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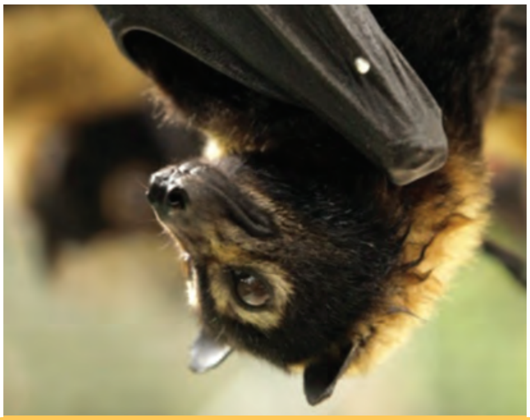
Final Report

Spectacled flying-fox monitoring in the Wet Tropics Region



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Australian Government
Department of the Environment

Reef & Rainforest
RESEARCH CENTRE

Spectacled flying-fox monitoring in the Wet Tropics Region

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Australian Government

Department of the Environment

Supported by the Australian Government's
National Environmental Research Program

Project 3.4 Monitoring of Key Vertebrates

National Library of Australia Cataloguing-in-Publication entry:

978-1-925088-52-6

This report should be cited as:

Westcott, D.A., McKeown, A. (2014) *Spectacled flying-fox monitoring in the Wet Tropics Region.* Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns (13pp.).

Published by the Reef and Rainforest Research Centre on behalf of the Australian Government's National Environmental Research Program (NERP) Tropical Ecosystems (TE) Hub.

The Tropical Ecosystems Hub is part of the Australian Government's Commonwealth National Environmental Research Program. The NERP TE Hub is administered in North Queensland by the Reef and Rainforest Research Centre Limited (RRRC). The NERP Tropical Ecosystem Hub addresses issues of concern for the management, conservation and sustainable use of the World Heritage listed Great Barrier Reef (GBR) and its catchments, tropical rainforests including the Wet Tropics World Heritage Area (WTWHA), and the terrestrial and marine assets underpinning resilient communities in the Torres Strait, through the generation and transfer of world-class research and shared knowledge.

Cover photographs: D. Westcott

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December 2014

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Abbreviations Used In This Report

WTR .... Wet Tropics Region

Acknowledgements

Jessica Tait and Humberto L. Perotto-Baldivieso of Cranfield University, England, contributed to the urbanisation component of this work. Louise Shilton conducted the counts in the first two years of the work. Egoitz Alkorta Miranda provided valuable assistance and provided a Basque flavour to the work.

Introduction

Monitoring is fundamental for the effective management of threatened species and underpins a data-based approach to environmental and conservation decision making. Monitoring contributes to decision making by providing data on a species' abundance and distribution and the dynamics in these measures, and when implemented in the context of management intervention makes the assessment of management needs and interventions, their appropriateness and effectiveness, possible (Elzinga 2001; Marsh and Trenham 2008; McDonald-Madden et al. 2010). Monitoring programs are applied in a broad range of contexts from conservation management (Cadiou and Yesou 2006), disease and invasion monitoring (Hochachka and Dhondt 2000; Devos et al. 2008) to stock assessment (Hagen and Loughin 2008). They form the basis of assessment for conservation listing under a variety of national and international frameworks, e.g. the EPBC Act and the IUCN Red List of Threatened Species (IUCN 2010). The important contributions that monitoring programs can make to management have seen renewed focus on the decision processes that lead to their implementation and to their design and analysis. Here we report on the results of a long term monitoring program that has focused on the EPBC listed spectacled flying-fox, *Pteropus conspicillatus*

The relationship between flying-foxes and non-Indigenous Australians has been a short but troubled one. In the very early days of settlement newspaper reports of flying-foxes expressed a sense of the novelty of the animals and drew on colonial experience in other parts of the Empire to understand them. This changed however with the depredations of flying-foxes on orchards quickly giving them a reputation as pests. Up and down the east coast, and including the Wet Tropics Region, newspapers reported the arrival and departure of flying-foxes, the damage they caused and the attempts of locals to discourage them. By the beginning of the 20^{th} century many regions had established Flying-fox Destruction Boards which sought to rid their region of the pests. By the mid-1920s however these boards, including those in the Wet Tropics Region, were abolished amid recognition that they had failed to achieve their goals. As a result of this failure, the Commonwealth invested in the first ecological study of flying-foxes in an attempt to find a solution to the problem. The resulting report and publications (Ratcliffe 1931; 1932; 1938), while they provided a great deal of contextual information on flying-fox ecology, provided little in terms of solutions to the problems the animals presented. In the years after Ratcliffe's pioneering work the management of flying-foxes reverted to efforts of individuals and local councils to disturb or destroy camps.

While much of the concern around flying-foxes has focused on their role as agricultural pests, flying-foxes have been viewed as urban pests since the 1800s. Their presence in the towns of the region are mentioned in diaries, newspaper reports and accounts from the earliest years of settlement. In Cairns, spectacled flying-foxes were responsible for frequent power outages in the early years of electricity and columnists in the early Cairns papers reported on their visits to gardens and of their descending in great numbers on the city from various camps in the swamps in and around the city. In different towns around the region there were attempts to move the animals on (Tolga Scrub 1932, Midgenoo and Mareeba 1937, Cooktown 1939, 1940, Pt Douglas 1941) but these invariably provided only temporary relief.

The annoyance value of flying-foxes seems always to provoke extreme responses, perhaps unsurprisingly given that the camps are active, odourous and noisy 24 hours a day. In Far North Queensland (FNQ) this has included calls to machine guns, flame throwers, aerial strafing and bombing of urban camps. In 1952 the Mayor of Cairns declined to pursue the use of napalm bombardments for fear of the consequences for neighbouring residential areas (Cairns Post, September 1952). The Council instead implemented a mangrove reclamation program that ultimately destroyed the camp but not the problem. The recent discovery that flying-foxes are reservoirs for bat Lyssa virus and Hendra virus (Halpin *et al.* 2007) has seen the issue of the amenity impact of urban camps combined with a campaign of fear over the potential for the transmission of these diseases to humans living near-by. This has again led to extrmeme demands for lethal control of flying-fox populations and the destruction of urban; a fight that is still being played out.

At the centre of this human-wildlife conflict are persistent and bitter debates about appropriate management responses. These 'debates' comprise stridently asserted claims that flying-fox populations are 'exploding' or in 'plague proportions' pitted against similar claims that they are in decline and endangered. Meanwhile exactly what the status and trends of flying-fox populations are remains uncertain. While it is clear that habitat loss and persecution have taken a toll on the spectacled flying-foxes in the last 125 years, it is not clear whether the species has recovered from any past declines, whether it is still declining or whether it is infact increasing.

This uncertainty places those responsible for flying-fox management in a difficult position. They are subject to strong and opposing demands for management interventions that too frequently require mutually exclusive courses of action. Their response to these demands should hinge upon i) the actual conservation status of flying-foxes, ii) an understanding of their spatial dynamics, iii) an objective assessment of their impacts and iv) the social values associated with the species, conservation and amenity. This can only be a difficult balance to strike in the case of a species that engenders such strong emotions and striking this balance is rendered only the more difficult by the lack of good information to inform about the species status and trends. In the absence of such data, management decisions must rely on opinion, leaving species management hostage to the perspectives of, or the pressures exerted upon, decision makers. In contrast, when reliable data on abundance and distribution is available, managers have a basis for assessing the likely impacts of any set of management options. This gives them a solid platform for making and justifying those decisions.

The aim of this long-term and on-going project is to fill the ecological information gap around spectacled flying-fox ecology and population dynamics in order to inform the development and implementation of policy for their management. Here we report on the long-term monitoring of the species population dynamics and examine their patterns of association with human settlement over the last decade and a half. Our reporting on the association with urban areas is based on our publication in the journal PLoS One (Tait *et al.* 2014).

Methodology

Population Monitoring

Since May 2004 monthly, daytime, walk-through surveys have been conducted at every camp in Wet Tropics Region (WTR). At the outset we identified all current and historical spectacled flying-fox camps in the region. This included 30 camps that had been monitored in the the period 1998 – 2003 (Garnett *et al.* 1999; Whybird 2000) and an additional 20 camps that had been reported since that time. Once incoporated into the study no camp was dropped and information on new camps has been continually sought from the public, a network of interested naturalists, and through telemetry studies throughout the monitoring period.

Each monthly census was conducted by a single counter with only one change in personnel in the period of the study (in 2006). Each monthly census was completed over a maximum of three consecutive days in order to minimise the chance of inter-camp movements and any resultant recounting of individuals.

In small camps (<1000 individuals), the counter counted all flying-foxes in a camp. In larger camps the density of individuals was assessed by counting the number of roosting individuals in randomly-selected roost trees, the average of these was then extrapolated to give a camp size estimate by counting the number of roost trees. Where access to the camp's interior was possible and the animals were not flighty, distance sampling, as described in the National Flying-Fox Monitoring Program (Westcott *et al.* 2011), was used.

Urbanisation

In order to examine how the distribution of the flying-fox population relative to urban areas had changed since the beginning of flying-fox monitoring in the Wet Tropics Region we also utilised, in addition to our own data, the annual and biannual surveys conducted by the Queensland Parks and Wildlife Service. In 1998 and 1999 these surveys were conducted in March and November while from 2000 to 2003 surveys were conducted in November only. These surveys involved positioning counters around the perimeter of camps to count the animals as they flew out of the camp at dusk, i.e. fly-out counts; see (Garnett *et al.* 1999) for a more detailed description. The QPWS data was then combined with our own data to describe patterns of association between flying-foxes and urban areas.

Urban camps were defined as camps surrounded by urban land use according to Queensland Government's land use classification (primary attributes), QLUMP 2009 (Queensland Government Information Service 2012) and our own on-ground assessment. Peri-urban camps were defined as those adjacent to urban land cover. Non-urban camps were those more than 250 m from any urban land use - a distance at which flying-foxes generally cause little concern. When referring to urban and peri-urban camps together we use the term urban-associated.

Details on the methods used in the analysis can be found in Tait *et al.* (2014).

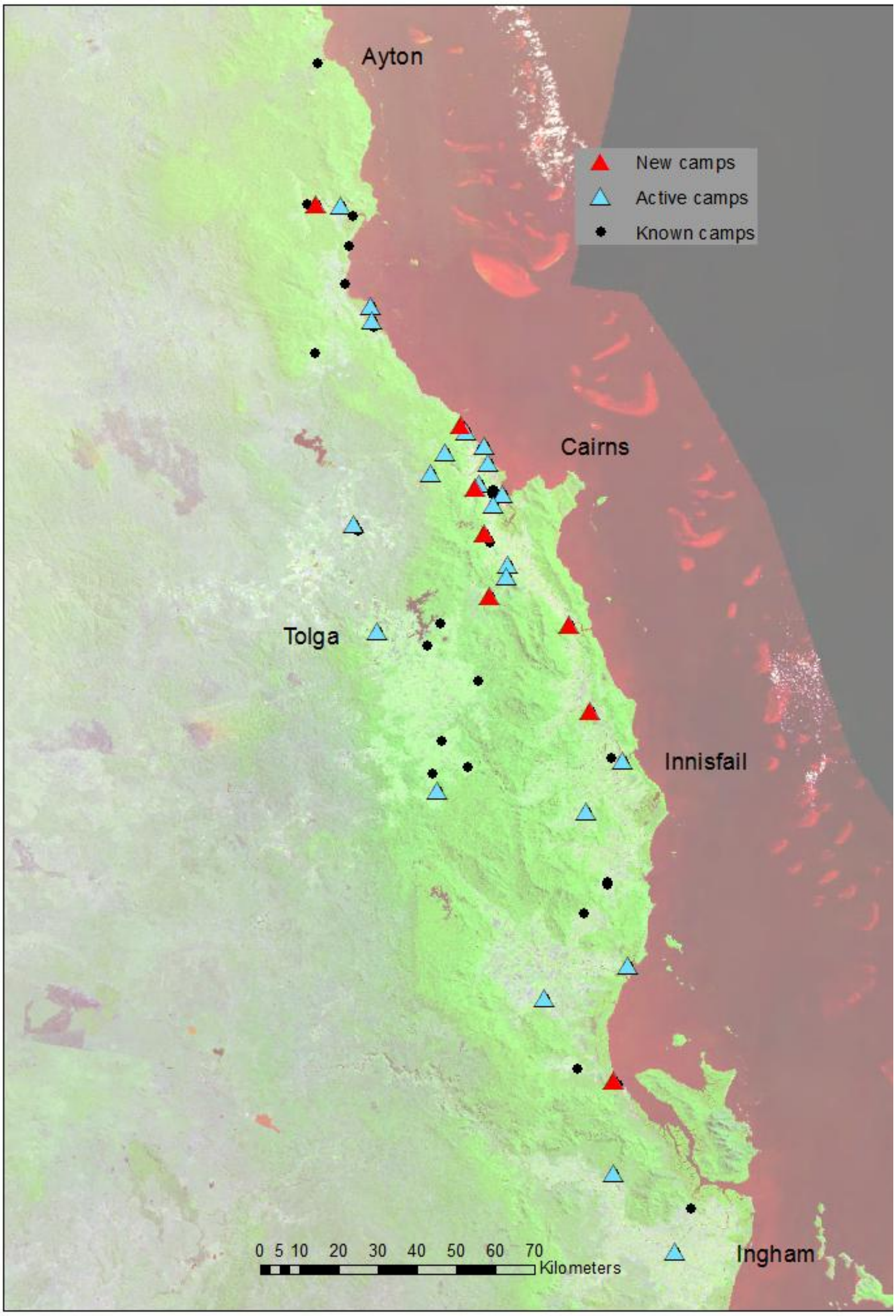

Figure 1. Distribution of spectacled flying-fox camps in the Wet Tropics Region showing camps identified during this work, other currently active camps and historically active camps.

Results

Population dynamics

The population counted in the first year of the monitoring was the highest recorded in the study with a maximum estimate in March of 2005 of 274,000 animals. In the following year this maximum estimate dropped to 214,750 and has fluctuated between 203,722 and 125,000 over the subsequent 9 years (**Figure 2**).

A simple regression of counted population size against month indicates a negative trend and is significant ($y=147,590-650.6*x$; $r=-0.39$, $p<0.001$) however it explains relatively little of the variation observed ($r^2=0.15$). This regression suggests that over the course of the 10 years of monitoring the counted population has declined by c. 82,000 individuals. To examine whether the high values in this first year drive the relationship we repeated the regression without the first 12 months of data. The regression remained strong and significant ($r=-0.32$, $p<0.001$).

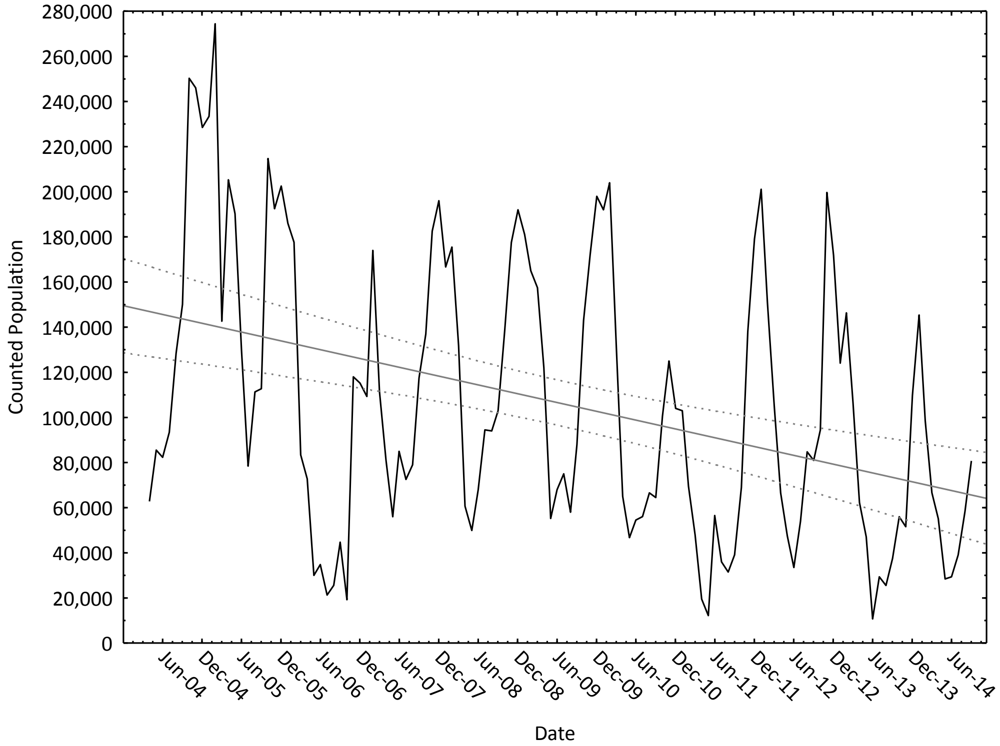

Figure 2. Population dynamics of the Wet Tropics spectacled flying-fox population over the period May 2004 to October 2014. Data shown are a line connecting monthly counts (to make the figure interpretable), the regression line of the count against time and the 95% CI interval of the regression.

We then repeated the analysis using just the data from the November surveys in each year. We did this to avoid a clear violation of the assumption of independence and thereby reduced the sample size inflation resulting from the use of all months in the analysis. November was chosen as the month in which the greatest proportion of the population was likely to be in camps (**Figure 2**) and a time when young-of-the-year were not yet independent and therefore were least likely to be incorporated into the count. The resultant regression was strong and significant ($y=197,700-1236*x$; $p>0.05$; $r^2=0.4$; **Figure 3**) and indicates a decline of 140,000. Removing the data point for Nov 2006, the year of Cyclone Larry, improves the fit and the resulting regression explains nearly all the variation observed ($y=240,920-1665*x$; $p<0.0001$; $r^2=0.91$). Performing the analysis using the peak observed in each summer period also gives a significant decline ($y = 233,090-7085.3*x$; $r = -0.6$, $p = 0.048$; $r2 = 0.37$) and a decline of 94,000 individuals.

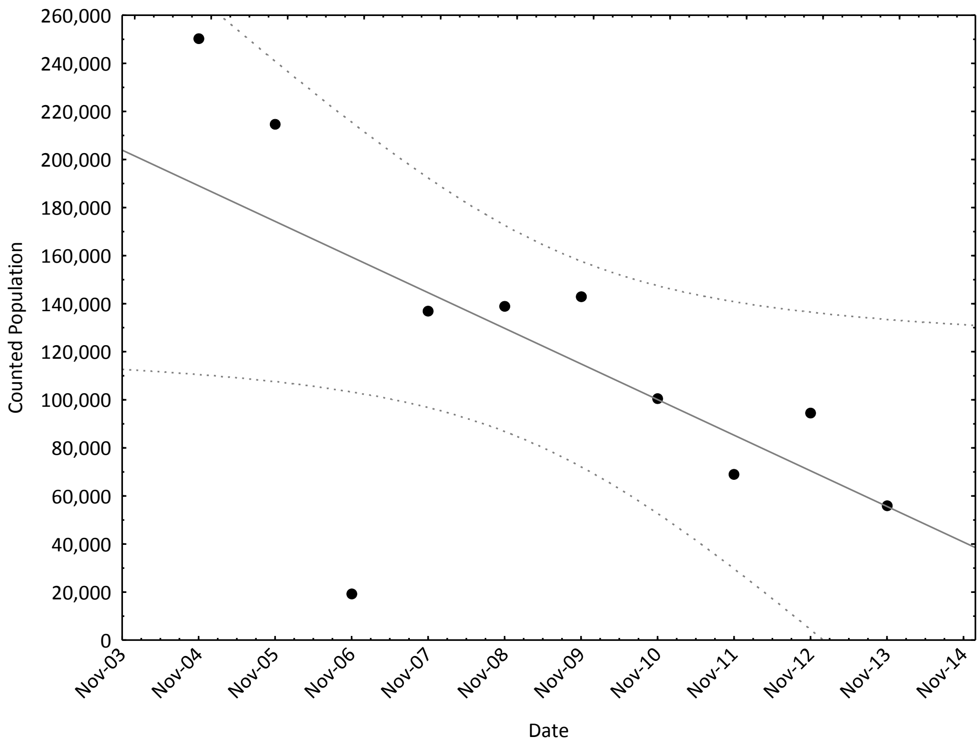

Figure 3. Relationship between the counted population during the November census in each year. The regression line and 95% CI of the regression are shown.

Both the maximum and the average size of camps declined over the 10 years of the monitoring ($r=-0.43$, $p<0.0001$ and $r=0.45$, $p<0.0001$ respectively). In the case of maximum camp size this was the case despite the largest camp sizes being recorded in the last two years of the study. Despite significant changes in camp use and the discovery of 12 new camps over the period of our monitoring the number of camps occupied at any given time remained constant across the study ($r=0.04$, $p=0.63$).

Urbanization

While the number of camps occupied remained constant the location of these camps relative to urban areas did not. Over the period of the study the number of camps associated with urban areas increased (# urban camps $r_p=0.64$, $p<0.01$, $n=15$; **Figure 5**;# urban & peri-urban camps $r_p=0.5$, $p<0.03$, $n=15$; # non-urban $p>0.05$).

At the same time the proportion of the counted population found in urban associated camps increased. This was the case irrespective of whether we considered the proportions recorded during November surveys only, the month for which we had data from every year between 1998 and 2012, ($r_p=0.69$, $p<0.005$, $n=15$), those for March and November surveys only, i.e. the months surveyed in all years except 2000-2003 ($r_p= 0.54$, $p<0.01$, $n=26$), or for all months for which we have data ($rp = 0.28$, $p < 0.005$, $n=111$). This trend was driven by a decrease in the use of non-urban camps (November only – $r=-0.81$, $p<0.001$, $n=15$; March and November – $r=-0.78$, $p<0.001$, $n=26$; all months – $r=-0.57$, <0.001, $n=111$) and an increase in the number of urban camps used per month over time (November only - $r=0.7$, $p<0.002$,$n=15$, November and March - $r=0.75$, $p<0.001$, $n=26$, all months – $r=0.56$, $p<0.001$, $n=111$).

GIS analysis indicates that though camps are closer to urban areas than would be expected by chance (Wilcoxon signed rank test, $Z = 33.26$, $p < 0.0001$) this was not a function of flying-foxes changing the location of their camps or the subset of camps they were using. Nor was the change a function of habitat loss or the encroachment of urban areas on camps. Details of this analysis can be found in Tait *et al.* (2014).

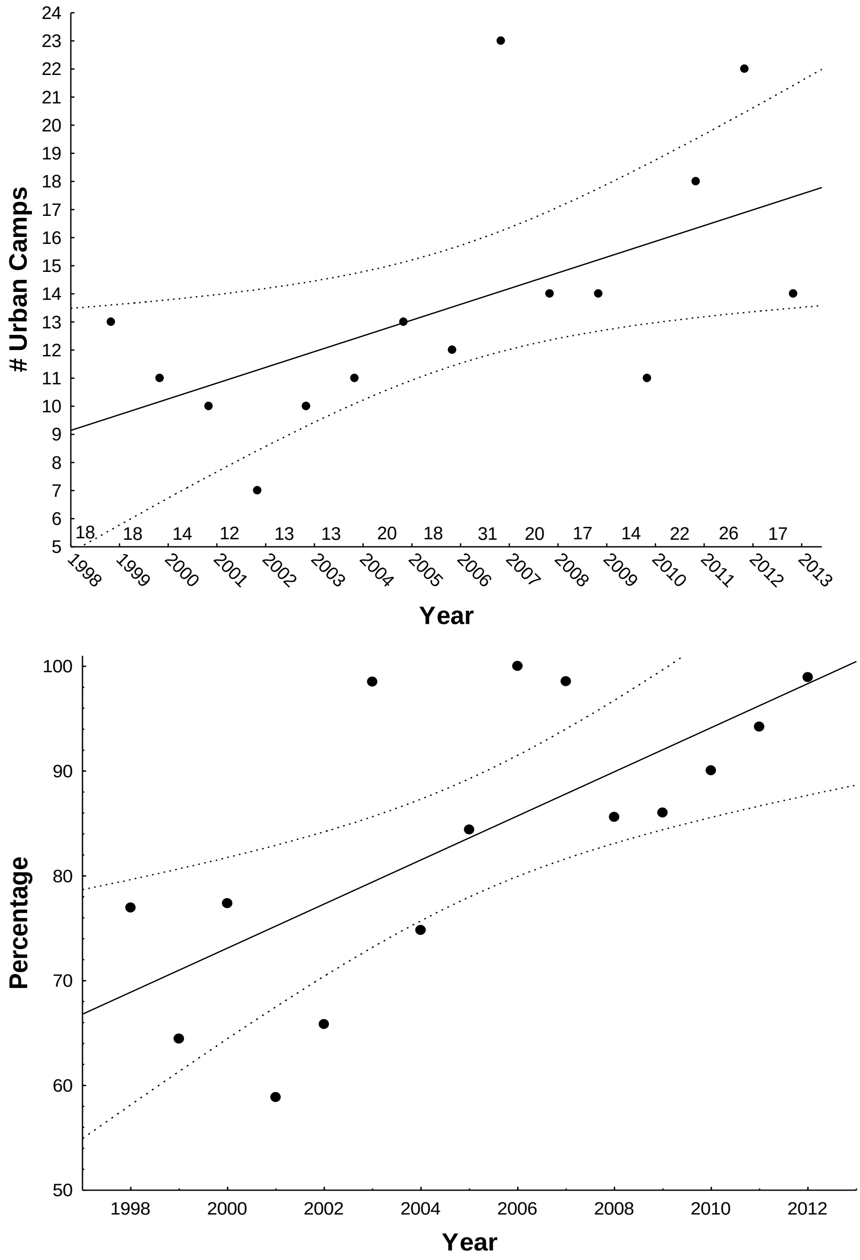

Figure 4. Changes in the a) number of urban associated camps and b) proportion of the counted spectacled flying-fox population roosting in urban-associated camps over the period 1998 to 2012. Figures after Tait et al. (2014).

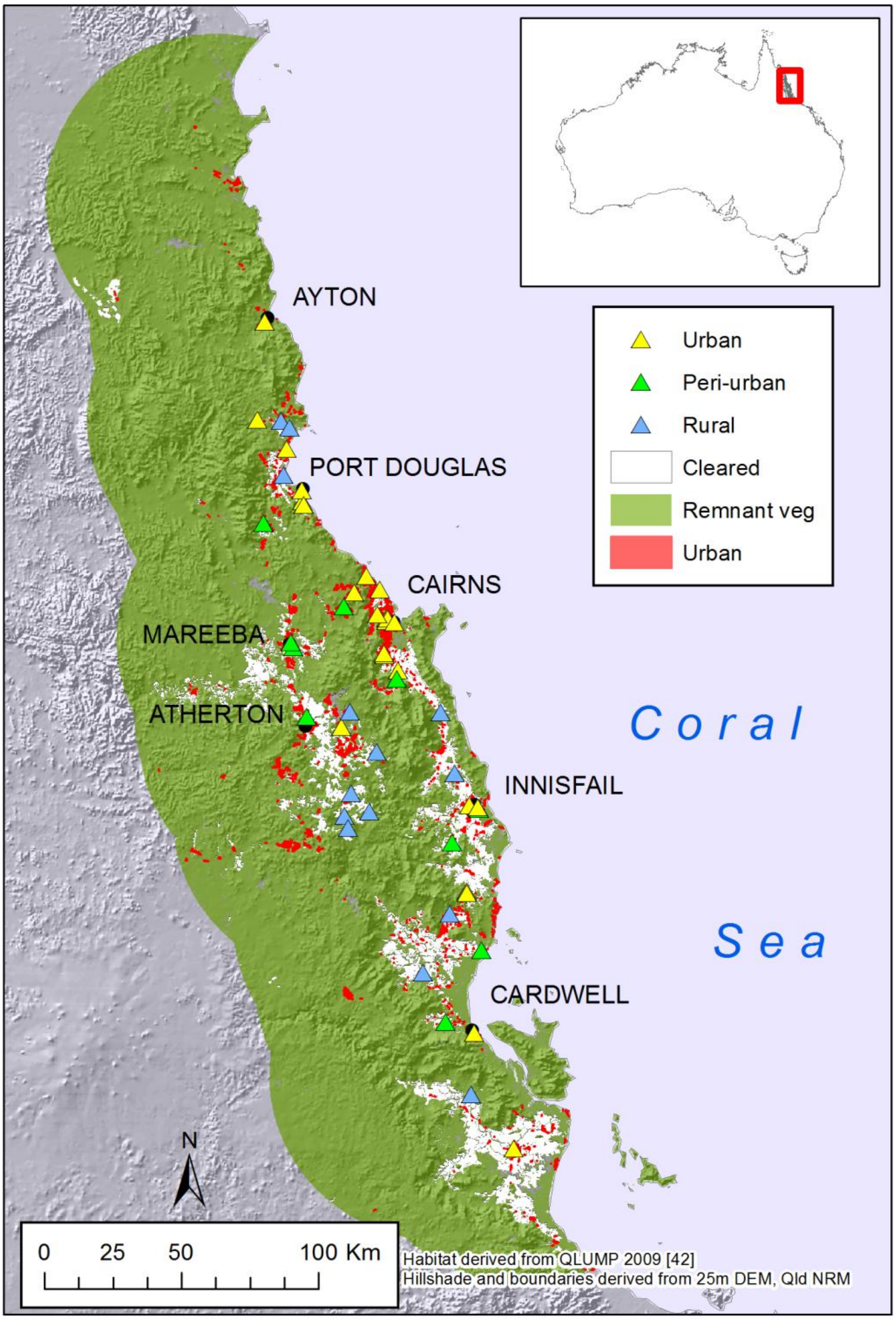

Figure 5. Distribution of urban, peri-urban and rural camps across the Wet Tropics Region (from Tait et al. (2014))

Discussion

Status and Trend

The long-term negative trend exhibited by the spectacled flying-fox (**Figure 2**) is a significant cause for concern with the regressions suggesting that between 82,000 and 140,000 animals have disappeared from the population over a ten year period. However, there are good reasons for caution before interpreting the results in this fashion.

First, is the fact that low peaks in one year tend to be followed by peaks at relatively normal levels (c. 200,000 individuals) in subsequent years (**Figure 2**). Since it is unlikely that such recovery, e.g. on the order of 60,000 individuals between December 2011 and December 2012, is entirely the result of reproduction in the 2011 breeding season we might conclude that some proportion of the population is moving out of the range of the counted population in low years. Thus a low in 2013 might be followed by a peak in 2014 dampening out a decline. This might occur because animals are roosting away from known camps within the region after disturbance or because the range of the species has shifted outside the region in which counts are being conducted, again possibly because of disturbance. The extreme annual fluctuations observed in the counted population support this contention. Telemetry studies conducted over the last few years provide some support for these suggestions (Westcott and McKeown, unpubl. data) but have identified only a low level of solitary roosting, ten new and relatively small camps, and no evidence of a shift in the species' range. Our conclusion based on these results is that while these hypotheses cannot be ruled out they also cannot explain the full extent of the decline suggested by the long-term trend. In otherwords, it appears increasingly likely, but not yet certain, that the decline is real.

An alternative hypothesis is that there is a counting error. This possibility is suggested by the very high numbers recorded in the first 12 months of the study and not since, perhaps an indication that we were at that time still learning how to count. This suspiscion was until recently supported by the fact that we had not subsequently record camps of the largest sizes that we saw in that first year. However, this argument appears now not to be so convincing as we have recorded our largest camp sizes in the last two years of the study. Irrespective, the high numbers recorded in the first year have little effect on the trend with a significant decline still documented even when the first 12 months of data are excluded.

Given these considerations our conclusion is that the decline is real, though because there is appears to be some movement in and out of the counted population, its true extent is possibly not as great as would appear from a simple examination of the data. In our modelling of the performance of monitoring of spectacled flying-fox abundance we (Westcott *et al.* 2012) concluded that a minimum of 13.5 years of data would be required to reach 80% confidence in a decline of 3.5% per annum. The data presented here suggests a decline of closer to 4-6% per annum but suggests that confidence in the interpretation will rely on additional ecological information. Data on the population peaks over the coming 18 months and the results of further telemetry work will be important for reaching a conclusion. In the meantime we conclude that there is sufficient reason to be concerned about the trend shown by the spectacled flying-fox and that while we are not yet fully confident we believe that it should be treated seriously until there is a clear indication that there is no longer any cause for concern.

Urbanization

Our data shows a clear pattern of urbanisation of the spectacled flying-fox population. Given that this species has a long association with urban areas it is difficult to explain why this pattern would be emerging at this particular point in time. The range of hypotheses to explain our data fall into four general categories: i) methodolical issues, ii) changes in the availability and distribution of suitable roost habitat, iii) disturbance in non-urban areas, and iv) the attractiveness of urban areas. We consider these hypotheses below but also refer readers to our journal publication (Tait *et al.* 2014).

Is it possible that bias in the sampling of urban and non-urban camps could potentially explain our results? This might be the case if, for example, urban camps are more likely to be idenitified, accessed and surveyed and therefore are potentially more likely to be monitored. Such bias is unlikely to explain our results however for the following reasons. First, camps are never dropped from our monitoring, even when they haven't been occupied for long periods, so there is no shift of monitoring through attrition to an urban focus that might result from ease of sampling. Second, non-urban camps are more likely to be overlooked than urban camps. If this were the case we would expect an initial bias towards urban camps that would decrease as the population became better known through broad-scale searches, reports from the public (Shilton *et al.* 2008) and telemetry studies (McKeown and Westcott 2012; Westcott *et al.* 2001). Instead we have seen the shift towards urban camps increase, not decline. Consequently, we feel confident that our results are not due to a sampling bias favouring urban camps.

Our data allowed direct assessment of hypotheses related to the effect of changes in landscape structure and the location of camps on their association with urban areas. We found i) no significant changes in land cover at the scale of the landscape as a whole or, ii) in the immediate vicinity of camps, and, iii) no movement of individual camps towards urban areas over the duration of the study. These findings do not support the hypotheses that urbanisation is occurring due to urban expansion towards camps, habitat loss, roost site loss or habitat fragmentation as has been suggested previously (Lunney and Moon 1997; Markus and Hall 2004; van der Ree *et al.* 2006; Williams *et al.* 2006).

While we cannot directly assess other hypotheses for urbanisation our data does allow some speculation about other potential drivers. Peaks in the urban-associated percentage of the population occurred in 1998, 2000, 2003, 2006-7 and 2011-12 and suggest that there are periodic shifts in the distribution of the population towards urban areas. Although the drivers of these temporary shifts are unknown, explanations could include the attraction of fruiting or flowering events near urban areas (Hall and Richards 2000), or disturbance events such as droughts (Tidemann and Nelson 2004), fires (Jenkins *et al.* 2007), cyclones (Craig *et al.* 1994; Esselstyn *et al.* 2006; Shilton *et al.* 2008), and human disturbance or culling at non-urban roosts or orchards (Hall and Richards 2000). While there were two major cyclonic disturbances during the study period, in 2006 and 2010 and preceding the peaks in 2007 and 2011 respectively, no disturbance events can be associated with the other peak years. While individual disturbance events may drive short term peaks in urbanization, there is a longer-term population shift towards urban areas is occurring that is independent of these.

The urbanisation of spectacled flying-foxes we have described has major implications for management. Flying-foxes are becoming increasingly urbanised and that the conflict their presence in urban areas engenders will not abate. The lack of evidence for loss of habitat or roosting sites as a driver of this shift raises the possibility that this is a behavioural response to the advantages offered by such locations. If this is the case then it is difficult to argue that moving problem urban camps on through the use of disturbance is likely to have any significant negative impacts on the population. Despite this, there is little evidence that past attempts to move urban camps have been successful or cost effective (Roberts et al. 2011) and this is confirmed for spectacled flying-foxes by newspaper reports from Far North Queensland over the last century (DAW, unpubl. data).

Resolving conflict over the presence of flying-foxes in urban areas will require an understanding of the reasons why flying-foxes are roosting in urban areas. Failure to address this question risks the perpetuation of a century old management approach that has been shown to be ineffective. This points to a need to explore new management options, particularly i) the identification of options that facilitate the co-existence of humans and flying-foxes, since management of the human side of the conflict is likely to prove more cost effective and successful, ii) identifying the actual drivers of urbanisation of flying-foxes to inform and managing this process, and, iii) development of guidelines for identifying appropriate camps for direct management and for conducting that management.

Conclusion

Our monitoring has highlighted two key results. First, the long-term trend in the spectacled flying-fox population shows a strong decline over the ten-year period our monitoring, on the order of 6% per annum. While we caution that additional monitoring is required before full confidence can be had that this decline is as severe as it appears, we suggest that until such monitoring is completed the decline be treated as real. Importantly, monitoring needs to be continued.

Second, the WTR flying-fox population is becoming increasingly urbanised, a process that can only inflame an already charged political situation. A century of attempted removal of flying-foxes from urban areas in the WTR suggests that we need to adopt a different approach. We recommend that resources be focused on i) understanding human – flying-fox conflict with a view to developing strategies to manage the component of the interaction we can most easily influence, the human side, ii) identifying the drivers of urbanization in flying-foxes, iii) the development of guidelines for camp management based on previous experience and for identifying camps for which different management approaches are most applicable.

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