-site impacts to individual birds, the cassowary impact assessment of the Ella Bay property concluded that both landuse options i.e., continued pastoral landuse and the Ella Bay Integrated Resort, posed threats to the cassowary population of Seymour Range. Using population viability analysis (PVA), this part of the report addresses the potential direct and indirect impacts of the EBIR on the viability of the cassowary population of the Seymour Range.

10.1 WHAT IS PVA?

Population viability analysis (PVA) is the quantitative evaluation of all known factors and their interactions that act on populations and contribute to their risks of short and long-term decline or extinction (Boyce 1992). In PVA, extinction vulnerabilities of small populations (generally <500 individuals) are estimated using computer simulation modelling (Clark *et al* 1991; Lindenmayer *et al* 1993). The ready availability of generic computer packages for running PVA has increased its use and subsequent application in conservation planning and endangered species management over the past decade.

PVA requires a sophisticated understanding of the biology of the species in question e.g., an extensive knowledge of its population dynamics, genetics, and spatial and temporal dimensions of population change (Noon *et al* 1999). As software programs become more accessible e.g., VORTEX, RAMAS, ALEX, etc., this basic biological knowledge is a prerequisite for conducting a PVA. Many Australian and overseas studies have shown that compared to other alternatives for making conservation decisions, PVA provides a rigorous methodology that can use different types of data, and incorporate uncertainties and natural variabilities that are relevant to specific conservation goals. (Akçakaya and Sjögren-Gulve 2000). The major disadvantages of PVA are its single-species focus and a requirement for data that may not be available for many species. However, in this study, we are dealing with the southern cassowary only, and extensive ecological data is available from previous studies of this species (Crome 1975, Crome and Benntrupperbaumer 1982, Moore 1998, 1999, 2000, 2003, 2007a-c).

10.2. THE USE OF PVA IN IMPACT ASSESSMENT

Population viability analysis has been used to assess the impact of human activities by comparing results of models with and without the population-level consequences of the human activity (Akçakaya and Sjögren-Gulve. 2000). In impact assessment, the greatest value of PVA lies with the fact that it focus on relative rather than absolute results, and the risks of decline rather than extinction (Akçakaya and Sjögren-Gulve 2000, Noon *et al* 1999). However, PVA is not a tool ideally suited for most impact assessment studies. This is primarily because the population dynamics are modelled at the 'population' level, rather than the 'local' level usually required for environmental impact assessments. As such, its application in impact assessment requires that specific biological and statistical conditions be met for its use to be valid. Even when those conditions are met, careful and cautious interpretation of the results is necessary to prevent the analyses becoming more confounding than they are constructive.

10.3 DEFINING THE STUDY BOUNDARIES

In the Terms of Reference for an Environmental Impact Statement for the EIS of Ella Bay Integrated Resort Project (EBIR) require:

- '*PVA at the local population level. This should include a clear indication of the sources and reliability of the relevant life history parameters used. Where possible, the parameters should include data that has been researched from the local population. It should include a discussion of the limitations of the results*.' (Coordinator General 2005).

To address this it is necessary to first define what area of cassowary habitat represents the 'local population level'.

10.3.1 Spatial context of Ella Bay Integrated Resort (EBIR)

The coastal cassowary habitat south of Cairns predominantly occurs as a narrow strip on the coastal ranges, which parallel the coast. This discontinuous band of vegetation varies from one to four kilometres in width over most of its 200-kilometre length. These forested coastal ranges are separated from the main rainforest blocks of the Wet Tropics region by extensive agricultural and urban clearing, and a major highway, forming a substantial obstacle to east-west cassowary movement. As a result, coastal populations of cassowaries have lost connectivity with the World Heritage Area to the west. Similar impediments to north-south movement by cassowaries along the coast exist at an increasing number of points along their coastal distribution, creating a series of eight small subpopulations faced with declining habitat and growing threats (Moore and Moore 2007b). The majority of these populations are either already isolated e.g., Moresby Range, or their connectivity is severely limited and at risk e.g., Mission Beach. Of the eight subpopulations, only five (Malbon-Thompson Range, Graham-Seymour Range, Moresby Range, Mission Beach and Hinchinbrook Island) are within the protected estate. The EBIR is located at the southern end of the Graham-Seymour Range subpopulation. In this study, the eight cassowary subpopulations are considered to make up the 'coastal metapopulation'.

The Graham-Seymour Range cassowary population is currently at risk of being separated into two smaller isolated populations. Figure 19 identifies the narrow vegetated corridors, which are all that now connects this population, and Appendix C contains photographs taken at each site. The corridors comprise:

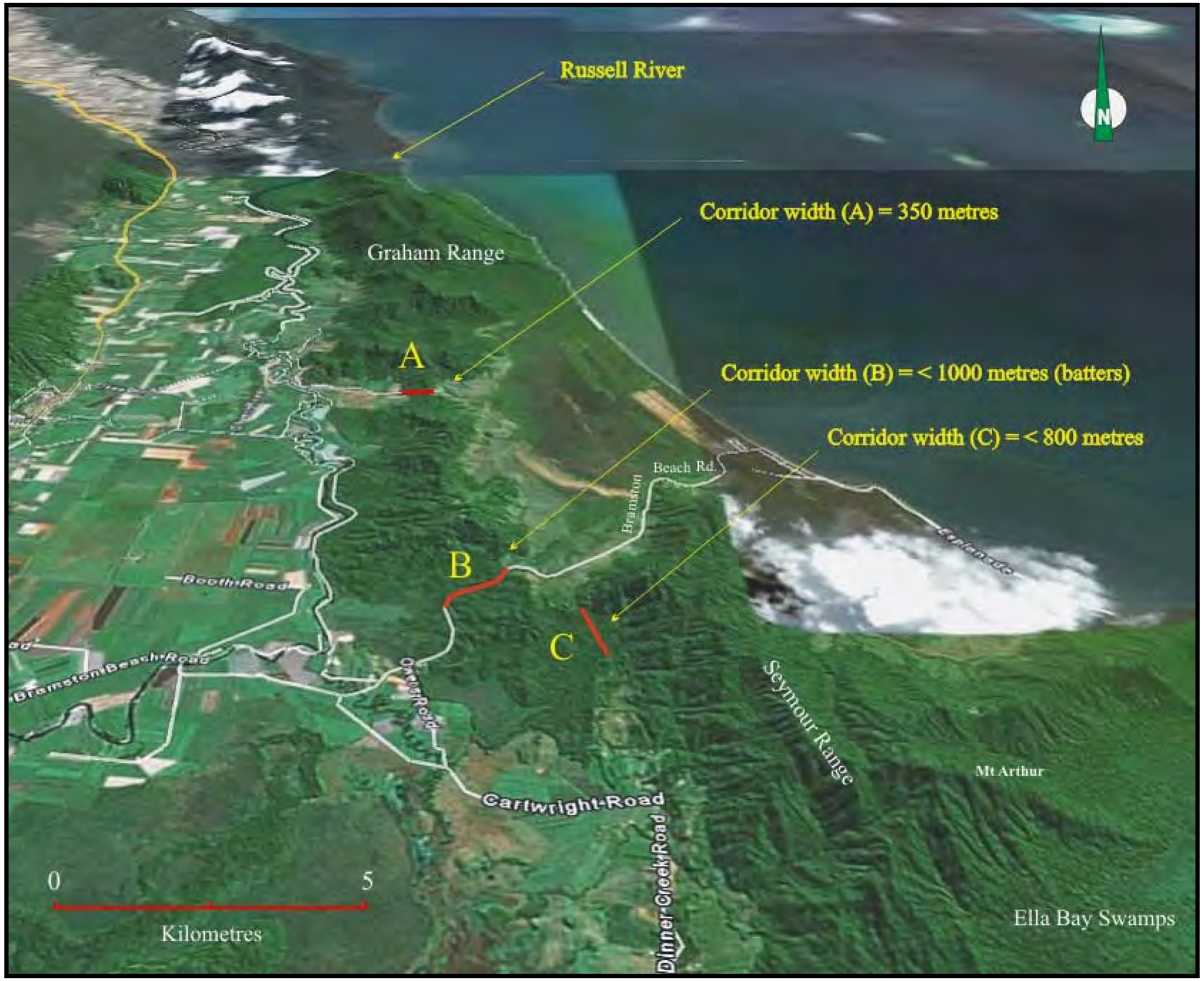
Corridor A = habitat bisected by the Buttigieg Access Road (<350 metres);

Corridor B = habitat bisected by the Bramston Beach Road (<1200 metres);

Corridor C = steep degraded hillside (<800 metres).

Figure 19

Cassowary 'at risk' movement corridors



As PVA deals with populations of animals or plants, it is not valid to subject only those birds identified in and surrounding the Ella Bay Property to a PVA, as they interact with, and are influenced by, the remainder of the Seymour Range cassowary population. Further, it is necessary to include Graham Range to the north in the population analyses, as the birds in this area constitute a functional part of the population. Therefore, the greater study area (located within the yellow rectangle), is bounded in the north by Russell River and to the south by the Johnstone River, and comprises both Graham Range and Seymour Range. While the local cassowary population potentially impacted by the EBIR i.e. Seymour Range, is located within the red rectangle (Figure 20).

11. METHODOLOGY

11.1 SIZE OF GRAHAM-SEYMOUR RANGE CASSOWARY POPULATION

Based on the approximate area of available habitat and using the population density measurements determined for the nearby Mission Beach population (Moore, 2003, 2007a) the estimated maximum population size of adult and independent cassowaries has been calculated for the Graham Range and Seymour Range populations (Table 7). The figures within brackets represent the minimum and maximum ranges for each calculation.

FIGURE 20

GRAHAM –SEYMOUR RANGE STUDY AREA

TABLE 7

ESTIMATED POPULATION SIZES

Cassowary Population	Approx area (km^2)	Estimated No. Adults[1] (min-max)	Estimated Total Population[2]	K (carrying capacity)	Comments
Graham-Seymour Range	93	38 (*31-45*)	61 (*51-73*)	73	Reduced carrying capacity due to steep terrain (25%) and *Acacia* spp. dominated mesophyll vine forest. Population density similar to Mission Beach. Probable cyclone refuge area. Northern end of Graham Range is severely disturbed.
Graham Range	42	17 (*14-20*)	27 (*23-33*)	33	
Seymour Range	51	21 (*17-25*)	34 (*28-40*)	40	

[1] Moore 2003, 2007a; [2] Adults and subadults i.e., independent birds

11.2 THE PVA SIMULATION PACKAGE

Version 9.72 of the VORTEX simulation software package (Lacy, 1993) was used to assess the viability of the Graham-Seymour Range subpopulation. VORTEX is an *individual-based* model i.e., it creates a representation of each animal in its memory and follows the fate of the animal through each year of its lifetime (Lacy 1993). It keeps track of the sex, age, and parentage of each animal, modelling demographic events (birth, sex determination, mating, dispersal and death) by determining whether any of the events occur for each animal in each year of the simulation. Events occur according to a Monte Carlo simulation of the effects of deterministic forces, as well as demographic, environmental, and genetic stochastic (chance) events on wild populations (Miller and Lacy 1999).

It is important to understand that VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters used as input to the model, and because of the random processes involved in nature. Interpretation of the output depends upon knowledge of the biology of the southern cassowary, the environmental conditions affecting the species, and possible future changes in these conditions (Noon et al 1999). For a more detailed explanation of VORTEX and its use in population viability analysis, refer to Lacy (2000) and Miller and Lacy (2003).

11.3 INPUT PARAMETERS FOR PVA MODELS

Input parameters for the PVA modelling are summarised in Table 8, with background explanation for all parameters provided in Appendix C.

TABLE 8

BASELINE PVA INPUT PARAMETERS

Model parameter	Data	Comments
Iterations	1000	
Years of population projection	100	
Mating system	Polygynous	Both male and females have multiple partners.
Age of first reproduction	4 years	Adult plumage is attained at approximately 4 years and birds are capable of breeding age in their fifth year.
Reproductive senescence	35 years	A conservative model using 35 years as the age of last breeding was selected.
Max. no. young	5	Offspring as percentage occurrence: 1 = 5% 3 = 40% 5 = 5% 2 = 20% 4 = 30%
Male breeding pool % (= Female parameter in Vortex)	33	This parameter has been modified to reflect the reversed sex roles in cassowaries (Lacy pers. comm. 2002). Male breeding numbers were calculated as follows: • 33% = breeding once in three years
Female breeding pool % (= Male parameter in Vortex)	100	As they have no commitment to parental responsibilities, it has been assumed that all adult females are available for breeding in a given year.
Mortality	Table 9	All models are based on age-specific mortalities using 'Low' or 'Moderate' mortality rates (Table 4: *sensu* Moore 2007c).
Initial population size	N	Based on overall density of independent birds i.e. adults and subadults was 0.78 birds/km^2 reduced by 25% (Table 8).
Carrying capacity (K)	N	The carrying capacity (K) is calculated as maximum density of independent birds i.e., 0.78 birds/km^2 (Moore 2007a).
Catastrophes	2	Two major parameters were modelled: <u>Catastrophe 1</u>: 5 % - Reproduction 0.05, Survival 0.65. <u>Catastrophe 2</u>: 3 % - Reproduction 0.50, Survival 90.
Genetic drift and in-breeding	No	Not included as uncertainty as to the exact role this would play in a long-lived species within a short timeframe.
Immigration/Supplementation	No	
Definition of extinction	Absence of one sex	

The input parameters of mortality rates and catastrophes are described separately and in more detail, as they are the foundation of the models analysed in this study.

11.3.1 Iterations and years of population projection

All models were simulated 1000 times over a 100 year projection period. Output results were summarised at 10 year intervals for use in the tables and figures that follow. All simulations were conducted using VORTEX version 9.72 (Miller and Lacy 2007).

11.3.2 Mortality rates

Although data suggest there may be differential mortality by sex, all models are based on age-specific mortalities which presume the same mortality rates for both sexes. Due to a lack of data on age-specific mortality rates in wild populations of cassowaries, the annual mortality figures used in the simulations are broad estimates reflecting a range of potential mortality rates. In a population viability study of the cassowary subpopulation of Mission Beach (Moore 2003, 2007b, 2007c), four models were developed in which mortality rates were designated as 'Low' , 'Moderate', 'High' and 'Study'. These are shown in Table 9 and described below.

'Low' mortality

It was concluded from past studies (Bentrupperbaumer 1998, Moore 2003, 2007a, Moore and Moore 2007b) that 'Low' mortality rates were ecologically unrealistic for Mission Beach, and for the majority of the coastal cassowary subpopulations (Moore and Moore 2007b. As such, the results of 'Low' mortality models in this study are better viewed as a theoretical benchmark with which to evaluate changes in the models, or as a desired management target.

'Moderate' mortality

'Moderate' mortality rates are based on a study of long-lived marine animals (Musick 1999), which concluded that k-selected groups with annual increase rates less than 10% were at particular risk of extinction. As such, 'Moderate' mortality rates were formulated to attain an annual recruitment of at least 10% (*sensu* Musick 1999) i.e., borderline reproductive success. In this way, small changes in the values of input parameters should reflect corresponding changes in cassowary population dynamics.

'High' and 'Study' mortality

'High' mortality rates were constructed to reflect the perceived high level of adult cassowary death at Mission Beach. An additional mortality estimate calculated by Moore (2003) i.e., 'Study', was based on data from previous studies (Bentrupperbäumer 1998; Crome and Moore 1990; Moore 1998, 1999, 2003, 2007a, 2007c) and was considered to most closely represent the true field situation at Mission Beach. This excessive mortality is due to the anthropogenic impacts associated with extensive urban development and high-use roads located within and adjoining cassowary habitat at Mission Beach. As 'High' and 'Study' mortality rates are currently not appropriate for the relatively undeveloped Graham-Seymour Range area area, 'Low' and 'Moderate' mortality rates have been used in this study.

The mortality columns in Table 9 comprise an estimated percentage mortality rate followed by a standard deviation (SD) due to estimated environmental variability e.g., 50 *(10)*. To assist in evaluating the likelihood of each set of mortality rates, the predicted offspring survival to adulthood resulting from each mortality model (i.e., recruitment), is given at the bottom of the table (Offspring Survival). The BLUE columns show the age-structured mortality rates used in these analyses.

TABLE 9

Percentage Mortality Rates (Percent/SD)

Age Class (yrs)	**STUDY (Moore 2003, 2007c)**	**% Mortality (± SD)**		
		High	**Moderate**	**Low**
0 - 1	70 *(10)*	75 *(10)*	**60 *(10)***	**50 *(10)***
1 – 2	50 *(10)*	60 *(10)*	**40 *(10)***	**40 *(10)***
2 - 3	40 *(10)*	40 *(10)*	**40 *(10)***	**30 *(10)***
3 – 4	30 *(10)*	30 *(10)*	**30 *(10)***	**20 *(7.5)***
Adults	4 (*1.5)*	7 *(3)*	**5 *(2)***	**3 *(1)***
Offspring Survival (Recruitment)	**6.3%**	**4.2%**	**10.0%**	**16.8%**

[1] Moore (2007c).

11.3.3 Natural catastrophes

In this study, environmental variability is incorporated as the standard deviation in mortality rates and the influence of catastrophic events. Located in tropical eastern Australia, Graham-Seymour Range is subject to severe climatic events such as cyclones, with heavy rains and strong winds (e.g., Cyclone Winifred in 1986, Cyclone Larry in 2006). In addition, "droughts" of lower than expected rainfall can occur, which reduce the amount of rainforest fruit and restrict the availability of water. Although rainfall figures can help identify drier cycles, an accurate measurement of the impacts of cyclones or other natural disasters on rare and endangered species is difficult to obtain. However, a comprehensive field survey at nearby Mission Beach prior to Cyclone Larry (Moore 2003, 2007a), had established that 110 cassowaries existed within the 102 km^2 study area, comprising 31 juveniles (28.8%), 28 subadults (27.3%), and 49 adults (43.9%). Using records of cassowary deaths and injuries kept by Queensland Parks and Wildlife Service (QPWS) following Cyclone Larry, it was estimated that approximately 35% of the known adult and subadult population died at Mission Beach as a result of the cyclone (Moore and Moore 2007b). Most dependent young i.e., juveniles, are believed to have died during or immediately following the cyclone. Using the 2006 cyclone mortality figures as representative of the Graham-Seymour Range population, two major catastrophes were included in all scenarios:

Catastrophe 1: 5% - Reproduction 0.05, Survival 0.65 (severe cyclones simulated as a 1:20 year event). This scenario results in a loss of 95% reproductive capacity and a 35% increase in mortality across all age classes.

Catastrophe 2: 3% - Reproduction 0.50, Survival 0.90 (severe drought or poor fruiting event simulated as a 1:33 years event). This scenario results in a loss of 50% of reproductive capacity and a 10% increase in mortality across all age classes.

11.4 MODELLED SCENARIOS

Three scenarios were modelled to explore the potential impact of the Ella Bay Integrated Resort (Table 10).

TABLE 10

PVA models – Graham-Seymour Range Cassowaries

Model	Scenario
1	PVA of the Graham Range and Seymour Range as a connected population i.e., dispersal between areas. To evaluate the viability of the connected population, the simulations were run with both 'Low' and 'Moderate' Mortality rates (Table 9).
2	PVA of Graham Range and Seymour Range as isolated populations i.e., connectivity lost and no dispersal between areas. Mortality rate is categorised as 'Low' (Table 9) i.e., no change in levels of threats.
3	PVA of Seymour Range as an isolated population i.e., connectivity lost and no dispersal between Graham and Seymour Ranges, and with an increased level of anthropogenic threats i.e., 'Moderate' mortality. Moore and Moore (2007b) concluded that the Graham-Seymour Range was currently experiencing this higher level of threat.

Although not specifically modelled for the Graham Range and Seymour Range populations in this study, the potential impacts of climate change on the coastal cassowary metapopulation were explored by Moore and Moore (2007b). Those findings are discussed in Section 13.1.

Model 1: Graham Range and Seymour Range as a connected population

Model 1 - 'Low' mortality

Graham Range and Seymour Range are currently connected by cassowary movement corridors, enabling birds to move freely within the entire area. In this analysis, therefore, the cassowary population is modelled as a single population. The results were then compared to Model 2 to evaluate the effect on the population of losing connectivity between the two areas. The model was first run with 'Low' mortality, representing the 'best-case' scenario of sufficient population recruitment and no significant habitat loss. As these conditions are not met for the Graham-Seymour Range population (loc. cit.), this scenario is considered in all models as a best-case scenario or desired management target, rather than an existing circumstance.

Model 1 - 'Moderate' mortality

A second scenario, 'Moderate' mortality, was then modelled to reflect the current level of population decline identified by Moore and Moore (2007b). That study and its implications for coastal cassowary persistence are discussed further in Section 13.

Model 2: Graham Range and Seymour Range as isolated populations

This model treats both populations i.e., Graham Range and Seymour Range, as two isolated populations with no opportunities for dispersal. Connectivity between the two range populations currently relies on three narrow movement corridors, all of which are compromised by different threat types (Section 10.3.1). This model looks at the capacity of each smaller population to survive in the event of a permanent loss of connectivity i.e., no dispersal between areas. As we are looking at the potential viability of a reduced population size only, this model has been simulated with 'Low' mortality rates (Table 9) i.e., lowest level of anthropogenic threats.

Model 3: Isolated Seymour Range with increased threatening processes

Due to the fragmented and isolated character of the coastal cassowary subpopulations, climatic, stochastic (chance) and anthropogenic impacts are the primary drivers of current population decline (loc. cit.). It is necessary, therefore, to determine the viability of the Seymour Range cassowary population under the current threat level i.e., 'Moderate' mortality, before assessing the potential contribution made by either of the two landuse options at Ella Bay. The impact of both landuse options can then be evaluated within the context of the cassowary population dynamics that will occur regardless of any direct or indirect impacts resulting from the intensification of development at the southern end of Seymour Range.

12. RESULTS

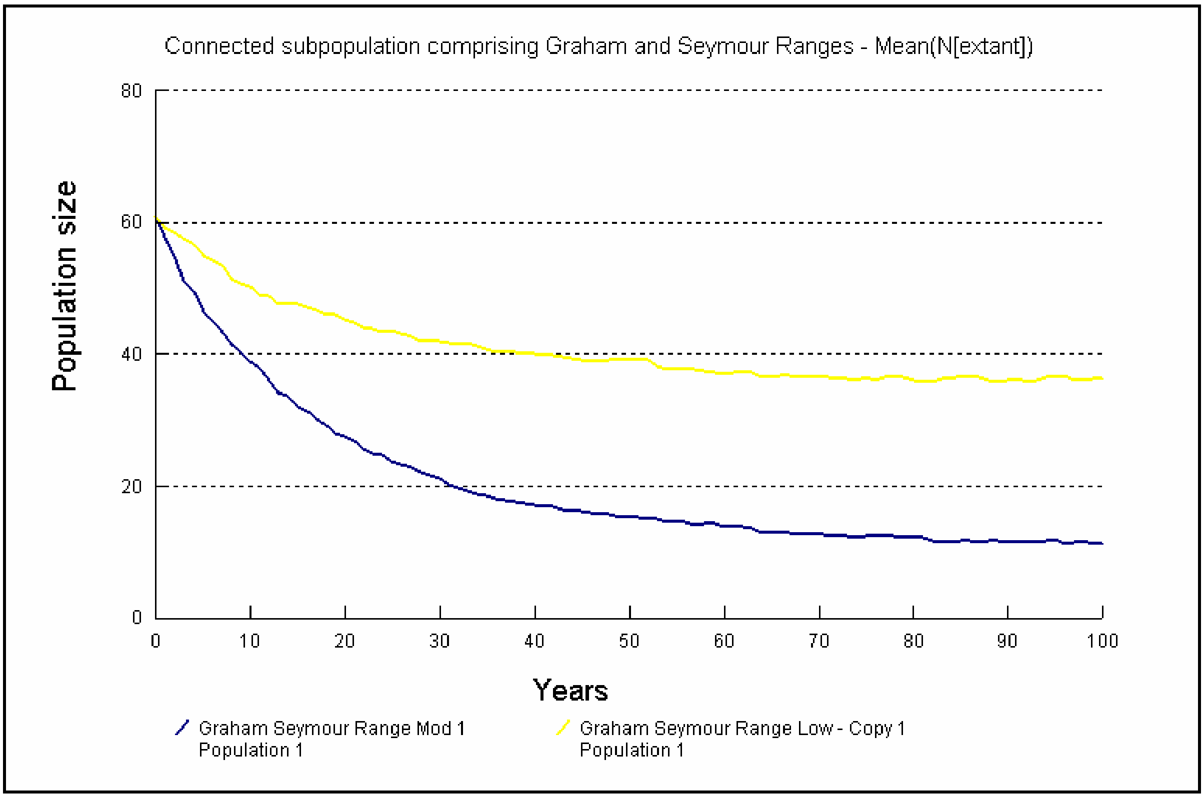
12.1 MODEL 1: GRAHAM RANGE AND SEYMOUR RANGE AS A CONNECTED POPULATION

Low mortality rates

Although mean deterministic growth remains positive over the 100 year simulation i.e., det.r = 0.012, this model indicates the Graham-Seymour Range subpopulation is already in decline. Under 'Low' mortality rates, population size is predicted to decrease by 41% i.e., a loss of 25 birds (Figure 21). Although this represents a significant decline, however, the connected subpopulation is still extant at the end of the 100-year projection period. While the probability of extinction (PE) of 0.17 is relatively low (Figure 22), Figure 23 demonstrates the stochastic variability inherent in all small animal populations. Due to the low PE, the predicted median time to extinction (MTE) has not been generated by Vortex.

Figure 21

Mean Number Extant of Connected Subpopulation – 'Low' and 'Moderate' Mortality



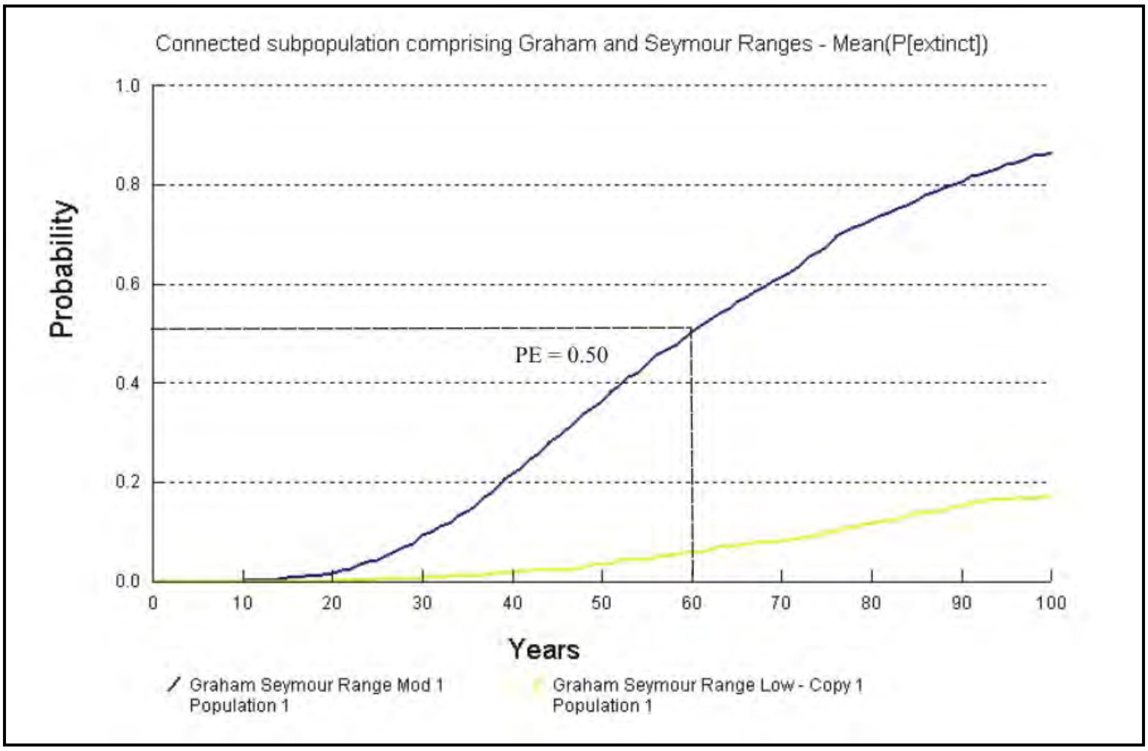
Moderate mortality rates

Under 'Moderate' mortality rates, deterministic and stochastic growth rates are strongly negative i.e., r_d = -0.036 and r_s = -0.040. As the deterministic growth rate (r_d) is negative, the connected population is considered to be in deterministic decline i.e., the number of deaths exceeds the number of births and the subpopulation will become extinct even in the absence of stochastic fluctuations (Miller and Lacy 1999)[1].

The combined negative growth rates culminate in a probability of extinction (PE) of 0.86 (Figure 22), approximately five times that of 'Low' mortality at 0.17. PE exceeds 0.50 at 60 years and population size is predicted to decrease by 82% i.e., a loss of 50 birds (Figure 21), Figure 23 shows the striking influence of stochastic growth rate on the subpopulation when the level of anthropogenic threats is increased in Model 2 ('Moderate' mortality). The predicted median time to extinction (MTE) at 'Moderate' mortality is 62 years.

Figure 22

Probability of Extinction for Connected Subpopulation – 'Moderate' mortality

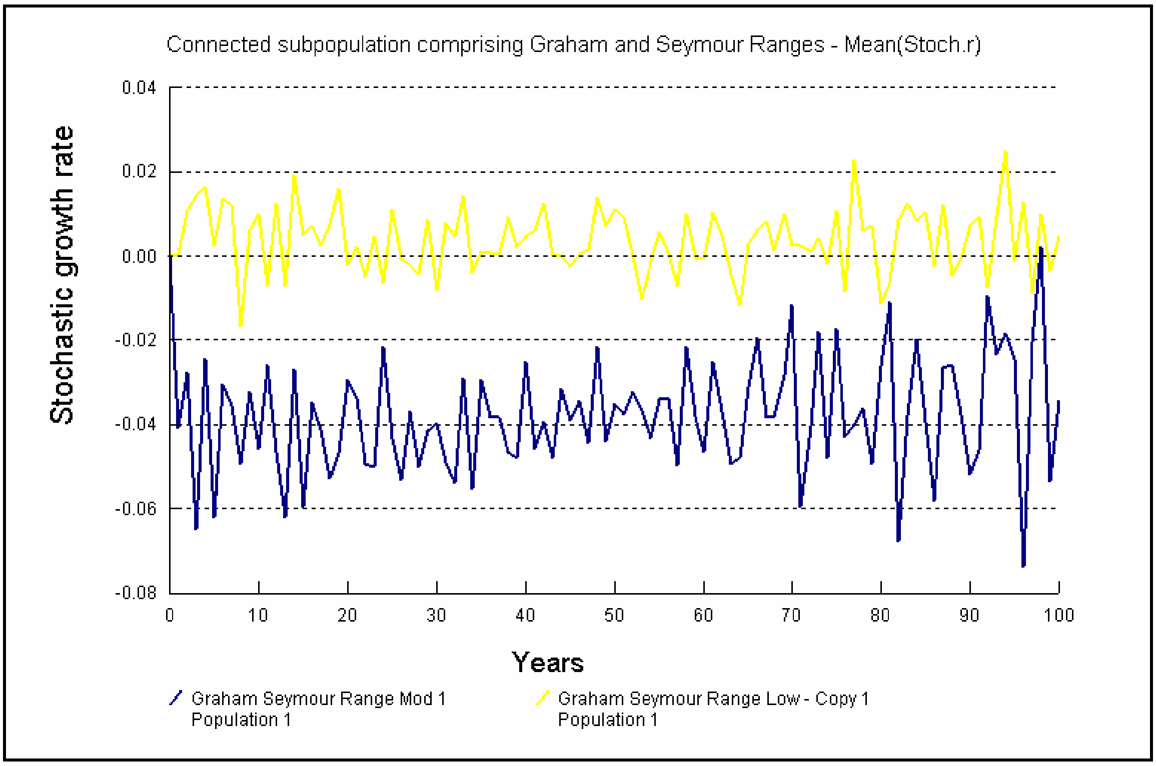


---

1 Positive values indicate population growth, while negative values indicate population decline. A population with $r_d<0$ is in deterministic decline (deaths >births) and will go extinct. The difference between the deterministic population growth rate (r_d) and the stochastic population growth rate (s_d) resulting from simulations can give an indication of the impact of stochastic factors on population persistence.

Figure 23

Mean Stochastic Growth Rate of Connected Subpopulation



12.1.1 Model 1 - Summary

The model indicates there is a high probability the connected cassowary population of Graham-Seymour Range may become extinct within the 100-year projection period, or survive as a non-viable population whose persistence is due to the extended longevity of the species (>40 years). The PVA shows the connected population is already declining, even under 'Low' mortality rates, with a predicted loss of 41% of its cassowary population within 100 years. Unfortunately, this population is currently experiencing 'Moderate' mortality (Moore and Moore 2007b). At 'Moderate' mortality both deterministic and stochastic growth rates are strongly negative, resulting in a severe deterministic decline. Reflecting this negative growth, population size decreases by 82% over the 100 years population projection and, as the population decreases in size, the dominating influence of stochastic events increases and the extinction spiral is firmly in place.

12.2 MODEL 2: GRAHAM RANGE AND SEYMOUR RANGE AS ISOLATED POPULATIONS – 'LOW' MORTALITY

This model shows the two halves of the subpopulation will experience great instability and rapid population loss if isolated from each other, even when the mortality rate is 'Low'. Total size of the two isolated populations is predicted to decrease by 33 birds i.e., a decline of 54%, compared with a decline of 41% if the two populations remained connected (Figure 24). The most marked effect of isolating the two populations, however, is the large increase in the probability of extinction, which rises from 0.17 when the two populations are connected, to 0.77 (Graham Range) and 0.54 (Seymour Range) when isolated (Figure 25). PE exceeds 0.50 at 55 years (Graham Range) and 92 years (Seymour Range) with mean times to extinction of 46 years and 56 years respectively.

Figure 24

Comparison of Mean Number Extant – 'Low' mortality

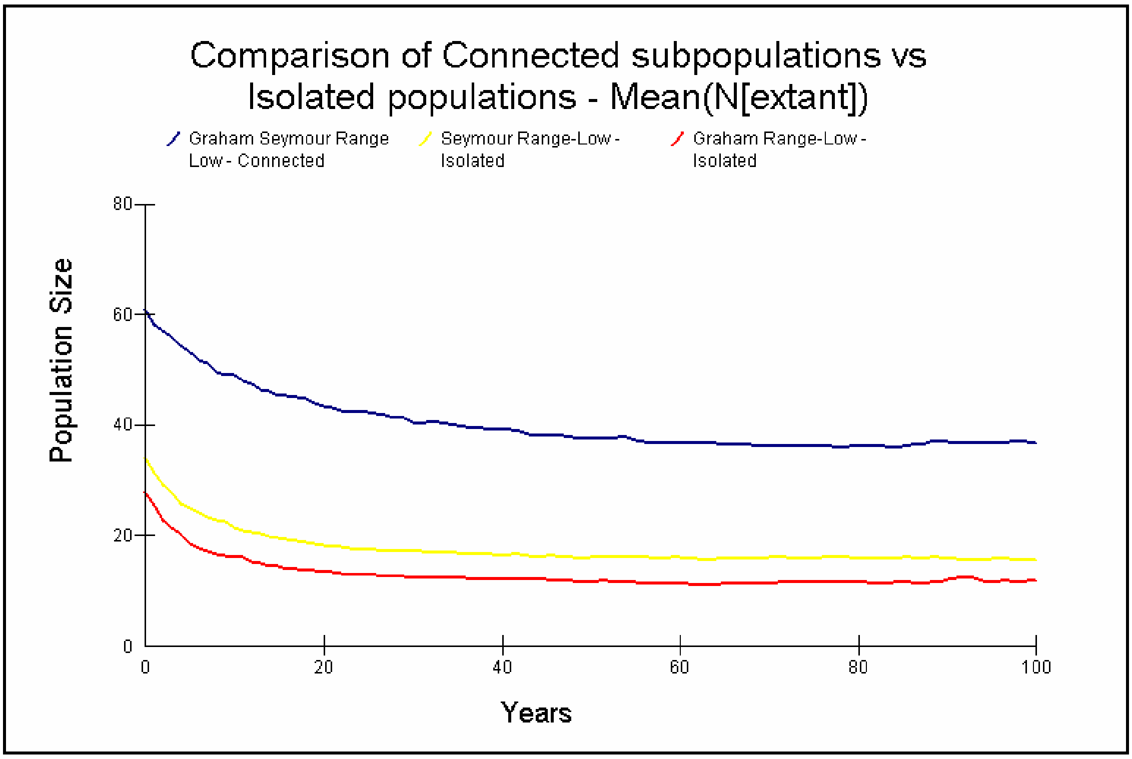
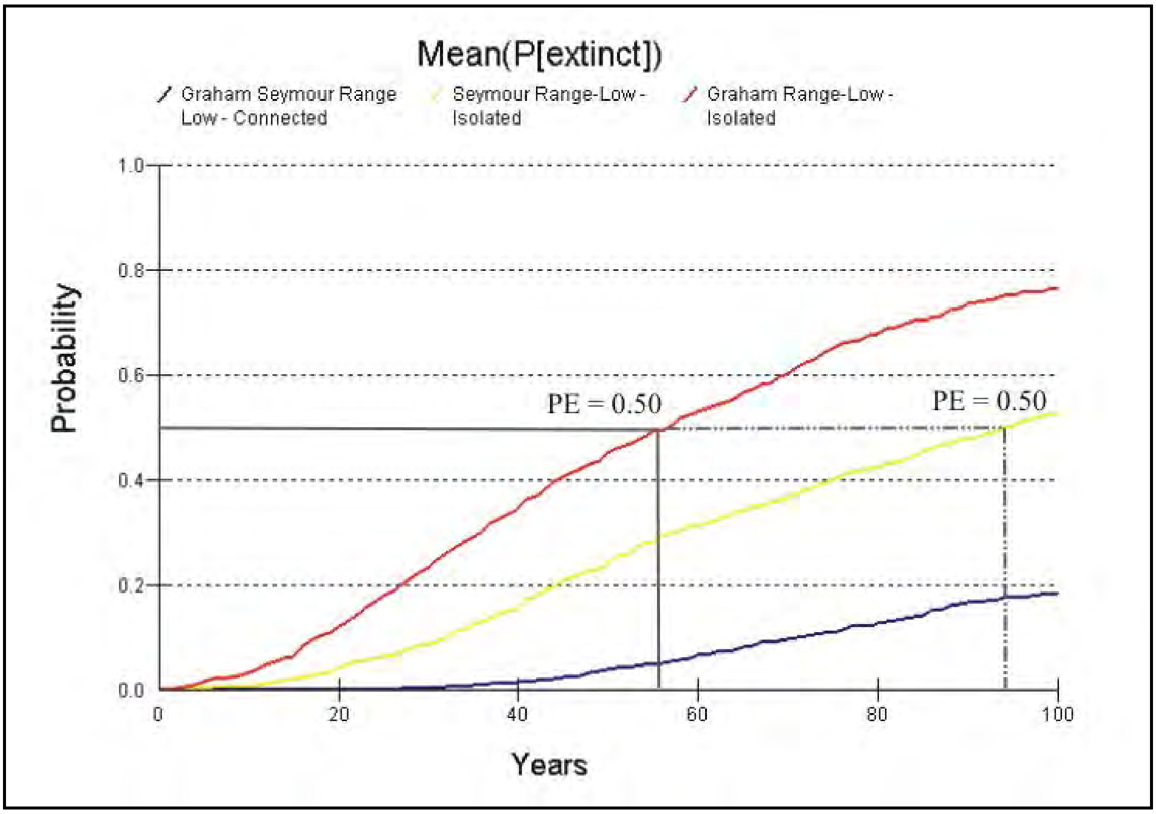


Figure 25

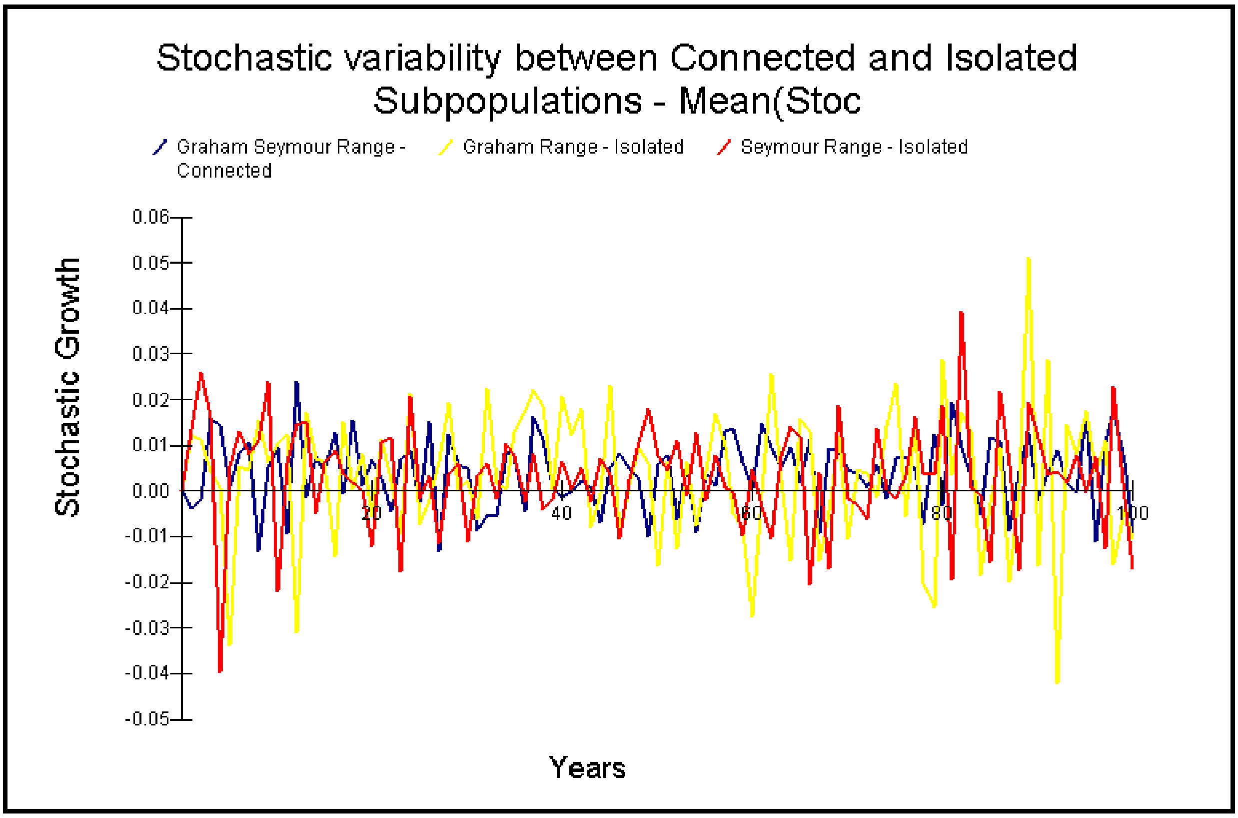
Comparison of Mean PE for Connected vs Isolated Populations



Population instability increases dramatically when the two populations are isolated from each other (Figure 26). The BLUE line on the graph represents the stochastic growth pattern when the two populations are functioning as a connected population. Although variable, it can be seen that growth predominantly oscillates around the neutral growth boundary (i.e., 0.00 growth rate). In contrast, the RED and YELLOW lines, which represent the two cassowary populations of Graham Range and Seymour Range when isolated, fluctuate widely, particularly in the case of the smaller Graham Range population. This deviation illustrates the theory that extinction may occur as a consequence of low population size.

Figure 26

Stochastic variability between Connected and Isolated Populations



12.2.1 Model 2 – Summary

Predictably, even under 'Low' mortality rates, the two isolated populations are extremely vulnerable to the effects of natural catastrophes such as severe cyclones. This is clearly demonstrated by the large spikes of stochastic variation indicative of small populations in trouble. As two small isolated populations, there is approximately 13% greater loss of cassowaries than if the two populations were functioning as a single connected population. In addition, the risk of extinction (PE) increases four-fold with the predicted mean time to extinction (MTE) dropping to 46 years. It is apparent that the isolated populations are significantly influenced by a smaller habitat area, which naturally results in small population ceilings, and the subsequent vulnerability of small cassowary populations to chance events. If connectivity is permanently lost, therefore, environmental stochasticity in the form of continued habitat degradation, variable fruiting regimes, and natural catastrophes such as severe cyclones, will dominate the population dynamics of the two small populations.

12.3 MODEL 3: SEYMOUR RANGE POPULATION WITH 'MODERATE MORTALITY (CURRENT LEVEL OF THREATENING PROCESSES)

Under 'Moderate' mortality rates, deterministic and stochastic growth rates are strongly negative i.e., $r_d = -0.036$ and $r_s = -0.039$. As the deterministic growth rate (r_d) is negative, the isolated Seymour Range population is considered to be in deterministic decline i.e., the number of deaths exceeds the number of births. Population size is predicted to decrease by 77% i.e., a loss of 26 birds (Figure 27) over the 100 years population projection and the combined negative growth rates culminate in a probability of extinction (PE) of 0.97 (Figure 28), approximately twice that of 'Low' mortality which is 0.54. PE exceeds 0.50 at 38 years. Figure 29 shows the influential role exerted by stochastic events at this higher mortality rate, resulting in a reduction in mean time to extinction from 92 years at 'Low' mortality, to 42 years at 'Moderate' mortality.

Figure 27

Comparison of Mean Number Extant – Isolated Seymour Range

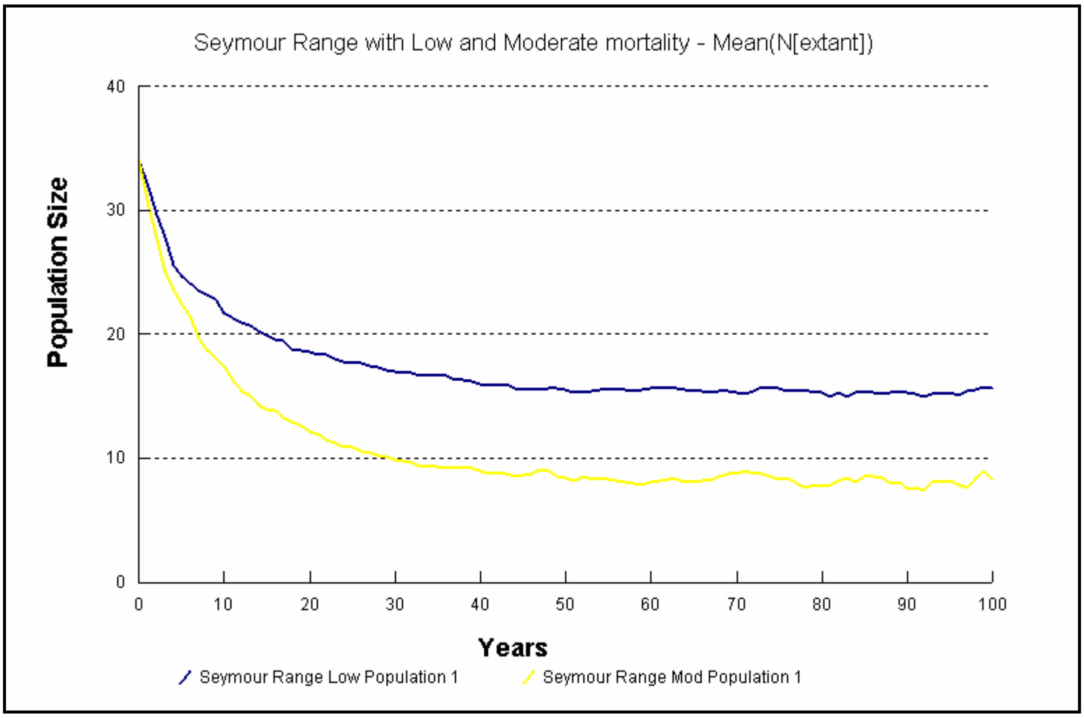


Figure 28

Comparison of Mean Probability of Extinction - Isolated Seymour Range

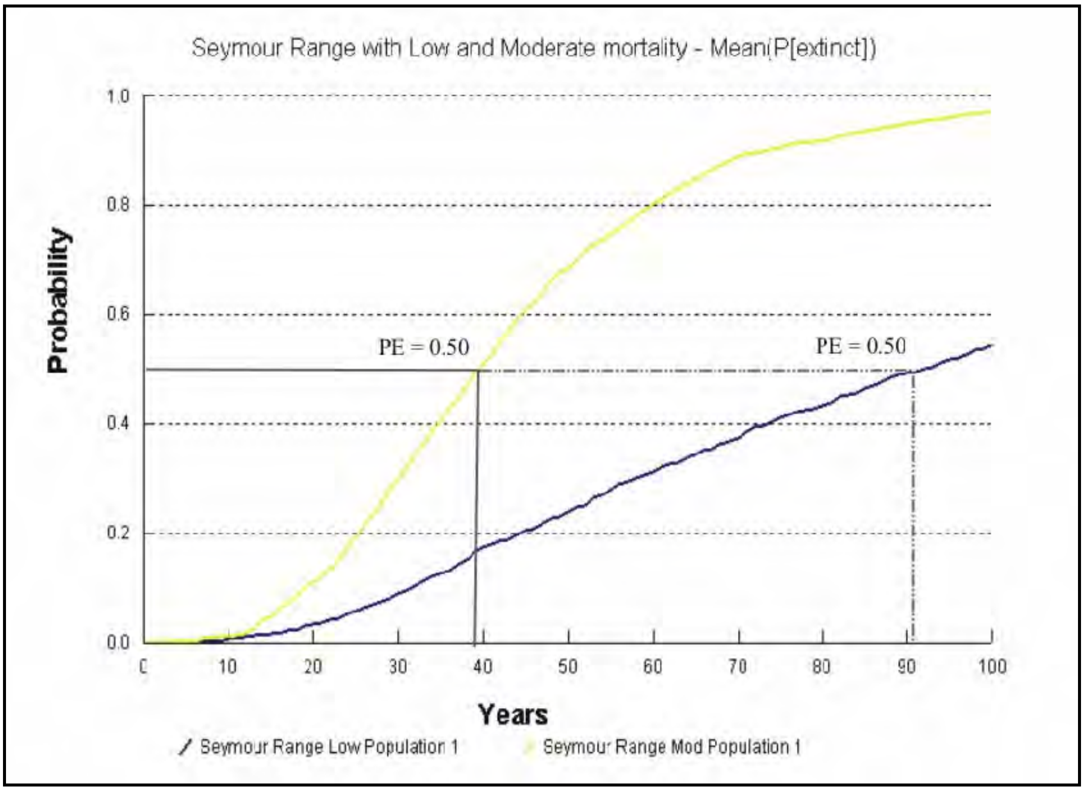
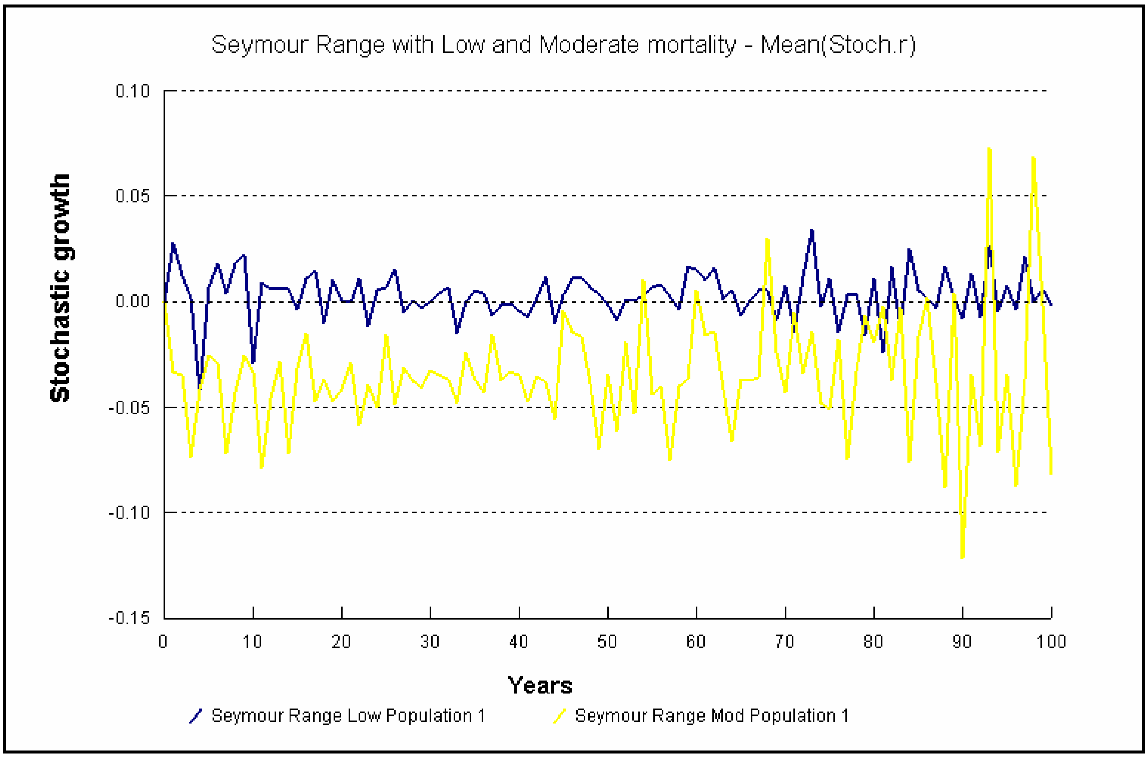


Figure 29

Comparison of Mean Stochastic Growth Rate - Isolated Seymour Range



12.3.1 Model 3 – Summary

With an estimated probability of extinction of 0.97, this model concludes that the disappearance of the isolated cassowary population of Seymour Range is certain at 'Moderate' mortality, possibly occurring in less than 50 years (mean time to extinction of 42 years).

12.4 SUMMARY OF ALL MODELS

Model 1 shows that deterministic and stochastic processes are forcing the connected population of Graham-Seymour Range into an extinction spiral. In a study on grizzly bear population dynamics Shaffer (1981), showed that populations in the size range of 50 to 100 animals would have difficulty surviving the joint action of these forces for more than a century. This PVA has shown Shaffer's findings also apply to small cassowary populations.

In the absence of future dispersal between the two currently connected coastal populations of Graham Range and Seymour Range, all PVA models indicate there is a high probability that both populations will die out within 60 years. However, if the levels of threat can be reduced to 'Low' and connectivity between the two protected and enhanced, the connected cassowary population should still be extant in 100 years, albeit with its population reduced to approximately 57% of the current estimated size (Figure 30). The predicted mean probability of survival over the 100 years for all models is shown in Figure 31.

Figure 30

Mean Number Extant - Summary of all PVA Models

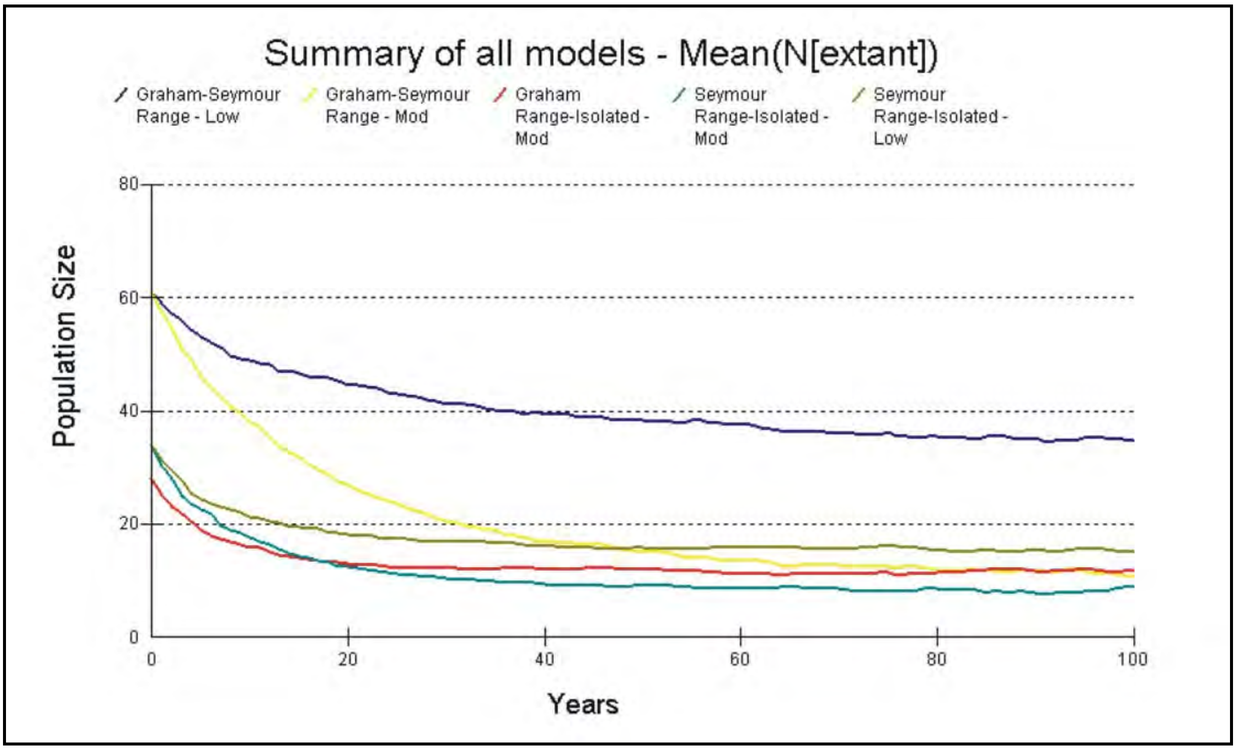


Figure 31

Mean Probability of Survival - Summary of all PVA Models

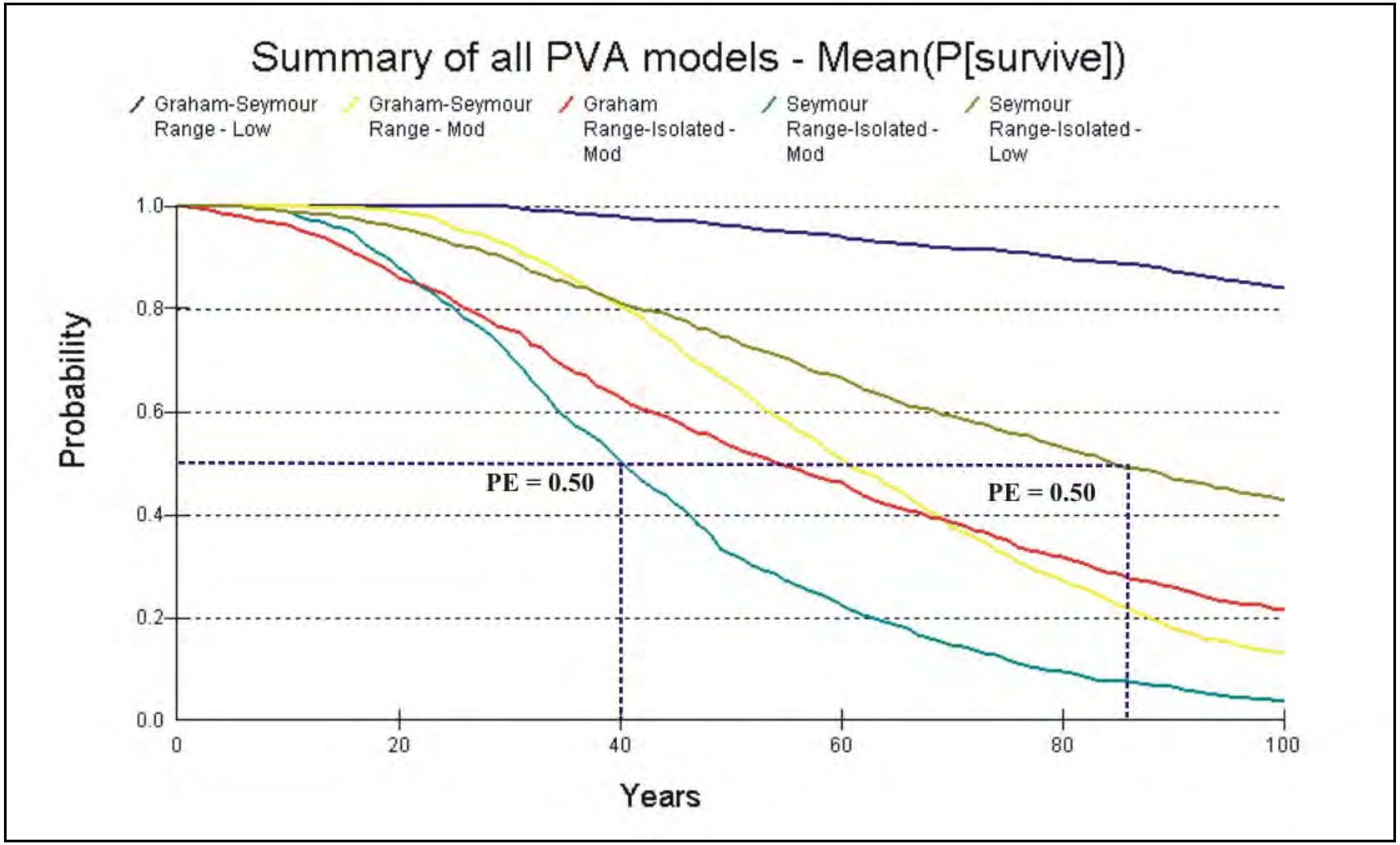


Table 11

Summary of PVA results

Population	Est. population (Ind. birds)	K	Mortality Rates	Det.r	Stoch.r	PE	Mean(N) Extant	MTE (Yrs)	Mean TE (Yrs)	Pop'n Loss (%)
Connected population (Seymour-Graham Range)	61	73	Low	0.012	0.004	0.17	36	0	68	41.0
			Moderate	-0.036	-0.040	0.86	11	62	57	82.0
Isolated - Graham Range	27	33	Low	0.012	0.003	0.77	12	55	46	57.0
Isolated – Seymour Range	34	40	Low	0.012	0.003	0.54	16	92	56	53.0
			Moderate	-0.036	-0.039	0.97	8	40	42	77.0

- **K** = Carrying capacity
- **Det.r** = Deterministic growth rate. If "r" is negative then the population is in deterministic decline (deaths outpace births).
- **Stoch.r** = Stochastic growth rate. The difference between the det.r population growth and the stoch.r growth rate can give an indication of the importance of stochastic factors as threats to population viability.
- **PE** = The probability of population extinction. Determined by the proportion of simulated populations that became extinct during the model's 100 years time frame.
- **Mean (N)Extant** = Mean final size of those populations remaining extant after 100 years.
- **MTE** = Median predicted time to extinction for those populations becoming extinct during the simulations.
- **Mean TE** = The mean predicted time to extinction for those populations becoming extinct during the simulations.

13. OTHER IMPACTS OPERATING ON CASSOWARY POPULATION

13.1 CLIMATE CHANGE IMPACTS ON COASTAL CASSOWARIES

The potential impacts of climate change on the viability of the Wet Tropics coastal cassowary subpopulations must be factored into the ominous predictions of Model 1 under 'Moderate' mortality rates. Climate change is predicted to have a significant impact on montane tropical ecosystems due to their steep environmental gradients and the limited ability of specialised species to relocate to more climatically suitable elevations or latitudes (Still et al 1999 *in Williams 2006;* Shoo *et al* 2004; Williams 2006). On the wet tropics lowlands, however, there is uncertainty among researchers about both the direction and extent of change. Most agree that the main drivers of change in forest structure and species composition will relate to increased cyclonic disturbance and more prevalent and longer dry periods (Kursar, 1998; Borchet 1998; Boose et al 2004). However, while rainforest ecosystems as an aggregate are very sensitive to decreased rainfall, Hilbert et al (2001) predict an increase in the extent of lowland mesophyll vine forest communities (*sensu* Tracey and Webb 1975) in the wet tropics with warming, even if accompanied by a 10% decrease in annual rainfall. Despite this, the reality for the majority of the coastal lowlands of the southern wet tropics is that there is little available area into which forest can either expand or shift in response to climatic change, as the surrounding land matrix is highly modified.

The linear nature of the majority of the remaining coastal fragments makes them particularly exposed to edge effects. When habitat patches decrease in size through fragmentation, the populations inhabiting them become more vulnerable to adverse environmental conditions prevalent at the edges of the habitat patch (Akcakaya et al 1999). The sharp contrast between forest and the adjoining farmland significantly increases the impacts of edge disturbance, resulting in a highly reduced interior of undisturbed habitat. As a result, any increase in severity or frequency of cyclones due to climate change will exacerbate disturbance impacts in these linear lowland fragments, leading to changes in both tree species composition and structure of lowland forests. It is probable that such changes will reduce habitat quality and thus, carrying capacity, for specialist fauna species dependent on high quality rainforest habitat. The cassowary is one such species.

The effects of predicted climate change scenarios on the metapopulation comprising the eight coastal cassowary subpopulations south of Cairns, were explored by Moore and Moore (2007b). In that study, the following scenarios were simulated to represent the loss or decline in the quality of cassowary habitat as a consequence of climate change:

Scenario 1. No climate change incorporated and no change to K (carrying capacity) for any subpopulation;

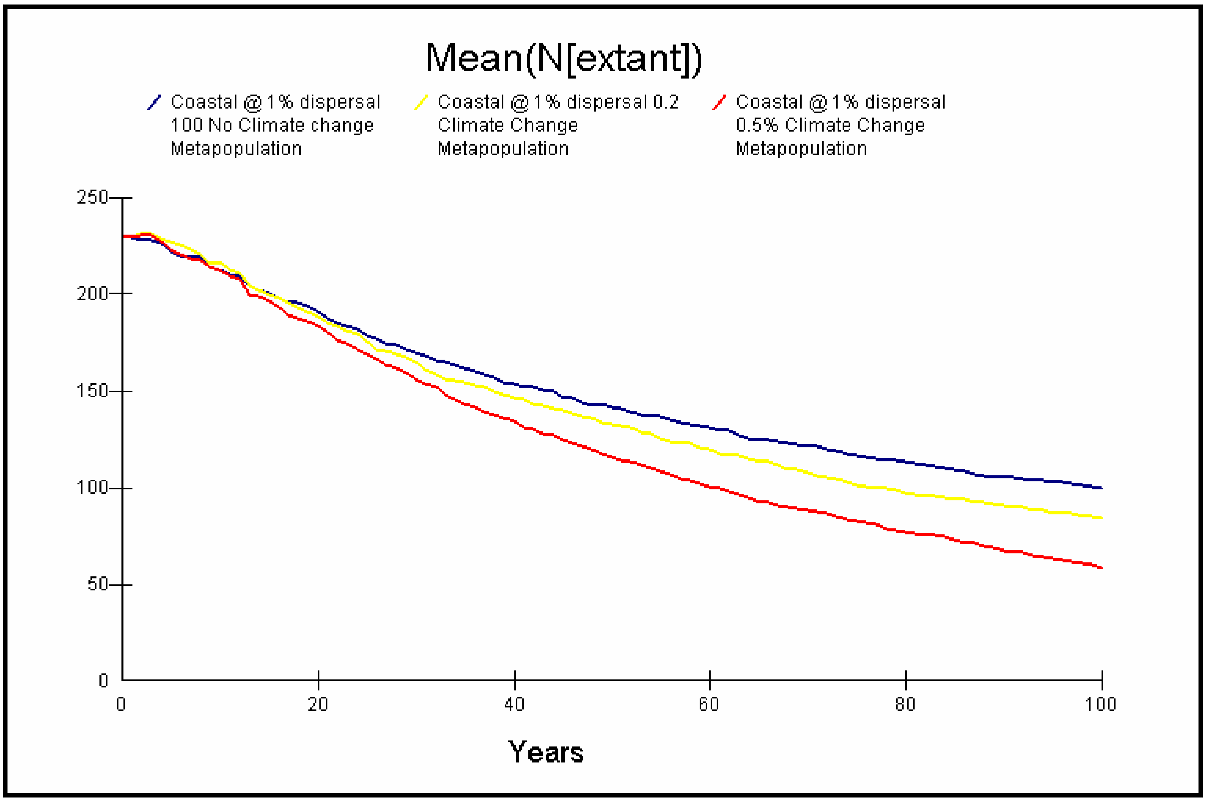
Scenario 2. 0.2% decrease in carrying capacity (K) per subpopulation per year i.e., 10% reduction in K over 50 years;

Scenario 3. 0.5% decrease in K per subpopulation per year i.e., 25% reduction in K over 50 years.

In the absence of climate change, the coastal cassowary metapopulation was predicted to decrease by 48% or 142 birds (Figure 32). However, decreases in carrying capacity of 0.2% and 0.5% per subpopulation per year due to climate change reduces the metapopulation by 69% and 79% respectively, i.e., a further 20-30% decrease in metapopulation size due to climate change.

FIGURE 32

Impact of climate change on the coastal cassowary metapopulation



13.2 OTHER IMPACTS OUTSIDE ELLA BAY INTEGRATED RESORT (EBIR)

The major processes influencing the rate of cassowary decline in the Graham-Seymour Range cassowary subpopulation are briefly discussed below.

Connectivity and Degradation

The PVA indicated that the major risk to the persistence of the Graham-Seymour Range cassowary subpopulation is the loss of connectivity between birds on the two ranges. This would create two small and non-viable populations with a greatly reduced persistence and a probability of extinction even at 'Low' mortality raised from 0.17 (connected populations), to 0.54 (Seymour Range) and 0.77 (Graham Range), once connection is lost.

Exacerbating the threat of connectivity loss is the degradation of much of the western side of the Graham Range. This reduction in the quality of cassowary habitat will certainly increase as coastal development and associated activities expand. The recurring cyclone damage to rainforest along this range has contributed by reducing both the available habitat and quality for cassowaries. The many weed-filled clearings are shifting the vegetation from rainforest to pioneering and secondary tree species, with limited food potential for cassowaries. Photographs of these impacts are provided in Appendix D.

Habitat loss

Cassowary habitat is still being cleared or modified by landowners on the Graham-Seymour Range, particularly along the western side of the Graham Range. Domestic stock, edge effects and weed infestations are contributing to this habitat loss and degradation. Photographs of these impacts are provided in Appendix B.

Roads and cassowaries

The threat of cassowary road death is greatest on the Bramston Beach Road where it crosses the Graham Range, and at the southern end of Seymour Range. Records from Mission Beach over 20 years (Moore 2003, 2007a, 2007c) indicate that road death accounts for >70% of all known cassowary mortality. As the Bramston Beach Road is similar in form to the high-speed roads which traverse cassowary habitat at Mission Beach (Appendix D), cassowary road death will increase as coastal development grows. To avoid duplicating the high number of cassowary road deaths that occur annually at Mission Beach, therefore, an effective cassowary road management strategy that includes traffic calming is essential to protect road-crossing cassowaries.

Dog attack

The incidence of dog attacks on cassowary in the Graham-Seymour Range is difficult to determine. The areas of Flying Fish Point and Ella Bay would appear to pose the greatest risk of attack, particularly as the human population increases. It has been estimated that dog attack in the more urbanised areas of Mission Beach is responsible for >22% of all known cassowary deaths (Moore 2003, 2007a, Moore and Moore 2007b).

Little Cove development

Although not part of the original Impact Assessment (Volume II), the approved subdivision of Little Cove impacts on the viability of the local Seymour Range cassowary population. The subdivision is located to the immediate south of the Ella Bay Property and in relatively close proximity to the eastern boundary of Ella Bay National Park. The Ella Bay Cassowary Survey (Volume I) showed that the area of the subdivision was used by cassowaries for foraging, and as a movement corridor to the foreshore of Little Cove.

13.3 RECOMMENDED MITIGATION ACTIONS TO CONTAIN POPULATION DECLINE

Mitigation strategies to reduce the potential direct and indirect impacts on the cassowary population living on and around the Ella Bay Property are presented in Volume II, and should be implemented as outlined. To these is added the following recommendations to mitigate existing development impacts on the Graham-Seymour Range cassowary population identified in this PVA:

1. A detailed cassowary management strategy for the Graham-Seymour Range coastal subpopulation should be developed, and its implementation supported by adequate funding. This management strategy should include:
   a. the maintenance and protection of the existing movement corridors linking the two range populations;
   b. the development and implementation of a cassowary road management strategy for the Bramston Beach Road;
   c. the implementation of an effective dog control program for the communities adjoining the Graham-Seymour Range. As council funding is limited for policing uncontrolled dogs, it may be necessary to request support from the developers for this action;
   d. as many of the indirect impacts outside of the EBIR are cumulative and thus cannot be avoided, appropriate land trade-offs and offsets should be explored.

14.0 REPORT SUMMARY

Determining the specific impacts on the isolated Seymour Range cassowary population from changing landuse options at Ella Bay is confounded by the population decline already in place. As a linear subpopulation which has lost all connectivity with the larger cassowary populations to the west, the Graham-Seymour Range population is currently experiencing high levels of anthropogenic impact, and declining rapidly as a result. Natural catastrophes in the form of severe cyclones and the environmental uncertainties of climate change, are hastening this decline. Regardless of the landuse choices made at Ella Bay, it is likely that the more localised of these impacts will be over-whelmed by the significant extinction vortex already in place. As such, trying to quantify the extent of the additional impact of either Ella Bay landuse options on the cassowary population is meaningless and thus, was not specifically modelled.

It is recognised, however, that the anthropogenic impacts associated with the Ella Bay Integrated Resort e.g., increased human population, road upgrades, increased traffic, and the increased presence of domestic dogs, are cumulative impacts on an already declining cassowary population. As such, any approval for the EBIR development to proceed may provide an opportunity for offsets to address the connectivity issues that are contributing to the population decline, as well as strategic land purchase, and scientific studies aimed at conserving the species in the Graham-Seymour Range and elsewhere along the Wet Tropics coast.

14.1. CAVEAT

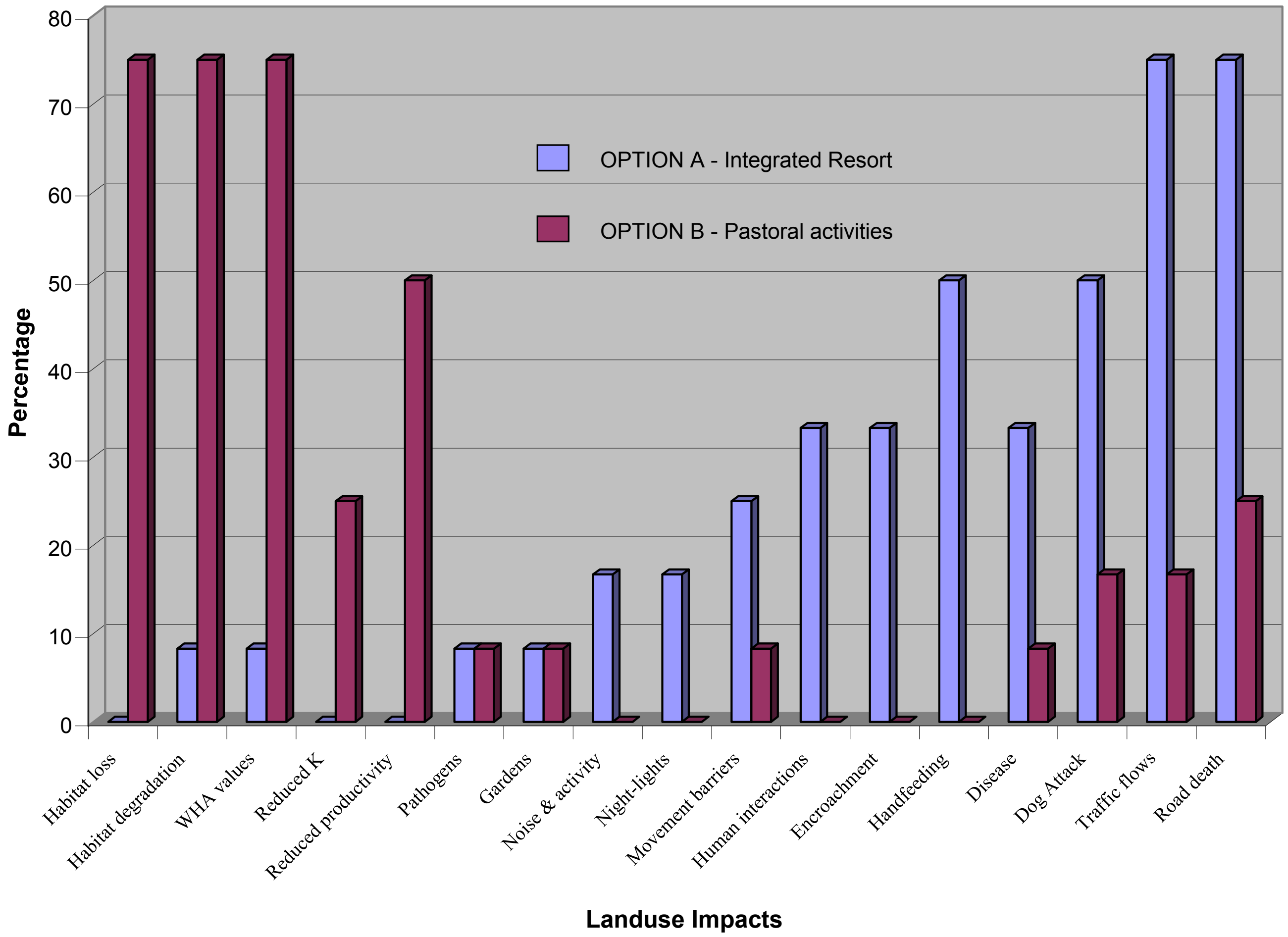
This report on the impacts of the Ella Bay Integrated Resort development on the endangered cassowary comprises three volumes:

1. Volume I – Cassowary field survey.
2. Volume II – Impacts and mitigation.
3. Volume III – Population viability analysis.

As such, it represents a consistent and coherent treatment of the potential impacts and outcomes on the local cassowary population of changing the landuse of the Ella Bay Property. All conservation recommendations and PVA findings made in this last volume (Volume III) are based on the interpretation of the results from the field survey (Volume I: Cassowary Field Survey), and the environmental impacts identified for Option A and Option B at Ella Bay (Volume II: Impacts and Mitigation). Thus, changes to the level and detail of mitigation actions recommended in Volume II may affect the outcome of the subsequent impact assessment, PVA analyses, and suggested management strategies. It is recommended, therefore, that any such changes to the mitigation actions outlined in that report should be assessed and justified as a separate report supplement, and attached to the final EIS document. Additionally, should any significant changes to the scale and design of the EBIR be proposed in the future, this cassowary impact assessment may not be valid and should be reviewed prior to decision making occurring.

Figure 13 (Refer Volume II: Impact Assessment and Mitigation Strategies)

Comparison of Environmental Impacts for Option A and Option B`



REFERENCES

Akçakaya H.R., and Sjögren-Gulve P, 2000. Population viability analysis in conservation planning: an overview. *Ecological Bulletins* 48:9-21.

Akçakaya H.R, Burgman M, Ginzburg L, 1999. Applied population ecology. 2nd Edition. Sinauer Associates, Sunderland, Massachusetts.

Bentrupperbäumer, J., 1998. Reciprocal Ecosystem Impact and Behavioural Interactions between Cassowaries, *Casuarius casuarius* and Humans, *Homo sapiens*. PhD. Thesis, James Cook University, Townsville Australia.

Boose E, Serrano M, AND Foster D, 2004. Landscape and regional impacts of hurricanes in Puerto Rico. *Ecological Monographs,* 74(2) 335–352.

Borchert R, 1998. Responses of tropical trees to rainfall seasonality and its long-term changes. *Climatic Change* 39: 381–393, 1998.

Boyce M, 1997. Population viability analysis: Adaptive management for threatened and endangered species. In: Ecosystem Management: (Eds) Boyce and Haney, Yale University Press.

Brook B, Burgman M, Akcakaya H, Grady, J, Frankham R, 2002. Critiques of PVA Ask the Wrong Questions: Throwing the Hueristic Baby Out with the Numerical Bathwater. Conservation Biology. Volume 16, 1, 262-263.

Clark T, Seebeck J, 1990. (Eds) In: Management and conservation of small populations. Chicago Zoological Society, Brookfield, Illinois.

Crome F.H.J., 1975. Some observations on the biology of the cassowary in northern Queensland. Emu 76: 8-14.

Crome, FHJ and LA Moore. (1990). Cassowaries in north-eastern Queensland: Report of a survey and a review and assessment of their status and conservation and management needs. *Austl Wildl. Res. 17:369-85.*

Crome, FHJ and LA Moore. (1988a). The cassowary's casque. Emu 88: 123-124.

Crome, FHJ and LA Moore. (1988b). The southern cassowary in north Queensland - a pilot study:

Volume 1: *Introduction, distributional survey and effects of habitat disturbance.*

Volume 2: *The biology of the cassowary: An analysis of information in cassowaries from the literature, zoos, museums and a public survey.*

Volume 3: *Techniques. An assessment of counting, trapping and handling methods and husbandry*.

Volume 4: *Summary and Management options.*

Reports prepared for the Queensland National Parks and Wildlife Service and the Australian National Parks and Wildlife Service.

Crome, F.H.J., Moore, L.A., 1990. Cassowaries in north-east Queensland: a report of a survey and a review and assessment of their status and conservation and management needs. Australian Wildlife Research 17, 369-385.

Crome, FHJ and LA Moore. (1993a). Cassowary populations and their conservation between the Daintree River and Cape Tribulation. Vol. 1 Summary. *A report to the Douglas Shire Council*.

Crome, FHJ and LA Moore. (1993b). Cassowary populations and their conservation between the Daintree River and Cape Tribulation. Vol. 2 Background, survey results and analysis. *A report to the Douglas Shire Council.*

Hilbert D, Ostendorf B, Hopkins M, 2001. Sensitivity of tropical forests to climate change in the humid tropics of north Queensland. *Austral Ecology* (2001) 26, 590–603.

Jorrisen F, 1973. The cassowary. North Queensland Naturalist 45: 2-3.

Kursar T, 1998. Relating tree physiology to past and future changes in tropical rainforest tree communities. *Climatic Change* 39: 363–379, 1998.

Lacy, R. C., 1993. VORTEX: a computer simulation model for Population Viability Analysis. Wildlife Research 20, 45-65.

Lindenmayer, D.B., Clark, T.W., Lacy, R.C., Thomas, V.C., 1993. Population viability analysis as a tool in Wildlife Management: a review with reference to Australia. Environmental Management, 17: 745-758.

Lindenmayer, D.B., Possingham, H.P., 1994. The risk of extinction: Ranking management options for Leadbeater's Possum using Population Viability Analysis. Centre for Resource and Environmental Studies, Canberra.

Manansang, J., Miller, P., Grier, J.W., Seal, U., (1996). Javan Hawk-eagle (*Sdpizaetus bartelsi*): Population and Habitat Viability Assessment. Conservation Breeding Specialist Group Workshop, Apple Valley, MN.

Meffe, G.K., Carroll C.R., 1997. Genetics: Conservation of diversity within species. In: Meffe and Carroll (Eds.), Principles of Conservation Biology Sinauer Associates Inc., Massachusetts, pp.161-196.

Miller, P.S., Lacy R. C., 1999 - 2003. VORTEX: A Stochastic Simulation of the Extinction Process. Version 8 Users Manual. Conservation Breeding Specialist Group, Apple Valley, MN.

Moore, LA and FHJ Crome. (1992). Report on a survey of cassowary populations in the Whitfield Range, north Queensland. *Internal Research Report*. CSIRO 17/3/92.

Moore, LA (1998). Cassowary Conservation Roads: A Management Strategy and Road Upgrade Assessment for El Arish and Tully-Mission Beach Roads, Mission Beach. *Report for Queensland Department of Main Roads.*

Moore LA. (1999). Road Crossing Strategies for cassowaries and other fauna: South Mission Beach Road, Mission Beach. *Report for Queensland Department of Main Roads*.

Moore, L.A., 2003. Ecology and population viability analysis of the Southern Cassowary (*Casuarius casuarius johnsonii*): Mission Beach, North Queensland. Masters of Science thesis, Department of Zoology and Tropical Ecology, James Cook University, Townsville, Queensland.

Musick J, 1999. Ecology and Conservation of Long-Lived Marine Animals. American Fisheries Society Symposium 23:1–10.

Noon B, Lamberso R, Boyce M, Irwin L 1999. Population viability analysis: A primer on its principal technical concepts. In: Ecological Stewardship: A Common Reference for Ecosystem Management. K. Johnson et al. (eds). Elsevier Science Ltd., London

Pulliam, H. R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652-661.

Pickett, S.T.A, Thomson J.N., 1978. Patch dynamics and the design of nature reserves. Biological Conservation 13, 27-37.

Possingham, H. P., 1994. ALEX: a model for the viability analysis of spatially structured populations. Biological Conservation 73, 143-150.

Reed, M., Murphy, D.D., Brussard, P., 1998. Efficacy of population viability analysis. Wildlife Society Bulletin 26, 244-251.

Ruggiero, L., Hayward, G., Squires, J.R., 1994. Viability analysis in biological evaluations: concepts of population viability analysis, biological population, and ecological scale. Conservation Biology 8, 364-372.

Shaffer, M.L., 1981. Minimum population sizes for species conservation. Bioscience 31, 131-134.

Still C, Foster, P, Schneider, S, 1999. Simulating the effects of climate change on tropical montain cloud forests. *Nature 398, 608-610.*

Tracey J, Webb L, 1975. Vegetation of the Humid Tropical Region of North Queensland. CSIRO Division of Plant Industry, Indooroopilly, 15 maps at 1:100 000 and key.

Williams S, 2006. Vertebrates of the Wet Tropics rainforests of Australia: species distribution and biodiversity. Cooperative Research Centre for Tropical rainforest Ecology and Management.

APPENDIX C

PVA INPUT PARAMETERS

Mating system

The mating system in cassowaries is poorly understood but appears to be a complex arrangement of simultaneous polygony (pair bond between a male and more than one female) and sequential polyandry (sexual relationship between a female and two or more males such that the incubating and caring for the young are left to the males) (Crome 1975; Bentruppperbaumer 1998; Moore 2003, 2007c). This is yet to be confirmed by long-term field studies and/or DNA investigation.

Age of first reproduction

The exact age of first breeding is unknown but adult plumage is attained at approximately 4 years of age (Crome 1975; Crome and Moore, 1990; Bentrupperbäumer, 1998; Moore, 2003, 2007a, 2007c). Although it is not certain that the birds can successfully breed at that age, it is probable they are capable of breeding within their fifth year. A minimum breeding age of four years has been used in this PVA.

Age of reproductive senescence

This is unknown. Cassowaries are known to live up to 50 years in captivity (Crome and Moore 1988), and observations at Mission Beach (Jorrisen 1978) have recorded males breeding for at least 14 years i.e., >19 years old. There are reports (with accompanying photographs) of an individual male cassowary breeding on Mt Whitfield Cairns over a 25-year period (Moore and Crome 1992) prior to being killed by dogs in 1995.

Owing to the known longevity of cassowaries and the uncertainty surrounding the age of reproductive senescence, a conservative model using 35 years as the age of last breeding was selected. By this age an individual would have only nested 10 times at 33% breeding

(1 in 3 years) or 15 times at 50% breeding (2 in 3 years). Given Bentrupperbaumer's data from Kennedy Bay (Bentrupperbaumer 1998), this could result in an individual male successfully producing from 7-10 young in his reproductive lifetime (33% and 50% @ 0.67 young/year).

Maximum number of young per breeding cycle

The maximum number of possible offspring per year was set at five. This variable remained constant in all simulations and comprised an estimate based on known breeding records and sightings of family parties at Mission Beach and elsewhere. Crome and Moore (1988) gathered data from the literature on twelve cassowary clutches from the wild, resulting in a mean clutch size of 3.9 (SD=0.99). They also documented four clutches laid in captivity comprising three sets of 3 eggs, and one each of 4 and 5. Three of the four nests found by Bentrupperbaumer (1998) had three eggs, the fourth having just two. Box 2 presents the offspring estimate based on these data and used in all simulations.

Box 4

Offspring as percentage occurrence

1 = 5%

2 = 20%

3 = 40%

4 = 30%

5 = 5%

Female breeding numbers (= male parameter in VORTEX)

The sex roles are reversed in cassowaries. Following advice (Lacy *pers. comm*. 2002) this parameter was used to reflect the male cassowary breeding numbers. Studies indicate that approximately 80% of cassowary males breed only once every 2-3 years, with only approximately 20% completing two breeding sequences within the three-year period (Bentrupperbaumer 1998). As such, male breeding numbers were calculated as 33% i.e., breeding once in 3 years.

Male breeding pool (= female parameter in VORTEX)

As above, this parameter was reversed to reflect the reversed sex roles in cassowaries. Although no data are available for this parameter, it has been assumed that all adult females are available for breeding in a given year, as they have no commitment to parental responsibilities. Bentrupperbaumer (1998) recorded one female in her study area laying eggs in at least two out of three years.

Sensitivity analysis

In this study, sensitivity analyses are encapsulated within the three simulated models (Section 12.4). Due to a lack of long-term field studies, some of the parameters used in the simulations were based on assumptions derived from previous studies, and augmented with data from this field survey. The baseline input parameters used in all analyses are presented in Table H.

APPENDIX D

PHOTOGRAPHS OF GRAHAM-SEYMOUR RANGE

CASSOWARY HABITAT

Plate 31 Corridor 1: Disturbed narrow vegetation corridor just south of Bramston Beach Road.

Plate 32 Corridor 2: Bramston Beach Road (looking east).

Plate 33 Corridor 3. Looking east towards the narrow corridor at Buttigieg Road, Graham Range. The remaining vegetation forming the corridor appears to be approximately 350m wide at this point (aerial map) and frequented by cattle.

Plate 34 Habitat degradation: western slopes of Graham range showing highly disturbed and weed infested clearings.

Plate 35 Habitat degradation: west side of Graham Range near Clyde Road showing high levels of disturbance and vegetation shift.

Plate 36 Recent clearing at the north end of Graham Range.

Plate 37 Loss of cassowary habitat due to property clearing and edge effect (western face of Graham Range).

Plate 38 Looking west to the longest section of cassowary crossing area along the Bramston Beach Road showing a stretch of road similar to that found in the Mission Beach area. The high speed environment of this road makes crossing extremely dangerous for cassowaries.

Plate 39 Section of Bramston Beach Road looking east. Note the cassowary road crossing point at the road curve and the 'blind' nature of the crossing point.

APPENDIX E

CASSOWARY PAPERS IN PRESS OR AT REVIEW

In press – Journal of Ornithology

Population Ecology of the Southern Cassowary *Casuarius casuarius johnsonii*, Mission Beach, north Queensland.

Author: L. A. MOORE

School of Tropical Biology, James Cook University, Townsville 4811, Queensland

Corresponding author: Leslie.Moore@jcu.edu.au

Abstract:

Little is known of the ecology and population dynamics of the world's largest avian frugivore. This study investigates the population of endangered southern cassowary at Mission Beach in northeast Australia, and examines the problems associated with determining population size and density of this keystone species. Using the results of an intensive field survey aimed at estimating absolute numbers of individual cassowaries, it explores the appropriate sampling methodology for rare and elusive species. Approximately 102 km^2 of rainforest was surveyed, using 346 kilometres of search transects. A total of 110 cassowaries comprised of 49 adults (28 male, 19 female, 2 unknown), 28 subadults, 31 chicks, and 2 independent birds of unknown status were identified. This is approximately 35% of the adult population previously estimated for the Mission Beach area. Overall adult cassowary density was 0.48 adults/km^2; density of independent birds i.e. adults and subadults was 0.78 birds/km^2. Mean indicative home range for adult females and males was 2.13 km^2 and 2.06 km^2 respectively. Mean indicative home range of subadults was smaller at 0.95 km^2. It was concluded that the previous practice of surveying small areas at Mission Beach (<4 km^2) has led to consistent over-estimation of cassowary population density, up to six times its real number. It is shown that a sample plot between 5-15 km^2 is necessary to approximate true cassowary density. These findings have significant application to the conservation of cassowaries in New Guinea and in the Wet Tropics World Heritage Area of Australia.

Key words:
Endangered, keystone, population size, density, home range, sample area

At review – Austral Ecology

Implications of environmental catastrophes and climate change for the management of an endangered species: the Southern Cassowary *Casuarius casuarius johnsonii.*

AUTHORS: L. A. MOORE [1] and N. .J. MOORE [2]

[1] School of Tropical Biology, James Cook University, Townsville, Queensland.
[2] School of Earth and Environmental Sciences, James Cook University, Cairns, Queensland.

CORRESPONDING AUTHOR: Leslie.Moore@jcu.edu.au

ABSTRACT

This study details the effect of severe Cyclone Larry on eight isolated cassowary subpopulations on the coast south of Cairns. The impacts of increased frequency and severity of similar environmental catastrophes as a result of climate change are also explored. At Mission Beach, Cyclone Larry caused the death of approximately 35% of the known adult and subadult population. Approximately 70% of these deaths were from vehicle strike and 22% from dog attack. PVA indicated that catastrophes in the form of severe cyclones double the probability of extinction for coastal cassowary subpopulations. All models revealed that the coastal subpopulations are in deterministic decline and that this will intensify as individual subpopulations decrease, leading to the extinction of five of the eight subpopulations within 100-years. The decline is caused by a combination of inadequate patch size, isolation from the main habitat blocks to the west, and high anthropogenic threats exacerbating the naturally low reproductive rate of cassowaries. Models showed that re-establishing connectivity between coastal subpopulations would accelerate the decline of the coastal metapopulation as a result of source-sink dynamics. All models indicate that subpopulations >45 birds are more stable without inter-patch dispersal, particularly when it involves interaction with smaller subpopulations of less than 10 birds. These smaller subpopulations, however, would not persist in the absence of dispersal from larger source populations. The PVA showed that climate change in the form of severe cyclones and modified habitat will speed up the current decline of coastal cassowary subpopulations by approximately 20-30% over the 100-year period. Management options are presented and discussed.

Keywords

Cyclone, deterministic decline, extinction, slow-fast continuum, inter-patch dispersal, PVA

At review – Animal Conservation

Does the history of the Moas suggest a future for the cassowary? The dilemma of slow birds in a fast world.

AUTHOR: L. A. MOORE

School of Tropical Biology, James Cook University, Townsville 4811, Queensland

CORRESPONDING AUTHOR: Leslie.Moore@jcu.edu.au

Abstract

This study explores the life history strategies of the cassowary using population viability analysis and contrasts the results with studies of the life-history and rapid extinction of the New Zealand Moa. It is concluded that the underlying mechanisms influencing the decline of the Australian southern cassowary are the same as those which caused the disappearance of the moas. The analyses indicate the isolated Mission Beach cassowary population is in deterministic decline and predicts this will intensify as the population decreases, leading to the extinction of the population within the 100-year projection period. Extinction of the Mission Beach cassowary population is predicted under most mortality values, with PE ranging from 0.85 – 0.98 and a median time to extinction from 34 to 72 years. To retain the existing population size in the absence of immigration requires 'Low' mortality rates across all age classes; male cassowaries to breed once in every two years; and a minimum offspring survival of approximately 27%. This is not achievable within the limitations imposed by the cassowary's K-selected reproductive strategies. The PVA simulations indicate that although strongly associated, PE is more influenced by age of first breeding than by the death of adults. The transition from the breeding at two years to breeding at three years is a critical population dynamic, significantly lowering population viability and taking the population into negative growth. This study demonstrates that the extant southern cassowary is a contemporary analogue of its extinct New Zealand relative the moa, and shows that its k-selected life history strategies prevent it from adapting to the environmental instability created by current human activities.

Key words:

slow-fast continuum, k-selected, deterministic decline, extinction, breeding age, moa, ratite

WORKING PAPER 3

CASSOWARY ISSUES

LES MOORE

CASSOWARY HABITAT ASSESSMENT AND PREFERRED ALIGNMENT IMPACT ASSESSMENT

Access Road, Ella Bay Integrated Resort

Report prepared

for

Satori Resorts Ella Bay Pty Ltd

L.A. MOORE
'Cloudhill'
63 Wooleys Road,
Millaa Millaa 4886
Queensland, Australia
Phone +61 7 4097 2107
Email: cloudhill@bigpond.com; lesmoore3@bigpond.com

CASSOWARY HABITAT ASSESSMENT

AND PREFERRED ALIGNMENT IMPACT ASSESSMENT

Access Road, Ella Bay Integrated Resort

Table of Contents

TABLES

FIGURES

BOX

APPENDIX A

CASSOWARY HABITAT ASSESSMENT
ACCESS ROAD, ELLA BAY INTEGRATED RESORT

1. INTRODUCTION

This cassowary habitat assessment provides a characterisation of the quality and value to cassowaries of habitat present within the corridor of the Ella Bay access road between Flying Fish Point and Ella Bay, near Innisfail. Using the results of previous cassowary field surveys of the coastal area (Moore 2003, 2005, 2006a-c, 2007a), cassowary habitat mapping provided by the Environmental Protection Agency (February 2004), and recent vegetation mapping carried out by 3D Environmental (2007), this report evaluates the capacity and suitability of remaining habitat to support cassowaries. The report specifically addresses:

1. Assessment of Road Alignment Options A – D
2. Description of the site in context of its local and regional context;
3. Data sources and methodology;
4. Weighting factors for vegetation categories;
5. Impact assessment and mitigation of preferred road alignment;
6. Uncertainties.

1.1 CONTEXT OF THE ELLA BAY ACCESS ROAD

1.1.1 Location and Description

The following road description is from BAAM (2007). The Ella Bay access road is located approximately four kilometres to the north-west of Innisfail within the Wet Tropics bioregion of Queensland (Figure 1). It commences from the southern end of Flying-Fish Point and runs north for approximately three kilometres where it ends at the proposed Ella Bay Integrated Resort site. This road alignment follows an existing gazetted unsealed road as it passes through, or adjacent to, Ella Bay National Park. The study area includes the gazetted road as well as Lot 246 on NR3550 and Lot 18 on USL35566. The northern and southern sections of the road are located on comparatively low-lying land with little undulation. However the central portion of the road skirts the coastal fall of the Seymour Range negotiating the coastal headland of Heath Point where it is incised into the steep hillside (BAAM 2007).

Several creek-lines of various sizes cross the road. The largest has permanent water and is located within the National Park towards the northern end of the road alignment. This creek-line has few riffle zones, replaced by pools of water with a sandy or sediment substrate, terminating seaward in a sandy swale which breaches the coastal foredune. Other smaller watercourses do not appear to contain permanent water, but are likely to run regularly with rainfall. These are typically steep, fast flowing streams with rock or boulder substrate. The study area which will contain the preferred road alignment is within the Wet Tropics World Heritage Area (WTWHA) and adjacent to the World Heritage Great Barrier Reef Zone.

FIGURE 1

Location of Ella Bay Access Road

1.1.2 Cassowary values

The Ella Bay access road is located at the southeast end of the Graham-Seymour Range (Figure 1), and adjacent to the Ella Bay National Park. The size of the Graham-Seymour Range cassowary subpopulation is tentatively estimated to be 51-73 independent birds i.e., adults and subadults. The Seymour Range section of this subpopulation is tentatively estimated to be 28-40 independent birds (Moore 2007a, 2007b). Population viability analyses indicate that along with the other coastal cassowary subpopulations south of Cairns, the Graham-Seymour Range cassowary population is undergoing a population decline. It is postulated that this decline is caused by inadequate patch size, isolation from the main habitat blocks to the west, cyclone-induced mortality, and high levels of historical and contemporary anthropogenic impact exacerbating the naturally low reproductive rate of cassowaries. The study also showed, however, that given adequate funding, appropriate management strategies were available to stabilise the population(s).

2. DATA SOURCES AND METHODOLOGY

All references used as a basis for this assessment are listed in the bibliography. The more recent reports which specifically addressed the site include:

- 3D Environmental (2006a). 'Vegetation Survey Report of the Proposed Ella Bay Integrated Resort Project' Report prepared for BAAM. Brisbane.

- 3D Environmental (2006b). 'Ella Bay Integrated Resort Project' Supplementary Section:

- BAAM (2006) 'Terrestrial and Freshwater Flora and Fauna Impact Assessment' Report prepared for Ella Bay Developments Pty Ltd. Cleveland, Australia.

- BAAM (2007) Terrestrial flora and fauna assessment and preferred alignment impact assessment access road, Ella Bay Integrated Resort. Report prepared for Satori Resorts Ella Bay Pty Ltd.

- Moore, L.A. (2007). 'Cassowary Assessment of the 'Ella Bay Integrated Resort Project' North Queensland 6 – 14 November 2006: Volume I Cassowary Field Survey; Volume II – Impacts and Mitigation; Volume III – Population Viability Analysis. Millaa Millaa, Queensland.

- ETS Group (2007) 'Ella Bay Access Road Strategy, Preferred Option Clearing Quantities.Report Prepared for Satori Resorts Ella Bay Pty Ltd.

2.1 CASSOWARY HABITAT CLASSIFICATION

It is unlikely that the classification of cassowary habitat by EPA (2004) was meant to be applied at the small scale required for evaluating the relative importance of cassowary habitat along the Ella Bay access road. As such, the assessment reported here was conducted as a pilot study of possible ways in which risk analysis could be used to classify the <u>value</u> of potential cassowary habitat. The following factors for each polygon were analysed:

- Cassowary habitat quality of existing vegetation;
- Risk to birds in accessing that vegetation.

These two factors will be considered in turn and used to devise weighting factors to inform the multi-criteria analysis.

In this study, cassowary habitat quality was assigned to three categories: High Quality Habitat, Moderate Quality Habitat, and Low Quality Habitat. Goosem (1992) prepared a management plan for Mission Beach in which the existing vegetation was classified according to its perceived significance to cassowaries. Some of his habitat zone definitions are extremely useful, particularly when mapping at a scale smaller than the regional ecosystem level used by EPA. As such, habitat quality criteria from his work are paraphrased in this report where appropriate.

High Quality Habitat (*sensu* '*Essential Habitat*' – *EPA*)

EPA (2004) described this category as "Regional ecosystems known to be preferentially used by cassowaries for breeding, feeding and general activity". It can be more fully described as possessing high cassowary population densities, containing known preferred breeding areas, providing refuge areas after natural catastrophes i.e., cyclones, and furnishing adequate food resources during lean times (Goosem 1992).

Moderate Quality Habitat (*sensu* '*General Habitat*' – *EPA*)

This habitat category includes 'General Habitat' as described by EPA (2004) i.e., "…sometimes provides linking habitat or movement corridors to traverse between regional ecosystems of essential habitat and is capable of supporting cassowaries infrequently but not during times of food shortage". Moderate quality areas generally comprise vegetation which is more disturbed and with less habitat complexity than 'High Quality' habitat.

Low Quality Habitat (*sensu Marginal or Alternative Habitat – EPA*)

These areas comprise native woodland or forest containing non-rainforest vegetation i.e., coastal woodland associations and *Melaleuca* communities with impeded drainage and coastal woodland associations. Although these areas are known to be visited by cassowaries, it is unlikely they can support permanent populations. In some circumstances, however, standing water present in *Melaleuca* communities provide an important source of water in dry periods and may be sought out by cassowaries. In these situations the otherwise marginal habitat takes on an increased importance in maintaining the local cassowary population.

2.2. HABITAT QUALITY VERSUS HABITAT VALUE

There is confusion regarding what constitutes cassowary habitat and what does not. This uncertainty arises when evaluations are made of small areas of relatively intact rainforest vegetation adjacent to, or contiguous with, areas where cassowaries are known to occur. In general, the decision to allow or facilitate cassowary access to such areas is made without taking into account the level of risk faced by birds in doing so. There is often a direct conflict between what habitat cassowaries can exploit i.e., capacity, and what is safe for them to make use of i.e., its suitability. A prosaic example of this reality might be that children will happily play on the road, but such behaviour is certain to decrease their survival probabilities. So it is with cassowaries. By allowing cassowaries into areas with high risk levels, the probability of death or injury increases to an unacceptable level. Areas of vegetation, therefore, although appearing superficially important to cassowaries, may instead function as ecological traps i.e., habitat which cannot sustain a population but nonetheless attracts individuals and elevates their extinction risk. It is important, therefore, to develop a weighting system which, while recognising habitat quality, incorporates the existing risk level if cassowaries utilise such habitat.

2.3 RISK ASSESSMENT METHODOLOGY

As the level of anthropogenic threat increases, the usefulness of otherwise suitable cassowary habitat decreases. The level of existing risk, therefore, should be factored into any assessment of cassowary habitat. The risk assessment approach used in this assessment attempts to establish the **Habitat Value** i.e., the true contribution made by habitat to conserving the cassowary populations in an area, and represents the weighting given to each vegetation category. The evaluation method also assists in identifying those areas that may be of increased benefit to cassowaries if successful mitigation is implemented. Table 1 presents the habitat quality and risk ratings used to arrive at Habitat Values for the vegetation adjoining Ella Bay access road.

As this is a pilot analysis which will be explored further in forthcoming cassowary studies, the risk levels have been limited to three to match those used in previous population viability analyses of the region (PVA) i.e.,' Low', 'Moderate', and 'High' (Moore and Moore 2007). It was established in previous PVA studies that the 'No Risk' category does not occur in coastal cassowary subpopulations of the Wet Tropics south of Cairns (Moore 2007a, Moore and Moore 2007).

TABLE 1

Habitat and Risk Ratings

Habitat quality	Rating	Risk Level	Rating
High Quality Habitat (i.e., essential/critical habitat)	3	High risk [1]	0.1
Moderate Quality Habitat (i.e., general/corridor habitat)	2	Medium risk [2]	0.5
Low Quality Habitat (i.e., marginal/alternative habitat)	1	Low risk [3]	1

[1] *High risk:* Birds subject to high levels of human generated risk on a daily basis.
[2] *Moderate risk:* Birds subject to high levels of human generated risk regularly.
[3] *Low risk:* Birds subject to some level of human generated risk regularly.

The possible outcomes of the habitat quality and risk rating system for all habitat scenarios are presented in Box 1. The Habitat Value increases from 0.1 for low quality-high risk habitat, to a maximum of 3.0 indicating the best quality for lowest risk habitat. These habitat values can provide a relative ranking or weighting of the vegetation along the road alignment.

BOX 1

HABITAT QUALITY x RISK LEVEL = HABITAT VALUE

High Quality Habitat		Risk Level	Habitat Value/Vegetation Category	
3	x	1.0 (Low Risk)	3.0	High Value
	x	0.5 (Moderate Risk)	1.5	Moderate Value
	x	0.1 (High Risk)	0.3	Negative Value
Moderate Quality Habitat				
2	x	1.0 (Low Risk)	2.0	Moderate Value
	x	0.5 (Moderate Risk)	1.0	Low Value
	x	0.1 (High Risk)	0.2	Negative Value
Low Quality Habitat				
1	x	1.0 (Low Risk)	1.0	Low Value
	x	0.5 (Moderate Risk)	0.5	Negative Value
	x	0.1 (High Risk)	0.1	Negative Value

3. RESULTS

3.1 CASSOWARY HABITAT QUALITY

Using the results of a field survey (Moore 2007a) and a fauna assessment by BAAM (2007), the vegetation within the study area was mapped as ‘High’, ‘Moderate’, or ‘Low’ Quality cassowary habitat (Figure 2). ‘High’ quality cassowary habitat occurs in the Ella Bay National Park (Location 1), the southern and northern sections of the Ella Bay road corridor (Locations 5 and 8), and the Little Cove development area. The Flying

Fish Point Reserve (Location 4) is classified as 'Moderate' quality cassowary habitat. The southern end of the Seymour Range (Location 6), although not given a cassowary habitat status in the EPA (2004) habitat mapping, has been classified as 'Low' quality habitat in this study.

3.2 CASSOWARY HABITAT VALUES

The potential outcomes of the habitat and risk assessment model for all habitat scenarios are presented in Box 1. The results show that any Habitat Value < 1 has a negative ecological value for cassowaries i.e., although such vegetation may comprise high quality cassowary habitat, the risk attached to using it makes it less suitable and is likely to lead to injury or death. Such a situation is recognised in the literature as an ecological trap. Habitat Values incrementally increase to a maximum value of 3, representing the highest value habitat that can achieved using this model. These values have then been attributed to specific vegetation blocks in the study area (Tables 2 and 3), and the cassowary habitat mapping revised in light of those results. To illustrate the mapping process used in this study, three cassowary habitat maps are included in Figure 2 i.e., **2a)** Cassowary Habitat Mapping of EPA (2004); **2b)** Habitat Quality mapping (LM this report); **2c)** Cassowary Habitat Value (LM this report).

TABLE 2

Habitat Value and Vegetation Categories along Ella Bay Access Road

Area Code	Location	Habitat Quality (capacity)	Risk Level	Habitat Value (suitability)	Vegetation Category
1	Ella Bay National Park	3	1.0	3.0	A
2	Heath Point	1	0.5	0.5	C
3	Beach front	1	0.1	0.1	D
4	**Flying Fish Point Reserve**	**2**	**0.1**	**0.2**	**D (B)***
5	Southern EB Road verge	3	0.1	0.3	D
6	South Seymour Range	1	0.1	0.1	D
7	Flying Fish Point west swamp	1	0.5	0.5	C
8	Northern EB Road verge	3	0.1	0.3	D

**** High risk habitat will be mitigated to Category B (Moderate Value Habitat) with raised bridges and fencing proposed by proponent.***

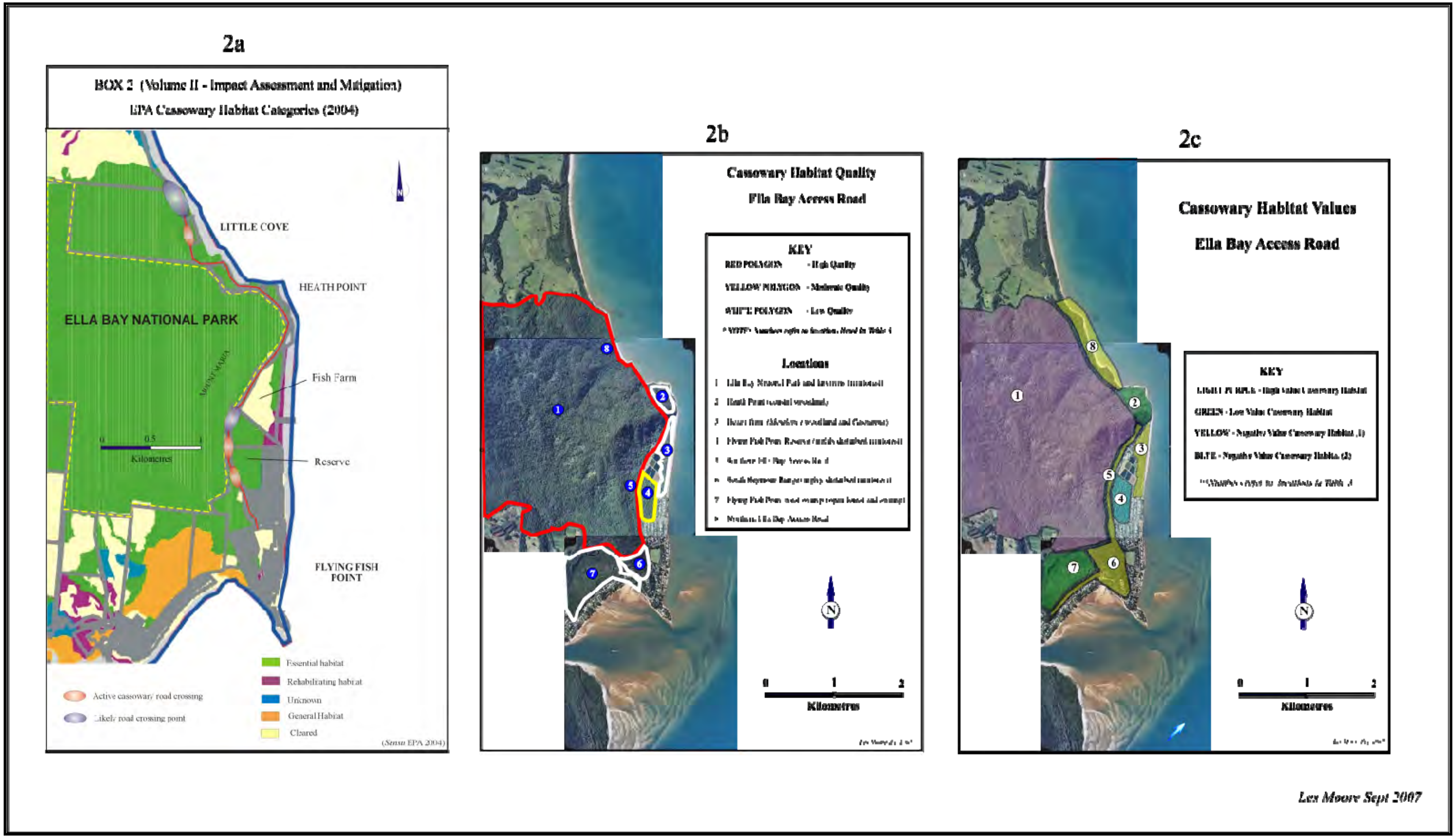
TABLE 3

Habitat values along Ella Bay Road (see Fig 1)

Cassowary Habitat Value	Location Codes	Comments
High Value	1	▪ no risk (away from boundaries) ▪ moderate risk adjacent to boundaries
Moderate Value	-	▪ not present in study area
Low Value	2, 7	▪ alternative habitat (unknown importance) ▪ moderate risk area (road, dogs, humans) ▪ non-rainforest woodland
Negative Value	3, 4, 5, 6, 8	▪ high risk area (roads, dogs, humans) ▪ habitat value of locations 4 and 5 (Reserve and adjacent road) can be increased to 'Moderate' using mitigation.

FIGURE 2a – 2c

Cassowary habitat values – Ella Bay access road



3.3 VEGETATION CATEGORIES

These results have been plotted onto the vegetation polygons along the Ella Bay Access Road using the ETS polygons as a baseline (Figures 3a-g). Four vegetation categories have been recognised as follows:

- Category A – High value (high quality and low risk)
- Category B – Moderate value (moderate quality and moderate risk)
- Category C – Alternative habitat (low quality, steep terrain)
- Category D – Negative value (varying quality and high risk)

3.4 OTHER CONSIDERATIONS

The following areas outside of the Ella Bay National Park would have functioned as high quality cassowary habitat prior to the existing road being built:

- The southern and northern sections of the Ella Bay Road;
- Flying Fish Point Reserve;
- Southern end of the Seymour Range west of the town of Flying Fish Point.

Currently all these areas pose great risks to those cassowaries using them, for what is minimal ecological benefit. Although categorised as Negative Value Habitat in this assessment, the Flying Fish Point Reserve may be pivotal to the continued presence of cassowaries in this south-east section of Seymour Range. Cassowaries must drink a number of times during the day and the streams between Flying Fish point and Heath

Point are ephemeral. The *Melaueca leucadendron* and featherpalm (*Archontophoenix alexandrae)* dominated communities within the Reserve, therefore, may hold the only water source available to cassowaries in this area during dry periods. Thus, the Reserve probably provides both food and water resources for cassowaries.

Figure 3a-g presents cassowary habitat values for the preliminary polygons mapped for the Ella Bay access road by ETS (2007).

FIGURE 3a

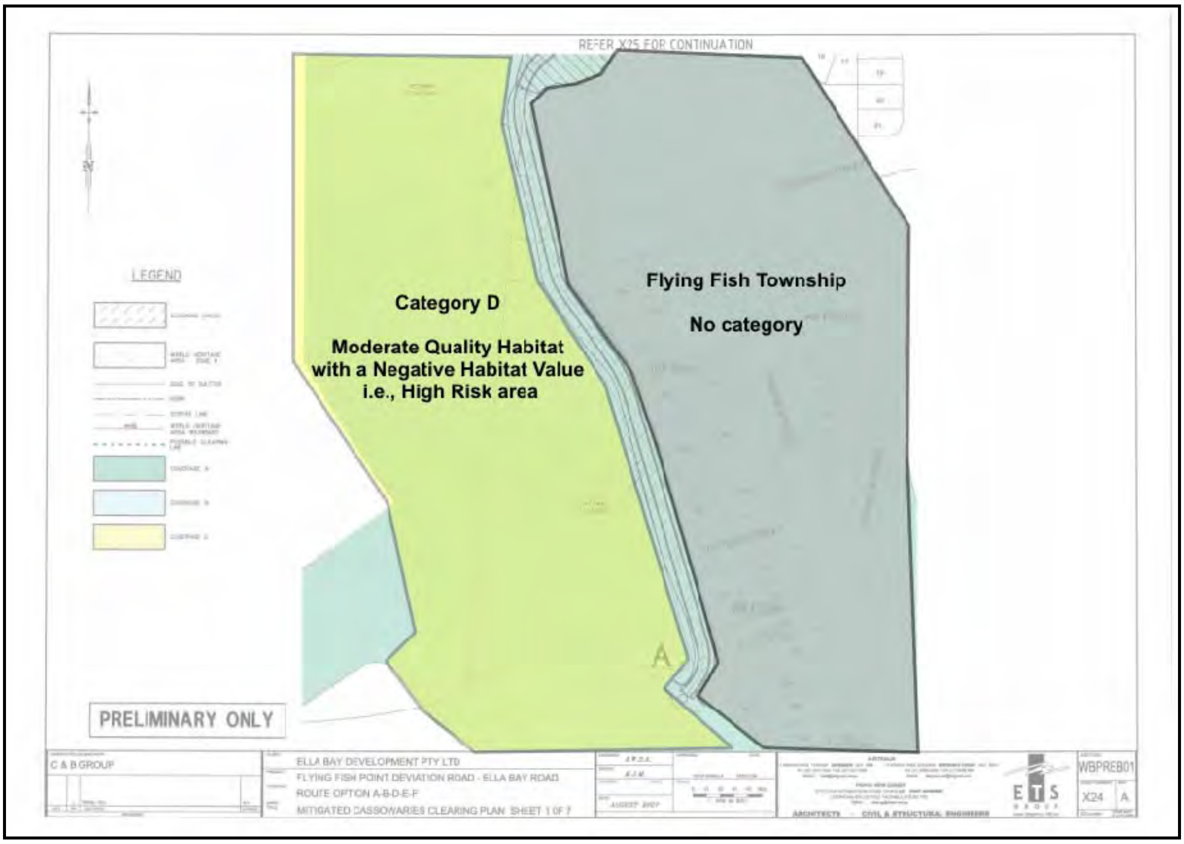


FIGURE 3b

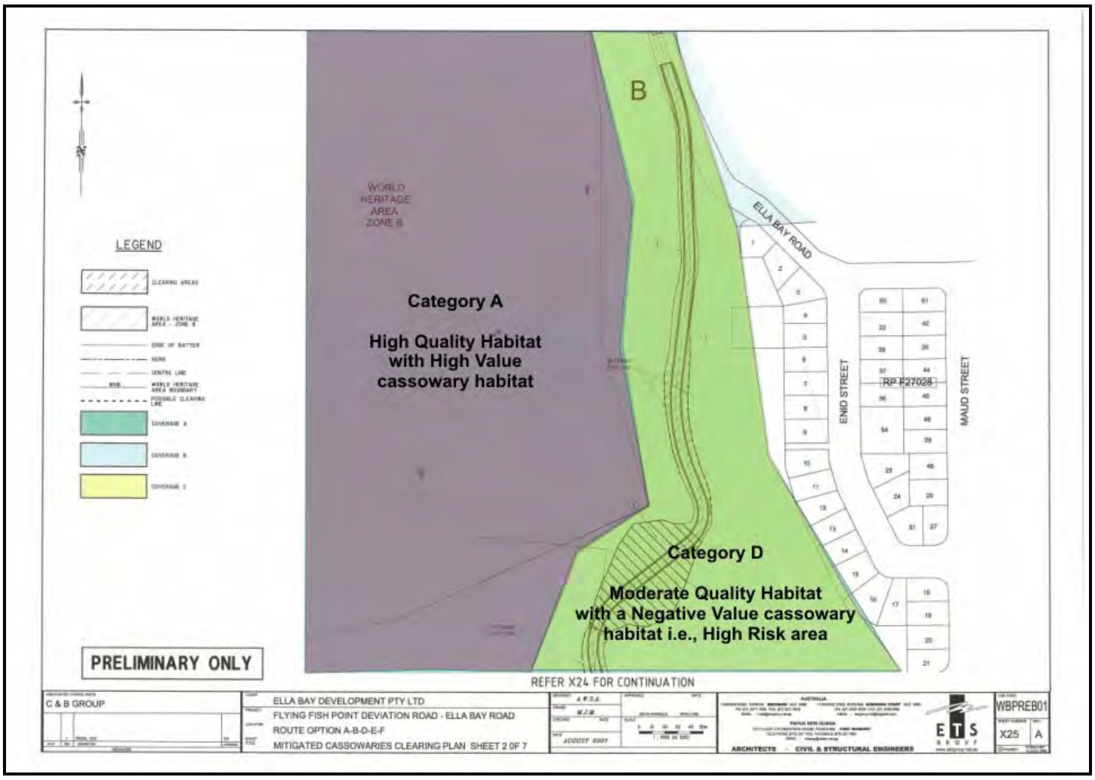


FIGURE 3c

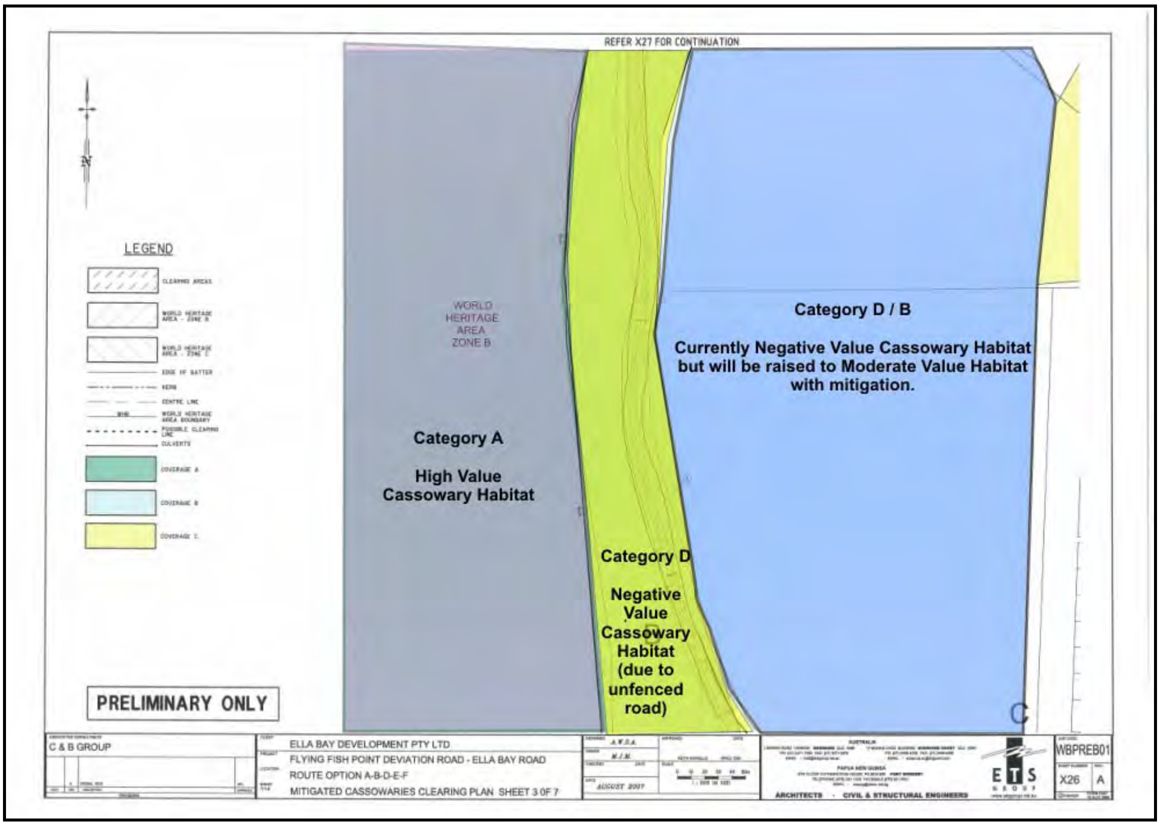


FIGURE 3d

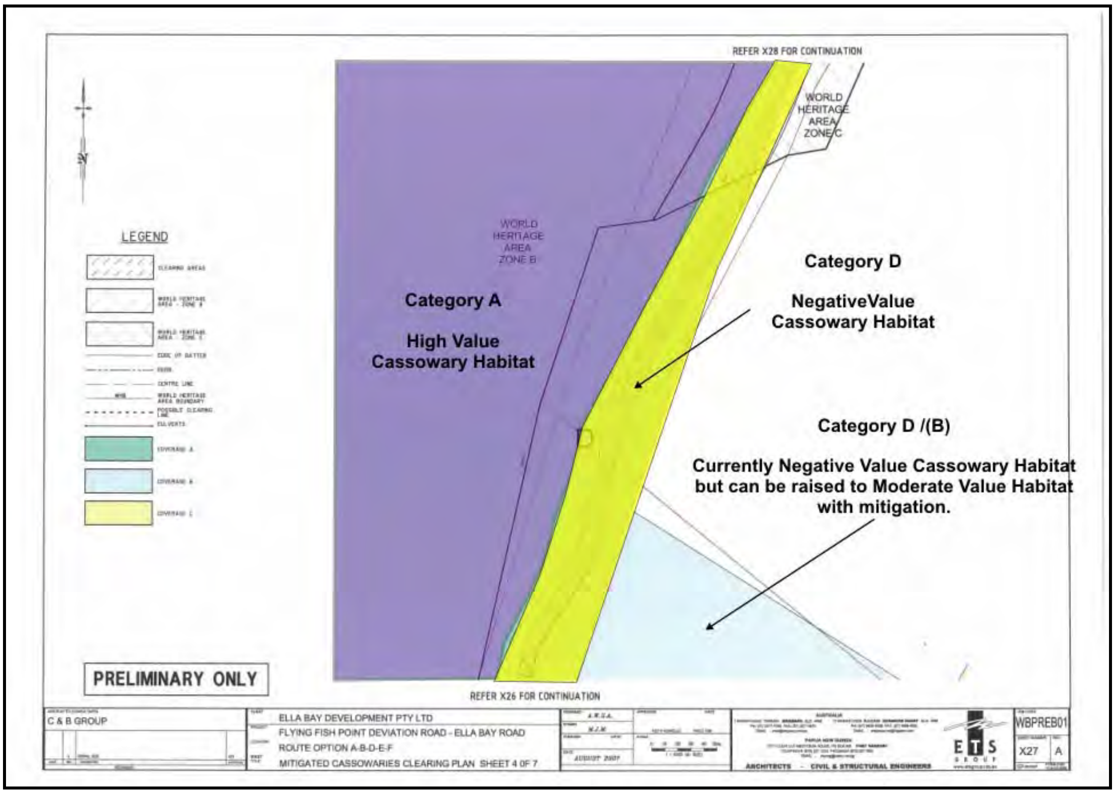


FIGURE 3e

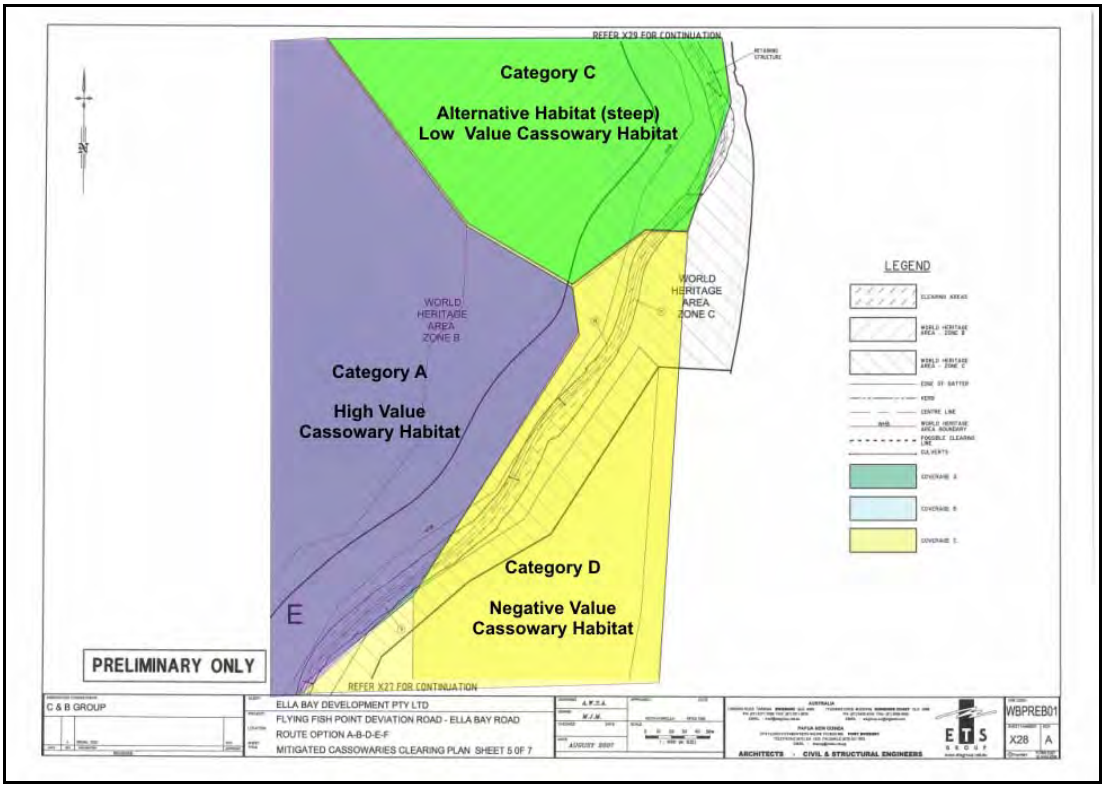


FIGURE 3f

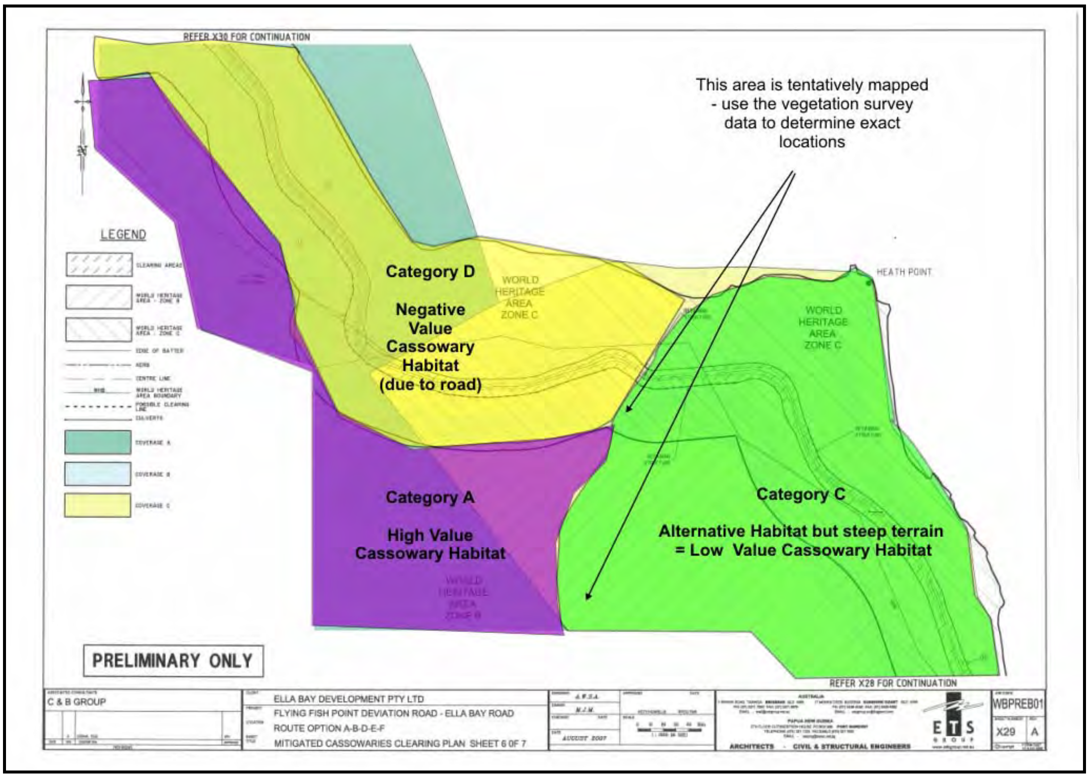
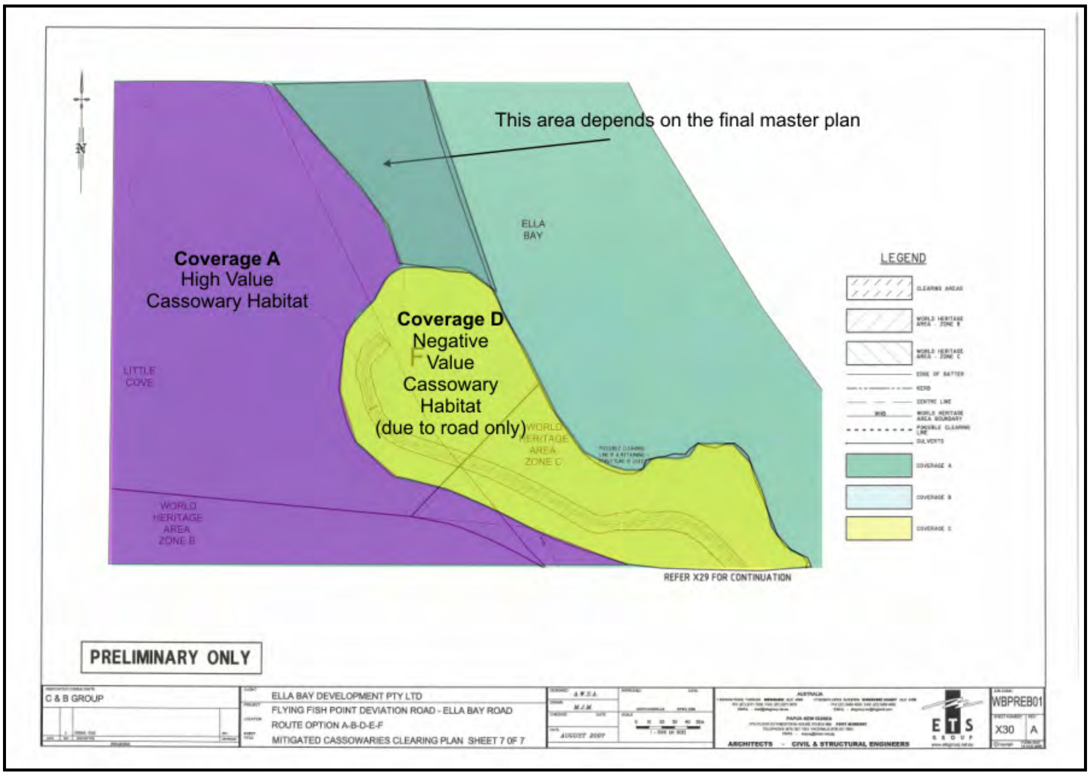


FIGURE 3g



4. IMPACT ASSESSMENT AND MITIGATION STRATEGIES

An assessment of the impacts on the local cassowary population of each of the original alignment options is provided in Appendix A. Proposed mitigation strategies have removed the risk issues associated with Option A [ACBD] and Options C & D [ABDE], with the addition of raised bridges and exclusion fencing allowing birds to safely cross the road into the Reserve.

4.1 ASSESSMENT OF PREFERRED ROAD ALIGNMENT

The preferred road alignment (previous Option D) is shown in Figure 4. Starting from its southern limit on the Flying Fish Point Road just south of the township, the proposed road alignment traverses approximately 0.94 km of forest, within unallocated state land, where no road currently exists. The alignment then joins with the existing Ella Bay Road alignment north-west of Flying Fish Point, following that road for approximately 3.7 km northwards within road reserve before reaching the southern end of Heath Point, some 2.76km from its starting point. From this location the proposed route runs northward along the existing road alignment to the southern boundary of the Ella Bay Integrated Resort area. The road enters the Wet Tropics World Heritage Area 1.78 km from the starting point of the road and leaves it at 3.63 km. The proposed road pavement width is 9m, although the clearing width varies with topography. Where the proposed road is aligned with the existing road, clearing is restricted to only those areas necessary for driver safety and road stability (BAAM 2007).

FIGURE 4

PREFERRED ROAD ALIGNMENT (<u>OPTION D: A-B-D-E-F Raised bridge and exclusion fencing)</u>

4.2 ROAD CROSSING CASSOWARIES

In previous work (Moore 2007a), three active cassowary road-crossing points and two likely road-crossing areas were identified along Ella Bay Access Road. The locations of these cassowary road crossing points are shown on Figure 5.

FIGURE 5

Cassowary Road Crossing Points 6 – 14 November 2006

4.3 THREATS ALONG SECTIONS A – E (Flying Fish Point to Heath Point)

The status of the cassowary habitat and the increased risks to birds using the road crossings are quantified in this report (Section whatever) and two threats are identified:

1. A reduced carrying capacity from loss of habitat leading to pressures on reproductive productivity and recruitment i.e., isolation of the Flying Fish Point Reserve.
2. An increased risk of road death to cassowaries occupying adjacent or nearby habitat due to increased traffic flows.

4.3.1 Mitigation

Cut and cover tunnel (A-B)

The proposed construction of a cut and cover tunnel between A and B will preserve connectivity to the southern tip of Seymour Range for cassowaries. As the construction and revegetation phases will restrict the use of the area by birds, the following recommendations are made:

- Best time to construct May-August – dry season
- Cassowary proof fence to be erected around the construction envelope to prevent birds entering the area during construction and revegetation phases;
- Education program for workers to prevent hand-feeding and other disturbances;
- Fencing on both sides of finished road to prevent access to road by cassowaries.

Fencing

To mitigate the risk of cassowary road death, fencing will be constructed along the entire length of Ella Bay access road, excluding section E – F, which will be subject to traffic calming studies (see below). Cassowaries are extremely strong, and birds are known to scale fences when upset or excited. As part of the proposed mitigation for the access road, therefore, a cassowary road-management research program will be undertaken to determine the appropriate height, structure, and screening methods for a cassowary-proof fence. It will also look at techniques to encourage the safe movement of small mammals and other terrestrial animals across the road. On-going monitoring of the efficacy of the fence will be included in the cassowary research program.

Elevated Bridge Overpasses (B-E)

Raised bridge overpasses will be constructed to allow cassowaries to pass beneath and access the Reserve without crossing the road (Figure 4). The bridges and their locations will be designed and constructed with regard to encouraging their use by cassowaries, and a planting program undertaken if required. The design of the raised bridge will incorporate low visual impact (cassowaries are wary of solid overhead structures), and allow light and rainfall to reach the ground below relatively unhindered.

4.3.2 Uncertainties

The bridges will be part of the cassowary road monitoring program to look at their efficacy using camera surveillance and ground survey. It is uncertain whether the northern bridge i.e., immediately prior to Heath Point, is beneficial to cassowaries. Although it facilitates cassowary access to the beach area, which possesses very little in the way of food resources, it potentially brings them into contact with humans and dogs. The road monitoring studies will need to assess whether this across-road access should be kept open for cassowaries or fenced off to protect the birds.

4.4 THREATS ALONG SECTION E – F (Heath Point to Ella Bay property gate)

The area of Heath Point comprises steep coastal headlands dominated by a complex of shrubland, low heathy or shrubby woodlands or open forests dominated by *Corymbia tessellaris* and *Lophostemon suaveolens* (BAAM 2007). Although probably visited by cassowaries it is categorised as marginal or alternative habitat. North of Heath Point to Point F, the vegetation comprises a mosaic of mesophyll vine forest on beach ridges, complex mesophyll vine forest, and non-remnant vegetation communities (BAAM 2007). Much of the area along the beach and east of the existing road has been a traditional camping area for local people from Innisfail and tourists. The threats identified in this area include:

1. An increased risk of road death to cassowaries occupying adjacent or nearby habitat due to increased traffic flows.
2. Adverse cassowary-human interactions.

4.4.1 Mitigation

This section of road is used extensively by cassowaries to move along and cross in a number of locations (Moore 2007a). Although there is a major crossing at a small stream 0.6 kilometres south of the Ella Bay Property gate, the birds may cross at many points, from the foot of the Heath Point headland to the gate. Due to the traditional use of this area by locals and tourists, there is a possibility of adverse interactions between cassowaries and humans. As use of the road and the beach will increase when the EBIR is constructed, this threat may need to be addressed. As such, the following mitigation strategy is recommended:

- Program to develop, trial, and monitor traffic calming strategies.

4.4.2 Uncertainties

If the monitoring of the area shows an unacceptable incidence of adverse cassowary-human interactions, the road will need to be fenced to prevent cassowaries accessing the beachfront.

4.5 SUMMARY

The proposed fence and funnel mitigation reduces the current high risk of road death for local cassowaries along the entire length of the Ella Bay access road. Along the southern road section, the construction of exclusion fencing and raised bridges will permit cassowaries to safely cross the road and access food and water resources within Flying Fish Point Reserve. In doing so it will increase the value of the cassowary habitat in the Reserve from its current assessment as Negative Value Habitat i.e., High Risk (0.2), to Moderate Value Habitat i.e., Moderate to Low Risk (>1.0).

The following recommendations were given in Moore (2007a) and have been included in the proponents offset package:

1. A detailed cassowary management strategy for the Graham-Seymour Range coastal subpopulation should be developed, and its implementation supported by adequate funding. This management strategy should include:

i. The maintenance and protection of the existing movement corridors linking the two range populations.

ii. The development and implementation of a cassowary road management strategy for the Bramston Beach Road.

iii. The implementation of an effective dog control program for the communities adjoining the Graham-Seymour Range. As council funding is limited for policing uncontrolled dogs, it may be necessary to request support from the developers for this action.

REFERENCES

3D Environmental (2006a). ‘Vegetation Survey Report of the Proposed Ella Bay IntegratedResort Project’ Report prepared for BAAM. Brisbane.

3D Environmental (2006b). ‘Ella Bay Integrated Resort Project’ Supplementary Section:

BAAM (2006) ‘Terrestrial and Freshwater Flora and Fauna Impact Assessment’ Report prepared for Ella Bay Developments Pty Ltd. Cleveland, Australia.

BAAM (2007) Terrestrial flora and fauna assessment and preferred alignment impact assessment access road, Ella Bay Integrated Resort. Report prepared for Satori Resorts Ella Bay Pty Ltd.

Buckley Vann (2006). Myola Planning Study: Proposed Amendments to Mareeba Shire Planning Scheme. Consultants report to Mareeba Shire Council.

Moore, L.A. (2006). ‘Cassowary Assessment of the ‘Ella Bay Integrated Resort Project’ North Queensland 6 – 14 November 2006: Volume I Cassowary Field Survey; Volume II – Impacts and Mitigation; Volume III – Population Viability Analysis. Millaa Millaa, Queensland.

EPA (2004). Distribution of Cassowary *Casuarius casuarius johnsonii* Habitat in the Wet Tropics Bioregion, Queensland.

ETS Group (2007) ‘Ella Bay Access Road Strategy, Preferred Option

Goosem, S (1992). Draft Management Plan Mission Beach Area, North Queensland. Queensland Department of Environment and Heritage Report, Far Northern Region, Cairns.

Moore, L.A (1998). Cassowary Conservation Roads: A Management Strategy and Road Upgrade Assessment for El Arish and Tully-Mission Beach Roads, Mission Beach. *Report for Queensland Department of Main Roads.*

Moore, L.A., (2003). Ecology and population viability analysis of the Southern Cassowary (*Casuarius casuarius johnsonii*): Mission Beach, North Queensland. Masters of Science thesis, Department of Zoology and Tropical Ecology, James Cook University, Townsville, Queensland.

Moore, L.A. (2005). Review of cassowary issues and management strategies and EPBC referral, Oasis Beachfront Resort, Mission Beach, North Queensland. Consultancy report for Biodiversity Assessment and Management Pty Ltd, Brisbane.

Moore, L.A. (2006a). Review of cassowary issues and management strategies and EPBC referral, Oasis Beachfront Resort, Mission Beach, North Queensland. Consultancy report for Biodiversity Assessment and Management Pty Ltd, Brisbane.

Moore, L,A. (2006b). Desktop assessment for Oasis Resort offset land at Mt Edna, Mission Beach, North Queensland. Consultancy report for Biodiversity Assessment and Management Pty Ltd, Brisbane.

Moore, L,A (2006c). Cassowary survey and impact assessment of Jubilee Grove – Stage 2, Innisfail, North Queensland. Consultancy report for Biodiversity Assessment and Management Pty Ltd, Brisbane.

Moore, L,A. (2007a). Cassowary assessment of the 'Ella Bay Integrated Resort Project' North Queensland:
Volume I – Cassowary field survey
Volume II – Impacts and mitigation
Volume III – Population viability analysis
Consultancy reports for John Holland Pty. Ltd.

Moore L.A. (2007b). Population ecology of the Southern Cassowary *Casuarius casuarius johnsonii*, Mission Beach, north Queensland. J. Ornithol (2007) 148: 357-366.

Moore L.A. and Moore N.J. (2007). Implications of environmental catastrophes and climate change for the management of an endangered species: the Southern Cassowary *Casuarius casuarius johnsonii*. Austral Ecology.

Moore, L.A. (2007d – in prep). Does the history of the Moa suggest a future for the cassowary? The dilemma of slow birds in a fast world. Animal Conservation.

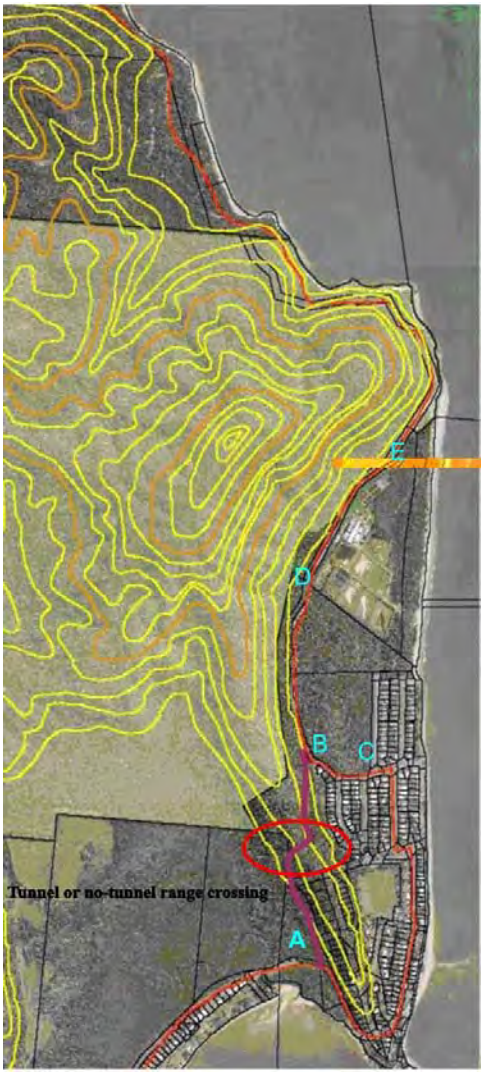
APPENDIX A

5. COMMENTS ON PROPOSED ROAD OPTIONS

Potential road alignments were examined using supplied variations of the route locations shown in Figure 4, and an assessment of their potential impacts on cassowaries xyz are given below:

FIGURE 4

Ella Bay Access Road Alignment Options



5.1 OPTION A: POINTS A-C-B-D (FIGURE 4)

This option does not address the high level of risk faced by cassowaries' crossing over the Ella Bay access road to forage in the Reserve. The current alignment of the road is the primary cause of the road and adjacent Reserve being classified as Negative Value Habitat i.e., birds utilising the vegetation in this area have an unacceptably high risk of injury or death.

5.1.1 Summary

Unless cassowaries are excluded (fenced) out of the road corridor and hence the Reserve, this option does nothing to reduce the risk level of local cassowaries along the Ella Bay access road. If the road is fenced to exclude cassowaries, the Reserve will be permanently lost to cassowaries for foraging. As such, this option is not supported.

5.2 OPTION B: POINTS A-C-D (FIGURE 4)

This route option uses the existing road through the Flying Fish Point township but is then re-aligned east of the Reserve and along the south and west boundaries of the fish farm to the north (Figure 4). Although this route effectively 'recovers' the cassowary habitat of the Reserve and adjacent section of Ella Bay access road, it does not remedy the problem of dog attacks on cassowaries at the southern end of Seymour Range and on the outskirts of Flying Fish Point. In addition, fencing will be required to prevent birds crossing the busy Innisfail Road to access the small area of mangroves to the south. Apparently, community resistance to an upgrading of the road corridor and an increased traffic flow through the township makes it uncertain whether this option will be adopted. Notwithstanding, it is an acceptable option and decreases the risk level of cassowaries considerably i.e., it is probable that with this option the cassowary habitat value in the Reserve can be improved from Negative to Moderate Habitat Value with appropriate mitigation.

5.2.1 Summary

This is an acceptable road alignment which will contribute significantly to reducing the risk level to cassowaries and will increase the Habitat Value of the Reserve and adjacent vegetation. However, it is dependent on community support for its placement. In the planning process, it would be valuable to address the problems of cassowaries crossing the Innisfail Road and the risk of dog attacks at the southern end of the Seymour Range and environs of Flying Fish Point.

5.3 OPTION C: INLAND ROUTE: NO TUNNEL - POINTS A-B-D (FIGURE 4)
OPTION D: INLAND ROUTE: CUT AND COVER TUNNEL (FIGURE 4)

While both of these options have the potential to reduce the risk of birds accessing the Innisfail Road to the south of Flying Fish Point, neither route option addresses the high risk area of the Reserve and adjacent fish farm. If the existing alignment through that area is unchanged and an exclusion fence erected, the Reserve will be permanently lost as a food resource and possible future breeding area for cassowaries. Although it is theoretically feasible to reduce the risk of road crossing birds by using various traffic calming techniques, there are no known traffic calming strategies that could guarantee the safety of birds crossing the road to access the Reserve.

5.3.1 Summary

These two options, while having a beneficial affect at the southern end of Seymour Range, will increase the risk level for cassowaries in the area of the Reserve and adjacent fish farm and, as such, is not supported.

5.4 OPTION E: POINTS A-B-C-D (FIGURE 4)

Option B (Points A-C-D) is an acceptable alignment option and results in a positive contribution to cassowary conservation in the area of the Reserve and fish farm. To reduce potential impacts to cassowaries and other fauna in the area of the range crossing, the road would need to be located as closely as possible to existing residential area and disturbed habitat. The route in this option includes the both Option C and Option D i.e., ‘no tunnel’ and ‘cut and cover tunnel’. Although an impact assessment of both options would need to be conducted prior to choosing which method to use to cross the range, the ‘cut and cover tunnel’ is likely to create less environmental impacts, both visually and ecologically, than the ‘no tunnel’ option.

5.4.1 Summary

If Option B is rejected by the Flying Fish Point community (i.e., road travelling through Flying Fish Point township), this route is considered an acceptable alternative. Prior to recommending the range crossing method however, an impact assessment would need to be conducted exploring any potential impacts on cassowaries, other fauna, and on the hydrology of the swamp and associated vegetation to the west of the proposed route. As the southern end of Seymour Range is classified as "Negative Value Habitat' i.e., unacceptably high risk of road death and dog attacks for cassowaries using it, consideration should be given to fencing at the point of the range crossing to prevent cassowaries from accessing the area. Such exclusion involves the loss of only an extremely small area of low quality and high risk habitat to the south of the range crossing (predominantly comprising houses and a busy road), while increasing the Habitat Value to the north of the crossing considerably (cassowary habitat contiguous with the Ella Bay National Park).

5.5. SUMMARY OF ROAD OPTIONS

The proposed road options and their appropriateness for cassowaries have been rated from Ranking 1 i.e., High Impact for cassowaries, to Ranking 2 i.e., Low Impact for cassowaries. Specific mitigation strategies are suggested for Options A, C, and D, which will significantly reduce the risk for cassowaries that cross the road to access the Flying Fish Point Reserve i.e., preferred option.

5.5.1 Ranking 1 – High Impact Options

- ***OPTION A: A-C-B-D (road-based traffic calming)***

This option is not supported i.e., with road-based traffic calming strategies, due to the permanent separation of the Reserve from the main forest block to the west, and a continuing, although lowered, risk to road crossing cassowaries.

- ***OPTION C:*** ***A-B-D (no tunnel – road-based traffic calming)***

So far as cassowaries are concerned, this option is no different than Option A.

- ***OPTION D :*** ***A-B-D (cut & cover tunnel – road-based traffic calming***

Refer to above comments.

5.5.2 Ranking 2 – Low Impact Options

- ***OPTION B:*** ***A-C-D***

This option is supported by EPA. The reserve will need to be fenced off from the road and the old road revegetated.

- ***OPTION 'B1': A-B-C-D***

This not considered a lesser option than Option B. If adopted, it would allow for cassowaries to be excluded from the southern tip of Seymour Range by cassowary-proof fencing.