6.1 j Cassowary Fence Trial 2010 Ella Bay

ELLA BAY
Far North Queensland

Report on

Cassowary Exclusion Fence Trials

At

Ella Bay

July 2011 Revision 2



Executive Summary

Road deaths are the primary threat to the survival of the endangered Southern Cassowary (*Casuarius casuarius johnsonii)*. Fencing of the road and exclusion of cassowaries from the road corridor has only been trialled in a few locations with partial fencing. The overriding concern with fencing has been the lack of an effective escape mechanism which would allow safe exit for cassowaries inadvertently trapped within a road corridor. Typically in the absence of an effective escape method, a gap in the fence or a funnel trap has been used to allow the cassowary access back through the fence. This has generally meant that the fence is not full length or of full height.

In these trials a continuous cassowary exclusion fence in conjunction with a one-way escape gate has been successfully demonstrated and proven as a practical and cost effective mitigation tool for a cassowary and wildlife barrier. The fence was designed to operate within the rainforest and was trialled in the open paddocks and in the rainforest including a category 5 cyclone. The one-way gate was trialled at the Johnstone River Crocodile Farm and has been reported in the report Volume 6.1i *Cassowary Escape Gate Trials at Johnson River Crocodile Farm.*

The fence was a 1.8m high suspension type utilising shadecloth suspended between strainer end assemblies and stretched taut between a top and bottom wire creating a “soft” physical and visual barrier. The top and bottom wires were held in place by shear clips attached to mid-span posts spaced at 12m intervals between the end strainer assemblies using the tension in the wires to maintain the fence taut.

A number of lengths of fence were constructed 18m, 100m, 200m, 300m in open paddocks and 4 x 30m lengths within rainforest vegetation. Initial trials of mid-span post spacing were at 5 to 10m with the final implementation at 12m with minimal sag. The wide spacing of the mid-span fence posts will minimise the disturbance and clearing required when the fence is run within the rainforest. Far North Queensland is subject to cyclonic winds and the fence has been designed to be pulled down and bundled for temporary storage during a cyclone event. This management technique reduces environmental impact of clearing, excavation and materials transport of cyclone resistant structures within the rainforest.

The shear clip was successfully trialled for protective release of the top wire from branch strike in high winds and for quick release of the shadecloth in preparation for cyclonic weather. During the period of the trials 3 cyclone events occurred with category 1, 2 & 5 cyclones. The management procedure for cyclone preparation will be to drop the fence from the top shear clip and place the top wire in the lower clip and then to bundle and tie the shadecloth with cable ties immediately prior to the cyclone approach. The 300m length of fence in open paddock was left upright for all cyclone events and was able to withstand the wind from the category 1 & 2 cyclone with only loosening of the mid-span posts but was destroyed by cyclone Yasi (category 5). The 4 x 30m lengths of fence within the rainforest were left upright for all cyclone events and survived all the cyclones intact with only shear clip release from branch drop. The 100m and 200m lengths of fence were dropped and bundled for the cyclones and survived intact ready to be reinstated.

The resilience and visual differentiation of the shadecloth for cassowaries was observed during trials of the one way escape gate at Johnstone River Crocodile Farm with captive cassowaries and in two cases with approach from wild cassowaries. The birds were observed not to test the fence and turned and moved away as if the fence appeared as a solid barrier.

The exclusion fence will enable funnelling of the cassowaries and wildlife over or under Ella Bay Road underpass or overpass structures. The fence must also function in a hostile environment of the rainforest with tree branch drop and intense weather including cyclones. The advantages of the suspension fence design and novel shear clips proved to be the simplicity, and functionality.

The trials demonstrated a successful strategy of using a shadecloth fence as a barrier for wildlife which is practical for the future use along the Ella Bay access road. This design and trial results will serve as the basis for future development.

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1. Introduction

The proposed upgrade of Ella Bay Road will include mitigation that aims to prevent road strike mortality for the endangered cassowary. The proponent has designed and is committed to constructing a road which will set new environmental standards and best practise mitigation to prevent cassowary road mortality and maintain habitat connectivity.

The access road from Flying Fish Point to Ella Bay is located on the eastern periphery of Seymour Range within 10 to 500m from the coast and is a known cassowary habitat with the road passing through the furthest extents of the home range of two to three birds. The home ranges have a limited seasonal access to the coastal vegetation.

The method of cassowary traffic mitigation practiced around the Mission Beach area is that recommended by Austroads DMR and FNQROC standard, which is to clear the road verges to maximise sight distance and minimise the risk of cassowary road deaths. This is used with a combination of traffic calming and in some restricted places intermittent roadside fence barriers. This has failed to reduce cassowary deaths at Mission Beach.

An effective method of excluding cassowaries from the road will be required to integrate with the underpasses to provide the most comprehensive mortality risk avoidance. The cassowary fence and barriers will be required to prevent the cassowary both visually and physically. Wire mesh or open mesh cyclone fences are the standard fauna exclusion fence types, however this fence type has had poor results with cassowaries. The birds are reported to be stressed trying to push through what is probably seen by them as a clear visual path, and rub up along the fence for hours trying to push through and injuries have also been reported (Goosem, et al, 2010b).

Best practice fauna sensitive road design as in “Roads in Rainforests” and in WTMA guidelines seeks to minimise clearing and resultant edge effects with minimum road widths and verges to maintain canopy connectivity.

This report focuses on the concept, design and initial trials for a cassowary exclusion fence. Other mitigation will be also used on this road alignment to prevent cassowary mortality caused by vehicle strikes such as, directional fencing, fauna underpasses, fauna overpass, reduced speed, signs, traffic calming devices, etc. Refer to Ella Bay Road Design and Environmental Management Report for details of installation location and extent.

The report in the SEIS *“Ella Bay Resort – Internal and External Fencing Strategy (2008) Prepared by The Missing Link Resource Coordinators Pty Ltd”;* identified, listed and ranked different possible fencing options for Ella Bay’s proposed access road. Subsequently a stakeholders workshop in Cairns 2008 provided further refinement of the design.

2. Design & Concept

The proponent’s strategy will be to use exclusion fencing to prevent cassowaries from entering the road envelope while guiding them towards safe crossing points. The fence will be required to meet the following essential criteria:

- Exclude cassowaries and small fauna from entering the roadway;
- Prevent injuries and death to cassowaries from collision with the fence;
- Act as a visual barrier to cassowaries;
- Be aesthetically sensitive, blending with the rainforest;
- Require minimum clearing and disturbance with easy installation;
- Be resilient to falling branches and debris;
- Be resilient to cyclonic destruction; and
- Have ease of maintenance and care.

The material selected for the fence was shadecloth, both as a visual barrier and as a soft resilient barrier. The fence height parameters were resolved to be a height of 1.8m and a nominal 100mm from the ground at the proponent's Stakeholders workshop (Ella Bay, 2008). It was also concluded that cassowaries rarely use steep slopes greater than 1:1 or where the embankment is vertically greater than 1.5m e.g. gabions walls; fencing would not be required in these areas.

The style of fence adopted was a "suspension fence" with fixed solid end strainers and the shadecloth suspended and tensioned between two wires with intermediate long mid-span carrier posts. Suspension fences are becoming more common in agriculture with support from environmental groups for wildlife friendly fencing. Suspension fencing in agriculture typically has 4 to 5 strands of high tensile light gauge wires with post spacings up to 50 metres and lengths up to 4000 metres. These long lengths and post spacings will not be possible with the additional tension and suspended mass of the shadecloth.

The fence will be located 3m to 12m within the vegetation parallel to the road alignment and within the road reserve. The fence will be required to perform in a difficult environment of the wet tropics within rainforest vegetation in cyclone prone area. The design, installation and maintenance will be required to overcome the major risks of;

- Branches from trees and shrubs dropping on the fence;
- Cyclonic conditions with damage from intense winds and debris;
- Fauna chewing and ripping the fence; and possibly
- Bushfire.

The shadecloth material will be neutral coloured (dark grey, black or dark green) to blend into the vegetation and will have a shade factor of greater than 40% to restrict the visibility of the birds through the fence and provide a significant differential appearance between the fence and the escape gates. The shadecloth will also restrict headlight disturbance within the rainforest. The shadecloth material will be 1.8m high and comprise a sleeve at the top and bottom to which a high tension wire runs. The fence will be tensioned from a strainer assembly with the lower wire tensioned to exclude fauna from lifting up the lower edge of the fence with a nominal 100mm gap and the upper wire tensioned to maintain the fence without sag. The goal will be to run the fence in as long a panels as possible with maximum span between posts as possible to minimise clearing and allow the fence alignment to weave through the rainforest trees.

The failure of shadecloth structures is common in cyclone prone areas and research has established that the shadecloth acts as an apparent solid sheet to high winds with little relief from the open weave (Letchford, Row, Vitale, & Wolbers, 2000). It is neither practical nor desirable to construct the fence to withstand a severe cyclone within the confines of the vegetation without substantial interference and clearing of the vegetation. For such a design the requirement would be 100mm steel posts at closer than 3m spacing concreted in to a depth of 1m and shadecloth to be permanently fixed to posts. This would be too invasive to the vegetation including particular tree roots and create extensive forest interior weed colonisation due to the extra clearing.

A valid engineering solution is to provide a design with a management procedure for extreme conditions. To minimise the damage impact to the fence and reduce the repair costs and downtime of the fence for cyclone events, the construction of the fence will require an operating procedure where the top carrier wire can be manually removed and restrained thereby reducing the threat of damage to the fence. The shadecloth fence will be effectively folded down to the ground and the shade cloth material tied every 2-3m in between posts by use of cable ties or similar to keep it rolled up and safe from damage.

A bushfire is a low risk in the rainforest and were this to occur in the fenced area, the same procedures detailed above will be implemented to minimise damage.

The fence will be required to be resilient to branch strike and a shear method developed such that in extreme conditions the shadecloth and carrier system will absorb shock loads.

The goal of the trials will be to develop and test a shadecloth fence that will be able to:

- Span long lengths between posts;

- Be taut with the lower wire able to prevent animals from lifting up the fence;
- Be resilient such that branch strike does not damage the fence;
- Easily pulled down on approaching cyclone events and reinstalled promptly; and
- Be easily repaired if damaged.

3. Methodology

The fence was developed through three trials of the different fence construction techniques and three different fences have been in place and in operation from November 2009. The design was elaborated by initial discussions and brainstorm sessions between staff and management of which evolved into basic designs which were put into practice in the field. At the end of each trial the results were analysed, further discussed, improved and applied to the design and construction of the subsequent trial.

Results were collected in the form of construction and assembly notes, daily observations, photographic recordings via handheld and motion detection wildlife cameras and observations post significant weather events.

4. Design and Results

Trial #1 - Johnstone River Crocodile Farm Innisfail QLD

The first fence trial was conducted during the Cassowary Gate Trial at Johnstone River Crocodile Farm Innisfail QLD during *August and September 2009.* A shadecloth fence was placed inside the enclosure of two (2) male cassowaries. The fence was set up in a funnel like manner to guide the cassowaries to the one way cassowary gate. The fence was loosely tensioned and was trialled as a physical barrier and to test for visual differentiation by the birds. For more information on this trial, (refer to Volume 6.1i *Cassowary Gate Trial*).

Results

The captive cassowaries were accustomed to cyclone-wire fences where the birds were observed to push against the fence and move along beside the fence typical of caged pacing behaviour a set distance from the fence occasionally rubbing against the fence. This behaviour has also observed with cassowaries trapped by a cyclone mesh fence in the wild. (A Hogg pers. Comm. Seahaven fence)

The shadecloth fence worked well as directional fencing providing a visual cue to the gate and the funnel entrance to the gate. This was demonstrated as effective from the start of the trials as the cassowaries immediately lined up to the escape gate as a means of access to their food supply. This is an important and significant observation as the cassowaries were captive in a cyclone mesh compound and the birds had no previous exposure to gates or a shadecloth fence. The birds' behaviour when introduced to the fence and gate differed to their normal behaviour when walking the compound mesh fence with the birds immediately differentiating the shadecloth fence to the gate and inquisitively moving towards the gate as the means of accessing their food. The cassowaries could see the food container and tried the direct route to their food source through the gate.

There was no sign of the cassowaries wanting to push through the fence which indicated it acted as an effective visual barrier. The fence was also effective as an injury reduction barrier with a bird on one occasion being startled and running into the fence and bouncing backwards from the taut material.

Figure 4.1 Trial #1 Fence and Cassowary Gate

Trial #2 – Ella Bay - Fence Development

This trial was to develop the suspension fence technique; a method of retaining the shadecloth fence in place by a top and bottom tensioned wires in sown sleeves and to develop a shear retaining clip (November 2009). A 100m long fence was constructed. This fence was subsequently modified and formed part of the 200m fence in Trial #3.

Design Details

A 100m x 1.8m shadecloth material was stitched to create a sleeve top and bottom which could carry a 2.8mm high tensile fence wire. This method of attaching the shadecloth to the wire was chosen over other methods (clips, wire ties) due to its practicality, strength, safety and most importantly the ability of stretching the shadecloth both vertically and horizontally without ripping the shadecloth. A 2.8mm high tensile with 8kN breaking strain wire was chosen as it is readily commercially available and had sufficient tensile strength to support the weight of the shadecloth material and make the shadecloth sufficiently taut to provide a solid barrier to wildlife. The high tensile wire will require a force equivalent to a static load 800kg on the wire to break it, therefore the probability of the wire breaking is reduced and debris should brush off the fence.

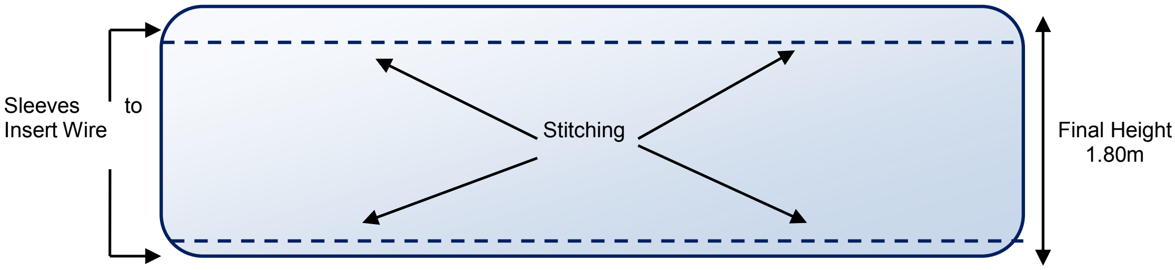

Figure 4.2 Shadecloth height and stitching details

One of the essential criteria for the fence is that the fence is able to be removed quickly and for it to be strong enough to take the tensioning strain horizontally without detaching from posts but releasing from the post if a sudden load such as a branch strike was applied vertically to the fence (figure 4.4).

A shear mechanism was developed to attach the shadecloth fence (top and bottom wires) to the fence posts; this device was designed using a standard steel 75mm R-clip welded to a galvanised coach screw. (figure 4.5).

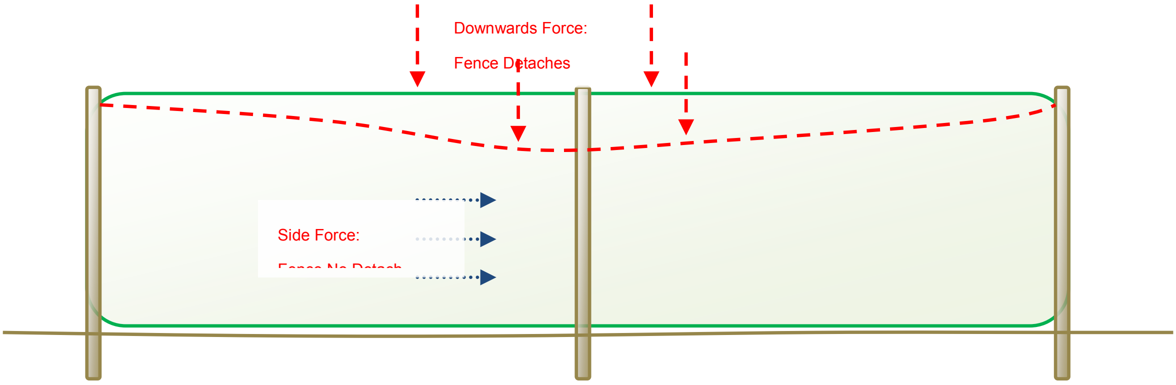

Figure 4.3 Fence Forces

Figure 4.4 R Shear Clip Design

Figure 4.5 R Shear Clip installed

The benefit of the R shear-clip is that the horizontal forces on the wire can be contained but the fence will be released when a vertical downforce is applied (ie falling branch). Once the clip or a number of clips are released the top wire will be required to suspend the fence with tolerable sag until maintenance staff can insert the wire back into the clip.

The wire was attached using fencing wire Gripples to a set of cattle yard strength turnbuckles to allow for minor tension adjustments post fence construction. The fence was tensioned top and bottom and the turn buckles were attached to the strainers with a nominal lower wire gap of 100mm. The shadecloth fence was clipped into place using the R shear-clips.

The diameter of the 2.8mm wire with the shadecloth was insufficient to be held within the R clip and some of the clips released immediately. Standard “Maspro clip” wire was used to hold the ends of the R-clips together and to create a stronger shear tension. Maspro clips were installed for the entire fence length.

Figure 4.6 Trial #2 Fence completed

Figure 4.7 Trial #2 Sag Test

Tests

The fence was tested as a suspension fence with post spacing at 5m, 7m, and 10m spacing. With the fence erected and all available clips attached; the sag between the fence posts was minimal in all spacings. A test where up to six (6) consecutive clips were detached from the top wire resulted in a sag where lowest point reached was to a height of 1.35m (Picture 4.6). Strength and fence integrity was not compromised with the six clips detached.

The action of detaching the wire out of the attachment clip device occurred only when significant downward force was applied by pulling on the top wire. The practice of re-clipping the wire back into the attachment clip and placing a new maspro clip was easily conducted by staff in seconds. The maspro clips assisted in holding the ends of the attachment clips. Further tests concluded that two (2) maspro clips substantially increased support to the attachment clip before detaching it and releasing the wire. The use of the Maspro retaining clips will possibly not be required when using larger diameter stranded wires.

Strength tests were conducted by pushing and pulling on the top and bottom wire horizontally and by pushing on the middle of the shadecloth fence to simulate an animal running into it. These tests resulted in no damage to the fence or its integrity and no injuries to the person as the tension of the wires combined with the elasticity of the shadecloth cushioned the impact and sprung back. The bottom wire was tested by pushing and pulling against it.

The fence was observed daily for a total of four (4) weeks where it was noticed on a number of occasions wallabies jumping and running into the fence. No wallabies were injured by the shadecloth fence as the stretched shadecloth absorbed the impact and sprung the wallabies back.

Trials #3- Ella Bay – Fence Trials

Trial #3 focused on

- Improving the construction for ease of installation and maintenance in a rainforest environment;
- Testing the catenary sag over distance;
- Testing assembly and component strength;
- Construct trial fences of 100m,200m and 300m length with 12m post spacing;
- Observation of fauna impact; and
- Extended testing in all weather conditions.

Design Details

The timber strainer posts were replaced with an 80mm steel pipe assembly structure with 40mm steel tube braces assembled with standard universal galvanised fence fittings. CCA treated pine logs were used for the mid-span posts at 12m spacings.

Figure 4.8 Pipe Strainer Design

Figure 4.9 Trial #3 Strainer and Turnbuckle

The mid-span post spacing of trial #2 proved to be too conservative with only millimetres of sag between posts. The spacing was increased to 12m as a practical distance given the constraints of running the fence within the vegetation along Ella Bay Road. The majority of the required fence runs (distance between strainer assemblies) along Ella Bay are relatively short between 100 to 300m between mitigation structures. Only one length is longer at 1055m however this fence will require a number of intermediate strainers to manage a fauna culvert and tight curvature. As a result of this it was decided to construct 3 fences of 100m, 200m and 300m under slightly different conditions. All fences would ultimately be exclusion fences for revegetation areas.

Stage 1 - West Side		Stage 1 - East Side	
Fence Chainage	Section Length (m)	Fence Chainage	Section Length (m)
100	285	90	295
385		385	
510	185	510	185
695		695	
695	1055	695	115
		810	
		1500	110
1750		1610	
2760	190	2850	100
2950		2950	
3015	200	3025	165
3215		3190	
3265	355	3265	150
3620		3255	
3990	20	3995	15
4010		4010	

Table 4.1 Ella Bay Road Stage 1 Cassowary fence lengths

Tests

The first test was to compare predicted calculated catenary sag to actual and suitability of the 8kN top wire. A 150m length of shadecloth fence without mid-span posts was tensioned by pulling in straight line with a tractor to breaking of the 8kN high tensile wire and the sag measured. (refer to Appendix 2)

The shadecloth fence (170g/m²) was lifted 1.5m off the ground at the centre of the span before the high tensile 2.8mm 8kN wire failed (the wire is rated at a minimum breaking strain of 8kN). The test was repeated two (2) times with similar results. The shadecloth fence only sagged 0.3m over 150m. In practice the top wire would be tensioned to 50% of the breaking strain with mid-span posts. If the shear clips fail and release the fence the additional mass of unsupported fence would not be exceeded only the sag would be greater. The theoretical sag for tensioning to 50% for 150m would be 1.1m of sag. That is if all the clips were released in a length of fence 150m long the fence would be 0.9m high in the centre. When the shadecloth starts to lift there is very little tension, but there is significant increase in force as the shadecloth mass is lifted due to the wire supporting the mass of the shadecloth which is progressively lifted from the ground with increase in tension.

Figure 4.10 Fence sag test – no posts

Figure 4.11 Fence erected for revegetation lot.

The second trial was to complete the fence by clipping up the top wire and then trial dropping the fence to simulate a cyclone event. The fence was dropped down by one person by un-tensioning the turnbuckles and eyelet bolts. The shadecloth was rolled and secured to the posts by the use of a plastic cable tie.

Re-erecting the fence was more difficult and specific tensioning equipment (small hand winch or lever system) will be required to re-join the top wire to turnbuckles.

Refer to fence performance in Cyclone & Weather Effects.

Figure 4.12 Dropped fence

Figure 4.13 Contained fence to posts

Fencing within Vegetation

All the initial testing was undertaken in cleared areas whereas the Ella Bay Road cassowary exclusion fence will be run within the vegetation. To test the constructability and efficiency of the shadecloth fence in densely vegetated rainforest environment, three trial fence sections were erected through thick vegetation. This test assisted in experiencing the issues and difficulties in constructing the fence without clearing. The fences were relatively short length 30m and constructed adjacent to and intersecting the riparian areas along the East West Creeks.

Within the vegetation both CCA posts and growing trees were used to support the top and bottom span wires. In the case of the growing trees the coach-screw end of the clip was screwed into the trees through the bark – no blazing was used. The vegetation was cleared by cane knife (machete) to walking path width to provide minimum access. The fence posts were dug by a one-man postborer where required and if possible trees were used to minimise disturbance. No evidence of weed incursion was found 18 months later.

The fence within the vegetation suffered no damage over the 2009/10 wet season with a number of small branches falling on the fence; not sufficient to release the shear clips and one section of fence partially flooded without damage to the fence. During the 2010/11 wet season the sections of fence were left erect for all cyclone events without being dropped.

Figure 4.14 Side view Fence through riparian vegetation. Untouched for 1½ years

Figure 4.16 End View Fence through riparian vegetation Untouched for 1½ years

Figure 4.15 Shear clip attachment to tree using coach screw Untouched for 1½ years

Figure 4.17 Fence within, dense vegetation showing minimal clearing

Photo Fig 4.17 was taken after erection, and photos Fig 4.14, 4.15 & 4.16 were taken after 1½ years after with the only maintenance being removal of a log and re-clipping the fence shown in Figure 4.28 and 4.29.

Weather Effects

The three trial fences 100m, 200m and 300m were built in open paddock areas in the north of the property. There was no evidence of any damage or deterioration to the shadecloth material due to high rainfall and direct sunlight during the period of observation of 1½ years. There was some loosening of the CCA mid-span posts during the period following high wind and soaking rains.

The 300m fence (4.18,19) showed loosening of the mid-span posts as a result of high wind events with peak gusts estimated at 60+km/h. Average windspeed data (5 minutes) collected from Ella Bay weather station on 15/03/2010 32+km/h, 22/10/2010 36+km/h, 25/12/2010 35+km/h, 23/01/2011 29+ km/h. The strong winds caused the shadecloth to act like a sail putting pressure on the posts.

The posts moved within the sandy soil. It was noted that even though the 300m fence was leaning to one side, very few clips were released and the tension of the wire held the integrity of the fence. Most importantly the fence remained secure.

Figure 4.18 Post movement from High wind

Figure 4.19 fence lay down from high wind

Tropical Cyclones

Three cyclone events occurred during early 2010-2011 cyclone season;

- Cyclone Tasha Cat 1 - 23/12/2010 crossed within 50km of Ella Bay – winds to 75km/hr
- Cyclone Anthony Cat 2- 22/1/2011 ran parallel 50km offshore – winds to 75km/hr
- Cyclone Yasi Cat 5 - 2/2/2011 crossed south of Innisfail – winds to 200km/hr.

The 300m fence was left erected for all cyclones. For Cyclone Tasha and Anthony no damage was recorded only the loosening of the fence posts as noted above due to high winds. The suspension fence concept worked as designed and the mid-span fence posts moved.

Cyclone Yasi Category 5 (February 2011) however provided extreme weather conditions to test the fence design and management.

- 100m fence. This fence had been dropped and tied for a long term trial on the ground. No damage.
- 200m fence. The middle section of this fence had suffered damage from a tractor slashing incident during 2010. The ends of the fence (30m) extended into vegetation and were left upright to evaluate damage from the cyclone. The fence remained intact with the only loss of integrity being that a 250mm diameter branch dropped on one section which released one of the shear clips. Refer to figure 4.28 and 4.29.
- 300m fence. This fence was left upright. The fence was located in a cleared paddock was exposed to the full strength of the cyclone Yasi The fence was damaged with the shadecloth ripping and CCA posts dislodged, however there was no strainer post damage.

Figure 4.20 Cyclone Yasi 100m fence dropped and tied - no damage

Figure 4.21 Cyclone Yasi 200m fence dropped and tied – no damage

Figure 4.22 Cyclone Yasi 300m fence- south No damage to shadecloth locally

Figure 4.23 Cyclone Yasi 300m fence north. Shade-cloth stripped and posts removed

Figure 4.24 Cyclone Yasi 300m fence - south. Clip did not release and fence ripped

Figure 4.25 Cyclone Yasi 300m fence south. Tree up-rooted, no damage locally

Figure 4.26 Cyclone Yasi 300m fence – Southern end. Cassowary gate and local shadecloth intact. Note vegetation damage behind fence.

The southern end was less damaged due to the predominant cyclone wind direction from the south. The shadecloth fence locally around the end strainer and the short length to the cassowary gate and within the vegetation were intact. The shade cloth was torn at attachment to the southern strainer assembly and at one mid-span post where the shear clip did not release. Only one mid-span post was dislodged. The vegetation damage directly behind the cassowary gate in Fig 4.26 is testament to the wind intensity.

At the northern end the fence near and within the vegetation performed well with no damage. The northern section of the fence from a mid point strainer was damaged by the breaking of the high tension wires and then flailing of the loose shadecloth with the wind. In all 8 posts were dislodged and swept away. The fence was extensively damaged for the last 50m with fraying of the shadecloth material.

Figure 4.27 Cyclone Yasi 300m fence Northern end. Fence into the vegetation intact and undamaged. The section of fence and posts from the mid-strainer destroyed.

Figure 4.28 Cyclone Yasi 200m fence dropped and tied (no damage)

Figure 4.29 Cyclone Yasi 200m fence after re-clip showing minimal impact

Fence and Cassowary Gate

The third trial was to construct a 300m length of fence and to use this fence for exclusion of wallabies from the North West revegetation site. The fence was a straight fence between two creeks and separated the cleared grass pasture favoured by the wallabies and the revegetation. The fence only provided partial exclusion from the revegetation with all other directions accessible through riparian vegetation or across creeks. Cassowaries are known to use the area around the revegetation trial area (NW). A cassowary gate at the southern end of the fence was installed and its usage was monitored by the use of wildlife cameras.

Cassowary evidence was found in the proximity, approximately 50m from the gate; however no cassowaries were recorded by the monitoring cameras either near the gate or using the gate. The trial was opportunistic and did not provide an exclusion that could specifically trial the gate for cassowaries. It was not in a known pathway nor was the fence sufficiently complete that cassowaries were forced to use the gate for access.

However Agile wallabies were recorded using the gate on numerous occasions. It appears that if the wallabies accessed the revegetation they then exited through the cassowary gate. there are no instances of the wallabies accessing the gate from the incorrect one way direction.

Figure 4.30 Cassowary Gate Revegetation site

Figure 4.31 Cassowary Gate

Figure 4.32 One of numerous examples of Agile wallabies using the cassowary one-way gate

Wildlife Fence Interaction

There are extensive numbers of Agile wallabies at Ella Bay and the grazing pressure in certain areas is extreme. The northwest revegetation area was home to between 50-100 wallabies and although initially sprayed with herbicide and laid fallow for over 6 months continued to attract wallabies to the area. The erection of the fence to exclude the wallabies and the planting of desirable palms and shrubs created a strong attraction for the wallabies such that they appeared to attack the fence. It was observed that the wallabies created many holes in the shadecloth material by jumping into the fence and damaging it with their hind claws or chewing and opening holes with their front paws on the fence. The wallabies were also found persistently digging the soft soil to make their way under the fence wire.

The holes were repaired by hand stitching a shadecloth patch or silicone gel to bond the materials together and at some locations logs were placed along the fence where the terrain dipped and created a larger gap between the fence and ground to dissuade digging.

Figure 4.33 Wallaby attack on the fence

Figure 4.35 Wallabies grazing and chewing on fence

Figure 4.37 Wallaby testing fence

Figure 4.34 Hole from wallaby claw

Figure 4.36 Temporary repair using glue on patch

Figure 4.38 Temporary repair using silicone

The extent of the repeated wallaby attack was unexpected and various efforts were trialled including gas cannon, Bitterant spray, and killing the grass for a further 20m to the fence without success. The only deterrent to be effective was a single electric wire running approximately 300mm above the ground. This instantly stopped the attacks and little further damage was caused. It is interesting that the wallabies repeatedly attacked the fence but did not venture around the ends of the fence through the vegetation or cross the creek from other clearings to reach the newly planted palms and shrubs.
It appears that the habituation of the displaced wallabies to that area was strong. After 12 months with an energised electric fence the fence was turned off and there were very few attempts to cut through the shadecloth.

Figure 4.39 Wallaby testing the electric fence

Figure 4.40 The deterrent has not yet worked

Monitoring cameras recorded two occurrences of cassowaries approaching the fence and one scat was recorded in the vicinity during one of the cassowary surveys.

On both occasions the cassowary approached the fence and turned away without touching the fence. In the sequence below the cassowary turned before touching the electric fence wire. This is a totally different behaviour to that reported and observed with Cyclone mesh fences where the cassowary tracks repeatedly back and forward along the fence and demonstrates the same behaviour observed with the captive cassowaries at the Johnstone River Crocodile Farm.

Figure 4.41 Cassowary interaction with the fence showing the cassowary turning and walking away. .

5. Cost Analysis Forecast

A budget costing of the fence of $90/m has been estimated from the trial. Table 5.1 and 5.2 provide the cost forecast for the proposed cassowary fence including one-way escape gates along Ella Bay Road. The costs are based on the current costs.

	Material	Labour Strainer/Posts	Labour Shadecloth	Totals
		Stage 1 West *2,290m*		
$ Fence Length	$ 130,622.28	$ 25,974.33	$ 40,552.08	$ 197,148.69
$per metre	$ 57.04	$ 11.34	$ 17.71	$ 86.09
		Stage 1 East *1,135m*		
$ Fence Length	$ 69,843.19	$ 12,881.33	$ 20,098.96	$ 102,823.49
$per metre	$ 61.54	$ 11.35	$ 17.71	$ 90.59

Table 5.1 – Stage 1 Cassowary Fence Cost Estimate

	Stage 1 *3,425m*	**Stage 2** *785m*	**Stage 1 + Stage 2**
Fence Total	$ 299,972.18		
Equipments	$ 6,500.00		
Construction Total	$ 306,472.18	$ 70,242.53*	**$ 376,714.71**
Total $ per metre	$ 89.48	$ 89.48	

Table 5.2 – Stage 1 + Stage 2 Cassowary Fence Cost Estimate

** Stage 2 cost was calculated by multiplying the $ per metre cost of stage 1 to the length of fence required*

6. Conclusion

The cassowary exclusion fence was successfully demonstrated and proved a practical and cost effective mitigation tool for cassowary and wildlife protection from vehicle strike along Ella Bay Road. The fence was tested in all conditions expected within the rainforest including a category 5 cyclone. The advantages of the suspension fence design and novel shear clips proved to be the simplicity, and functionality.

The suspension fence comprised a 1.8m shadecloth material suspended between strainer end assemblies and stretched taut between a top and bottom wire creating a "soft" physical and visual barrier. The resilience and visual differentiation of the shadecloth for cassowaries was observed during the one way escape gate trials and in two instances in the field trials.

The "R shear clip" design proved functional in cyclone management with storage of the shadecloth by dropping and tying; and an elegant solution for its simplicity for minimising damage from branch strike during testing under the most arduous conditions of Cyclone Yasi,

The fence section within the vegetation survived intact without storage during 3 cyclones; Tasha; Anthony and Yasi (Cat 1, 2 & 3) with demonstration of the shear clip release during cyclone Yasi. The fences that were in open paddocks survived intact without storage during cyclones Tasha and Anthony, while during cyclone Yasi the fences that were stored by dropping and tying survived without damage. The 300m fence left upright during cyclone Yasi was destroyed. The management practice of temporarily storing the shadecloth fence during extreme weather events proved to be a successful.

The proposed management practice will be that the fence will only be pulled down immediately prior, during and immediately post adverse weather events. (Moore, 2009) has indicated that following cassowary surveys at Ella Bay area in February 2008, that cassowaries relocate during the extreme wet season to higher ground on the Graham Seymour Range, and this may be tied to cyclonic threat (Buosi, 2009b) this would significantly reduce the risk of interaction. However additional traffic management procedures will be required to minimise the risk of cassowary vehicle strike while the fence is down, such as temporary warning signs will be used identifying that the fence has been temporarily removed and the vehicle speed limit reduced to 40km/hr.

The fence was damaged by the chewing and sharp claws of the wallabies and a single strand electric wire was used to prevent further damage. The requirement of an electric wire was thought to be solely a characteristic of the large wallaby population and would not be necessary along Ella Bay Road. If the electric wire is required it is thought that it will only be a temporary until the small macropod population has become familiar with the fauna underpasses.

Further investigation will be required with sourcing stainless steel components for the shear clips, turnbuckles and wire, testing shear clips and wire diameter release force to eliminate the Maspro clip and optimising the cost of the sleeved shade cloth.

Appendix 1 – Fence Trials Specification Table

	Trial #1 JR Croc Farm	Trial #2	Trial #3				
			Sag test	100m fence	200m fence dropped tied	300m fence Revegetation	Within vegetation
Fence Material	120gsm	170gsm	170gsm	170gsm	170gsm	170gsm	170gsm
Total Length	17.8m	100m	150m	100m	200m	150m x 2	Multiple lengths
Fence Posts	Star Pickets	CCA Posts 2.4m (0.6m deep)	N/a	CCA Posts 2.4m (0.6m deep)	CCA Posts 2.4m (0.6m deep)	CCA Posts 2.4m (0.6m deep)	CCA Posts 2.4m & Trees
Post Spacing	1.6m, 6.7m, 2.9m, 3.3m, 3.3m	5m, 7m, 10m	N/a	12m	12m	12m	various
Height	1.9m approx	1.8m	N/a	1.8m	1.8m	1.8m	1.8m
Strainer Posts	N/a	Wood Logs 400mm width, 1m deep	Metal posts 3.25m x 80mm diameter (1.35m deep, concreted)	Metal posts 3.25m x 80mm diameter (1.35m deep, concreted)	Metal posts 3.25m x 80mm diameter (1.35m deep, concreted)	Metal posts 3.25m x 80mm diameter (1.35m deep, concreted)	Metal posts 3.25m x 80mm diameter (1.35m deep, concreted)
Strainer Assembly	N/a	H Frame Wood Logs	Metal post 3.25m x 40mm diameter @ 45 angle (concreted)	Metal post 3.25m x 40mm diameter @ 45 angle (concreted)	Metal post 3.25m x 40mm diameter @ 45 angle (concreted)	Metal post 3.25m x 40mm diameter @ 45 angle (concreted)	Metal post 3.25m x 40mm diameter @ 45 angle (concreted)
Wire	Standard fence wire	2.8mm High tensile	2.8mm High tensile	2.8mm High tensile	2.8mm High tensile	2.8mm High tensile	2.8mm High tensile
Tension	Low/hand tension	High/machine tension	High/machine tension	High/machine tension	High/machin e tension	High/machine tension	Low/hand tension

Appendix 2 – Fence Sag Versus Tension

The theoretical cassowary fence sag was calculated from the calculation of catenary sag of incremental unit mass of a stretched wire. The red and orange bands represent the change in tension and sag for the top wire as the mass of shadecloth is lifted as the wire is shortened (screwed up) and the tension increased. The red band represents full tension to breaking while the orange represents tension to 50% of breaking strain which would be the typical top wire operating tension.