The provision of canopy bridges to reduce the effects of linear barriers on arboreal mammals in the Wet Tropics of northeastern Queensland.

Thesis submitted by

Nigel Graeme WESTON, BPD (Planning) (Melbourne University), PG.Dip.Sci (James Cook University) in August 2003

For the degree of Master of Science in the School of Tropical Environment Studies and Geography and the Centre for Tropical Urban & Regional Planning at James Cook University of North Queensland
STATEMENT OF ACCESS

I, the undersigned, the author of this thesis, understand that James Cook University will make it available for use within the University Library, and, by microfilm or other means, allow access to users in other approved libraries.

All users consulting this thesis will have to sign the following statement:

In consulting this thesis I agree not to copy or closely paraphrase it in whole or in part without the written consent of the author; and to make proper acknowledgement for any assistance that I have obtained from it.

Beyond this, I do not wish to place any restriction on access to this thesis.

............................................  ................................

NIGEL GRAEME WESTON
STATEMENT OF SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education.

Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

........................................  .....................

NIGEL GRAEME WESTON
ABSTRACT

In 1995, Queensland Environmental Protection Agency personnel designed and built an inexpensive aerial connection (canopy bridge) across a rainforest road near Cairns in northeast Queensland. This was done in response to studies showing that habitat fragmentation caused by roads was isolating animal populations and impeding genetic interchange. Tree-dwelling species appeared to be particularly susceptible and it was reported that canopy connections were probably crucial for some rare species in the Wet Tropics. The canopy bridge was subsequently promoted by the Main Roads Department, among others, as a means of encouraging safe fauna movement across road corridors in the region. As the effectiveness of these had not yet been determined, it was recommended that canopy bridge trials be undertaken.

A review of the existing scientific literature and secondary sources revealed that the first bridge for arboreal mammals was built in 1963 in Longview, Washington State, United States, to promote the safe crossing of a busy highway by squirrels. Since then, crossing structures have been erected in at least ten countries. These range from simple ropeways to more elaborate structures. As of this writing, at least four canopy bridges are being trialed or considered for use in Australia.

The trials I conducted at the existing bridge near Cairns, using methods such as spotlighting, analyses of hair and faecal pellet samples and remote photography, demonstrated that at least five arboreal and scansorial mammal species were using it to cross the rainforest road. When it became clear that arboreal species were indeed using
the existing bridge as a crossing route, additional studies were initiated. These were designed to test whether design and position influenced usage of the bridges by arboreal mammals. Two simplified bridges were erected along an abandoned snig track near Millaa Millaa on the Atherton Tablelands. This decision was based on several factors including prior knowledge of arboreal mammal assemblages within the area and the presence of suitable vegetation. Another consideration was the narrow configuration of the track resulting in overlapping tree canopies that were unlikely to impede the movement of arboreal mammal species. The animals generally preferred to use the natural crossings with only two verified crossing events recorded.

One of the simplified bridges used over the snig track was subsequently removed, lengthened and installed along an old highway between Millaa Millaa and Ravenshoe on the Atherton Tablelands. The most important consideration in this instance was the configuration of the road corridor – it was of a sufficient width and length to represent a likely impediment or heightened risk for the movement of arboreal mammals. Although it took five months for a verified crossing event to occur, these events increased in frequency the longer the trial continued until they became commonplace. In total, 52 completed crossing events involving at least four arboreal mammal species were recorded over an 80-hour period. Thirty-five involved rainforest ringtails, 16 involved brushtails, one a striped possum and another an unidentified small mammal. This equates to a crude possum-crossing rate of one every 1.5 hours. However, the rate increases to approximately one possum-crossing every hour when the time between the bridge being installed and the first crossing event (presumably a period of familiarisation) is discounted and to just under three crossings per hour over the final twelve hours of direct
observation at the site. It remains unclear how many individual animals made the crossing, although repeat sightings of the same individual were likely.

A constraint of this study was that replication was impossible due to financial and bureaucratic constraints. However, a pilot study such as this was needed to provide insight before a more large-scale highly replicated study could be attempted. The study showed that arboreal and scansorial mammals would use canopy bridges to cross roads in the Wet Tropics region, especially where no canopy connectivity remains. It could therefore be argued that the conservation of some arboreal species would benefit from canopy bridges becoming a standard feature of road design. Canopy bridges could also become tourist attractions and raise community awareness about the dual problem of roadkill and habitat fragmentation. In this way, canopy bridges have the potential to pay an important role in the presentation and transmission of World Heritage values in the Wet Tropics.

*Keywords: canopy bridge, arboreal mammals, roads, Wet Tropics.*
# CONTENTS

## CHAPTER 1: GENERAL INTRODUCTION

1

**INTRODUCTION**

1

**THEORETICAL AND APPLIED RELEVANCE OF THE RESEARCH**

2

**AIMS OF RESEARCH**

5

  **Research questions**

  5

**THESIS OUTLINE**

6

## CHAPTER 2: REVIEW

8

**INTRODUCTION**

8

**ROAD EFFECTS**

9

  **Roadkill**

  9

  **Road-effect zone**

  12

  **Barrier effect**

  13

  **Arboreal species at risk**

  14

**REDUCING ROAD IMPACTS**

16

**LINKING LANDSCAPES**

18

**TECHNOLOGICAL SOLUTIONS**

19

  **Wildlife crossing structures**

  20

  **Crossing structures for arboreal species**

  23

    **Ropeways**

    25

    **Pole bridges**

    30

    **Monkey bridges**

    31

    **Rope tunnels**

    35

    **Other structures**

    36

**SUMMARY**

38

## CHAPTER 3: IMPLICATIONS FOR MANAGERS OF ROAD SYSTEMS AND WILDLIFE IN THE WET TROPICS REGION

39

**INTRODUCTION**

39

**BIODIVERSITY CONSERVATION**

40
CHAPTER 4: USE OF CANOPY BRIDGES BY ARBOREAL MAMALS IN THE WET TROPICS REGION – MATERIALS & METHODS

INTRODUCTION

OVERVIEW OF STUDY AREA

SITE SELECTION

B Road
Snig track
Old Palmerston Highway

ARBOREAL SPECIES ASSEMBLAGE

STUDY SITE DESCRIPTIONS

B Road (Site 1)
Snig track (Site 2)
Old Palmerston Highway (Site 3)

B ROAD: FIELD STUDY

Scat collection
Remote photography
Direct observation (spotlighting)
Data logging
Hair sampling
Playback calls

SNIG TRACK: FIELD STUDY

Scat collection
Remote photography
Direct observation (spotlighting)
RESULTS OF CANOPY BRIDGE TRIALS UNDERTAKEN IN THE WET TROPICS REGION

Species use 130
Rope tunnel 131
Rope ladders 132
Ropeways 133

THEORETICAL IMPLICATIONS 134
Canopy connections and climate change 136

PRACTICAL IMPLICATIONS 142
Presentation of World Heritage values 144
Permit requirements 148
Vandalism 149
Bridge placement 151

FUTURE RESEARCH 154
CONCLUDING REMARKS 156

BIBLIOGRAPHY 157

PERSONAL COMMUNICATIONS 182

APPENDICES

Appendix 4.1 Detailed plant species lists from the three study sites
Appendix 4.2 QDMR Old Palmerston Highway bridge permit conditions
Appendix 5.1 Barbara Triggs’ hair and scat analyses
Appendix 5.2 Selected Buckshot RTV photographs taken at the B Road site between 29/12/01 and 9/2/02
Appendix 5.3 Scat collection results from the snig track site (22/1/01-26/3/01) (D. Clague, pers. comm.)
Appendix 5.4 Selected stills captured from video footage of two crossing events at the Old Palmerston Highway site (27/3/02 & 31/8/02)
Appendix 6.1 Selected press clippings
Appendix 6.2 Articles written for Wildlife Australia on this project
Appendix 6.3 Road hierarchy in current core bioclimatic zone of rainforest folivores
Appendix 6.4 Problem (high mortality) spots and prioritised potential corridors for tree-kangaroos in the study area (from Izumi 2002)
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Wet Tropics region, northeast Queensland, with the World Heritage Area shaded</td>
</tr>
<tr>
<td>2.1</td>
<td>First ropeway in Longview, United States</td>
</tr>
<tr>
<td>2.2</td>
<td>Red squirrel using a ropeway on the Isle of Wight, England</td>
</tr>
<tr>
<td>2.3</td>
<td>Ropeway erected above Easthill Road, Ryde, on the Isle of Wight</td>
</tr>
<tr>
<td>2.4</td>
<td>Channel Highway ropeway, Kingston, Tasmania</td>
</tr>
<tr>
<td>2.5</td>
<td>A simplified illustration of the pole bridge at the Rio Claro farm of Duratex S.A., Lencois Paulista, Sao Paulo, Brazil</td>
</tr>
<tr>
<td>2.6</td>
<td>Colobridge across the Diani Beach Road, Diani, Kenya</td>
</tr>
<tr>
<td>2.7</td>
<td>An Angolan colobus monkey using a colobridge in Kenya</td>
</tr>
<tr>
<td>2.8</td>
<td>Monkey bridge in Punta Laguna, Mexico</td>
</tr>
<tr>
<td>2.9</td>
<td>A Taiwanese macaque relaxes on a monkey bridge near Nantow, Taiwan</td>
</tr>
<tr>
<td>2.10</td>
<td>Monkey bridge across the New Cross Central Taiwan Highway, near Nantow, Taiwan</td>
</tr>
<tr>
<td>2.11</td>
<td>Rope tunnel across a forestry road in the Wet Tropics, Australia</td>
</tr>
<tr>
<td>2.12</td>
<td>A sugar glider takes advantage of a route to an isolated tree. The generic name for this species, <em>Petaurus</em>, translates to 'rope dancer' (Lindenmayer 2002).</td>
</tr>
<tr>
<td>3.1</td>
<td>Recorded locations of the lemuroid ringtail possum, with WTWHA shaded. Scale 1:6 million approx.</td>
</tr>
<tr>
<td>3.2</td>
<td>Canopy bridge</td>
</tr>
<tr>
<td>4.1</td>
<td>Study site locations</td>
</tr>
<tr>
<td>4.2</td>
<td>Canopy bridge held taut by plastic spacers and attached to telegraph poles at each end</td>
</tr>
<tr>
<td>4.3</td>
<td>Snig track site, showing wide bridge in foreground, narrow bridge at rear and collection nets underneath</td>
</tr>
<tr>
<td>4.4</td>
<td>Canopy bridge being installed over the Old Palmerston Highway, April 2001</td>
</tr>
<tr>
<td>4.5</td>
<td>Aerial photo showing the Old Palmerston Highway wending its way through the Maalan State Forest (arrow shows approximate location of bridge). Scale 1:25,000 approx.</td>
</tr>
<tr>
<td>4.6</td>
<td>4.6a, left, Data logger (<em>Tinytag Plus</em>) attached to an infrared detector, enclosed within a weatherproof case and powered by a 12-volt rechargeable battery; b, right, A 3-section extension ladder was used to access the logger to download data to a laptop computer</td>
</tr>
</tbody>
</table>
4.7 Hair curtain used to test for the presence of folivorous species on the wide bridge

4.8 4.8a, left, Scat trap; b, right, Scat traps in place under Old Palmerston Highway bridge (note hairtube at far end of bridge)

5.1 Lemuroid ringtail scats deposited in net below B Road bridge on 30/7/00

5.2 Remote photos taken at the entrance to the B Road bridge (clockwise, from top left): a, First photo of a rainforest ringtail (prob. *H. lemuroides*), taken 13/1/00; b, Lemuroid ringtail, taken 23/4/00; c, Green ringtail, taken 12/5/00; d, Lemuroid ringtail, taken 29/8/00 (note B&W film)

5.3 Conventional photos of rainforest ringtails moving along the top surface of the B Road bridge: a, left, Lemuroid ringtail with back-young heading north-south on 14/10/00; b, right, Herbert River ringtail heading in the opposite direction on 30/11/01

5.4 5.4a, left, Conventional photo showing a Herbert River ringtail approaching the data logger on top of the B Road bridge; and b, right, moving through the structure on 25/10/01

5.5 Total number of hits recorded by the data logger installed on top of the B Road bridge between 25/11/01 and 29/12/01

5.6 5.6a, left, Remote photo of lemuroid ringtail inspecting the B Road rope on 17/10/00; b, right, One of many remote photos of track maintenance activities taken on 18/10/00

5.7 Remote photos of two arboreal mammals attending a flowering bumpy satinash, *Syzygium cormiflorum*, near the snig track bridge site: a, left, Striped possum; and b, right, Long-tailed pygmy possum

5.8 Remote photo of unidentified mammal on the wide bridge, taken 15/1/01

5.9 Remote photos of a Herbert River ringtail crossing the wide bridge on a, top, 4/11/01; and b, bottom, 13/11/01

5.10 Remote photos of a brushtail on the Old Palmerston Highway bridge, taken 9/9/01

5.11 Lemuroid ringtail photographed crossing the Old Palmerston Highway bridge at 10.15 pm on 26/10/01 (note scat collection devices)

5.12 5.12a, top, Coppery brushtail photographed crossing the Old Palmerston Highway bridge in a north-south direction at 9.00 pm on 8/3/02; b, bottom, Lemuroid ringtail heading in the opposite direction at 8.00 pm on 19/6/03

5.13 Crossing events observed in subsequent five hour periods spent at the Old Palmerston Highway site between 7/4/01 and 2/7/03 (n=53)
<table>
<thead>
<tr>
<th>FIGURE</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.14</td>
<td>5.14a, top, Richly-coloured coppery brushtail crossing the Old Palmerston Highway bridge at 10.30 pm on 8/11/02; b, bottom, Sub-adult and adult Herbert River ringtail crossing simultaneously at 12.32 am on 20/6/03</td>
<td>121</td>
</tr>
<tr>
<td>5.15</td>
<td>Crossing events observed between 7.45 pm and midnight on 19/6/03 and between midnight and 5.45 am on 2/7/03 (n=26)</td>
<td>122</td>
</tr>
<tr>
<td>5.16</td>
<td>Brushtail hair attached to tape on the hair curtain installed on the Old Palmerston Highway bridge</td>
<td>124</td>
</tr>
<tr>
<td>5.17</td>
<td>5.17a, left, Old Palmerston Highway bridge after being vandalized in early December 2001 (ht. 4.75 m) and b, right, Correct height of bridge (ht. 7.5 m)</td>
<td>127</td>
</tr>
<tr>
<td>6.1</td>
<td>Accessible areas continue to be cleared in the Wet Tropics region. This photograph was taken near Site 3 in March, 2001.</td>
<td>137</td>
</tr>
<tr>
<td>6.2</td>
<td>Current core bioclimatic zone of rainforest folivores (after Kanowski 1999)</td>
<td>138</td>
</tr>
<tr>
<td>6.3</td>
<td>Core bioclimatic zone of rainforest folivores after a 1°C increase in temperature (after Kanowski 1999)</td>
<td>139</td>
</tr>
<tr>
<td>6.4</td>
<td>Core bioclimatic zone of rainforest folivores after a 2°C increase in temperature (after Kanowski 1999)</td>
<td>140</td>
</tr>
<tr>
<td>6.5</td>
<td>Excerpt from children’s book, ‘Animals at Risk’ (Keyt 1998)</td>
<td>145</td>
</tr>
<tr>
<td>6.6</td>
<td>Water vine, <em>Cissus hypoglauca</em>, creeps over the original bridge on the B Road. This is a favoured food species of the rainforest ringtails (Winter &amp; Goudberg 1995b).</td>
<td>147</td>
</tr>
<tr>
<td>6.7</td>
<td>A roadkilled striped possum along Yorkeys Knob Road, at a location where the road bisects a riparian corridor. This species was recorded using canopy bridges to cross both the B Road and Old Palmerston Highway.</td>
<td>154</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Wildlife crossing structures (from Reynolds 1998)</td>
<td>21</td>
</tr>
<tr>
<td>3.1</td>
<td>Rare and threatened terrestrial mammals of the Wet Tropics</td>
<td>50</td>
</tr>
<tr>
<td>3.2</td>
<td>Length of roads in rainforest within the Wet Tropics (Source: Wilson 2000)</td>
<td>52</td>
</tr>
<tr>
<td>4.1</td>
<td>Target species accounts (from Menkhorst &amp; Knight 2001)</td>
<td>70</td>
</tr>
<tr>
<td>5.1</td>
<td>Scats collected from the road surface beneath the B Road bridge at intervals between 13/1/00 and 13/10/00</td>
<td>95</td>
</tr>
<tr>
<td>5.2</td>
<td>Scats collected from the net hung under the B Road bridge at intervals between 13/1/00 and 26/10/01</td>
<td>96</td>
</tr>
<tr>
<td>5.3</td>
<td>Crossing events observed on the B Road bridge in 40 spotlight hours between 28/7/00 and 29/12/01</td>
<td>100</td>
</tr>
<tr>
<td>5.4</td>
<td>Crossing events captured by the Buckshot RTV unit on the B Road bridge between 29/12/01 and 9/2/02</td>
<td>103</td>
</tr>
<tr>
<td>5.5</td>
<td>Scats collected from the centre of the net hung under the B Road rope at intervals between 12/8/01 and 29/12/01</td>
<td>105</td>
</tr>
<tr>
<td>5.6</td>
<td>Scats collected between 12/12/00 and 25/3/01 from the net hung under the wide bridge across the snig track</td>
<td>110</td>
</tr>
<tr>
<td>5.7</td>
<td>Scats collected between 12/12/00 and 25/3/01 from the net hung under the narrow bridge across the snig track</td>
<td>110</td>
</tr>
<tr>
<td>5.8</td>
<td>Crossing events observed on Old Palmerston Highway bridge in 80 spotlight hours between 7/4/01 and 2/7/03</td>
<td>117</td>
</tr>
<tr>
<td>5.9</td>
<td>Results of analysis of hair tapes taken from the traps installed on the Old Palmerston Highway bridge in August 2001</td>
<td>123</td>
</tr>
<tr>
<td>6.1</td>
<td>Arboreal/scansorial mammals recorded on the bridges erected at my three study sites</td>
<td>131</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I owe a debt of gratitude to many more people than can be listed here. First, I would like to acknowledge the support, encouragement, patience and guidance provided by Professor Helene Marsh (TESAG) throughout the duration of this study. More than this, I thank her for inspiring me to undertake postgraduate studies at James Cook University. I would also like to acknowledge the interest shown in my work by Associate Professor Steve Turton (TESAG & Rainforest CRC) and Associate Professor David King (CTURP, TESAG).

I have unashamedly followed in the footsteps of Rupert Russell, who not only thought about building bridges but also followed through with the construction of the first canopy bridge on the B Road in 1995. This was just one of the myriad ideas Rupert has shared with me. I am also indebted to Miriam Goosem for giving me the opportunity to undertake this fascinating study and for her assistance throughout. Both Rupert and Miriam also provided constructive and generous comments on the text.

David Rivett and staff at Environment North deserve special mention. David not only helped initiate the study (which was not altogether altruistic, given that Main Roads was his major client at the time!) but also gave great support while I was in his employ and continues to do so. I must also acknowledge the financial assistance provided by Main Roads, Cooperative Research Centre for Tropical Rainforest Ecology and Management, Australian Geographic and the Wildlife Preservation Society of Queensland.
Many people assisted me with fieldwork and I am especially grateful to the Clague family - Doug, Sandy and Chris, as well as Olivia Whybird- who housed and fed me and provided stimulating conversation for long periods during the study. Much of the work undertaken would not have been possible without their help. I am particularly thankful to Doug who assisted with bridge construction, scat collection, plant identification and so on and so on.

As my principal field assistant, Joe Sambono provided much of the grunt (both intellectual and physical) that powered this thesis. It was Joe who invented the hair curtain and suggested it be called a SETI (Super Effective Trapping Implement); perhaps his only advice I did not heed. Other people who helped with fieldwork were: Geoff Ahearn, Syb Bresolin, Tonya Chellingworth, Amanda de Silva, Mike and Sue Frankcombe, Corinne Hanlon, Lars Kazmeier, Birgit Kühn, Martin Kroker, Troy Minniecon, Andrea Moorhead, Steven Nowakowski, John Pink, Romina Rader, Jason Shaffer, Lydia Sutakowsky, Wally Usatov, Sylvia Walker, Angela Willett, Robyn Wilson and Andrea Yates.

I am grateful to Bob Jago and Bruce Wannan for their botanical inventory of the B Road site that appears at Appendix 4.1.

My thanks go to all the people who have aided my research in their professional capacities. This includes staff of the then Department of Natural Resources (Forestry, now QPWS) in Atherton and at Tinaroo Falls who assisted with permits and information, as well as staff from Main Roads, the Environmental Protection Agency (particularly Mike Trenerry who shared with me his considerable knowledge as well as his photo
library) and the Wet Tropics Management Authority (particularly Steve Goosem, Bruce Jennsion and Terry Webb for providing technical information, and M’lis Flynn who prepared the map that appears on p. 67). Thanks also to Trevor Parker from CSIRO, Atherton, who prepared the climate change maps, and of course Barbara Triggs, who conducted the hair and scat analyses.

I thank the many staff and students from James Cook University and the Rainforest CRC who have provided friendship and lively discussions throughout the five years of this study. Particular thanks go to: fellow possum researchers Robyn Wilson, Andrew Krockenberger and John Kanowski for their personal observations, suggestions and criticisms; Emily Bolitho for preparing the ‘lemur’ distribution map and Steve Williams and co. for use of the unpublished data upon which it is based; Steve Delean and Michael Steele for their statistical advice; Jann O’Keefe for her technical support; Yoshimi Izumi for allowing me to reproduce the figures that appeared in her thesis; and Karen Coombes and Neil McLaughlan for their help and hospitality ‘up the hill’. I also thank Deb Harrison for putting up with me (and my mess) during the latter stages of the completion of this thesis.

I have benefited from the exchange of information and ideas with a number of researchers working on similar projects in Australia and around the world. I am especially grateful to Chris Moon, Rodney van der Ree, Tom O’Sullivan and Zoe Tanner for sharing their experiences with me. I would especially like to thank Associate Professor Paul Beier of the Northern Arizona University for pointing me in the direction of overseas work; Helen Adams of the Wight Squirrel Project and Paula Kahumbu and Francis Ndiege of the Colobus Trust for so freely giving of their time and information;
Peter Reynolds for providing me with a copy of his Churchill Fellowship report; and
Professor Claudio Valladares Padua of the Brazilian Centre for Conservation Biology for
sending me his paper on pole bridges and a delightful video of a tamarin using one.

I would also like to thank those who responded to my questioning and cajoling on the
subject of possums and crossing routes, such as Margit Cianelli, Kay Coomber, Alastair
and Amanda Freeman, Tania Simmons and John Winter.

The Tableland Yidinji and Mamu Tribal groups generously gave me permission to work
on their traditional lands. Special thanks go to Syb for guiding me through her country
and to Troy for helping me out on his (Ma:Mu luck!). Similarly, I thank Thorold
Brotherton for allowing me access to his property. This research would not have been
possible without the assistance of these and many other people.

Finally, on a personal note, I thank my family, friends and neighbors for their support and
curriculum and Lydia for this and so much more.