WWF

REPORT

AUS

2017

Australian animals lost to bulldozers in Queensland 2013-15

Australian animals lost to bulldozers in Queensland

2015 -16 update

Shortly after the release of the recent WWF report Australian animals lost to bulldozers in Queensland 2013-15[1], new tree clearing data and maps have been released by the Queensland Government showing a 33% increase in areas cleared relative to the prior year 2014-15.

We have re-estimated the numbers of mammals, birds and reptiles losing their habitat and killed as a result of bulldozing of bushland in 2015-16.

Approximately half the total area cleared in 2015-16 (395,000ha) according to the Queensland Government SLATS report, we estimated to comprise remnant and advanced regrowth forest or woodland (199,273 ha) (Table 1). We only estimated animals killed on the basis of this area, not on total area cleared.

We conservatively estimate 44.7 million individuals were killed due to bulldozing of bushland in 2015-16, composed of 1.1 million mammals, 3.7 million birds and 39.9 million reptiles.

This represents a 30% increase in numbers killed annually relative to the previous two years.

A comparison of these new estimates with the earlier 2013-15 estimates, broken down by state development regions is shown in table 1 below. A map of regions is shown as Figure 1.

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23 Oct 2017

1 Cogger H, Dickman C, Ford H, Johnson C and Taylor MFJ, 2017. *Australian animals lost to bulldozers in Queensland* 2013-15. WWF-Australia technical report.

Table 1: . Updated estimates of areas of habitat cleared and numbers of animals killed in 2015-16, relative to estimates for 2013-15, by state development region.

	2013-15 annual rate					2015-16				
	Cleared (ha)[2]	Nearest 1000 killed				Cleared (ha)[3]	Nearest 1000 killed			
Regions[1]		Mammals	Birds	Reptiles	Total		Mammals	Birds	Reptiles	Total
Bundaberg/Maryborough/Burnett	5,997	138	148	1,199	1,486	6,650	187	159	1,330	1,676
Rockhampton, Central and West	38,426	174	680	7,685	8,539	48,196	212	960	9,639	10,811
Toowoomba, Darling Downs and West	75,525	312	1,106	15,105	16,523	83,686	337	1,343	16,737	18,417
Cairns and Far North Qld	13,351	19	314	2,670	3,003	20,157	53	491	4,031	4,575
Gulf	2,715	4	41	543	588	7,825	17	124	1,565	1,706
Mackay/Whitsunday	12,823	93	241	2,565	2,898	27,317	181	512	5,463	6,156
Townsville and North Qld	2,317	15	46	463	525	3,297	15	73	659	747
SEQ Brisbane	168	9	3	34	45	140	7	4	28	39
SEQ North	429	22	12	86	119	612	31	13	122	166
SEQ South	552	28	18	110	157	428	22	12	86	120
SEQ West	796	41	24	159	224	966	49	26	193	268
TOTAL (1000s)	**153,098**	**855**	**2,634**	**30,620**	**34,108**	**199,273**	**1,112**	**3,718**	**39,855**	**44,685**

1. 2013-15 data as found in the Appendix in the report Cogger et al (2017) cited above. For regions see Figure 1.

2. Remnant as mapped in Queensland Government's Regional Ecosystems v9 (2013) and detected as cleared in SLATS 2013-15 as well as non-remnant that had not been detected as cleared in the entire SLATS record from 1988, and was also 11% or greater Foliage Projective Cover in 2013 (woodland or forest).

3. Remnant as mapped in Queensland Government's Regional Ecosystems v10 (2015) and detected as cleared in SLATS 2015-16 as well as non-remnant that had not been detected as cleared in the entire SLATS record from 1988, and was also 11% or greater Foliage Projective Cover in 2014 (woodland or forest). Note that the 2015 FPC layer not available yet.

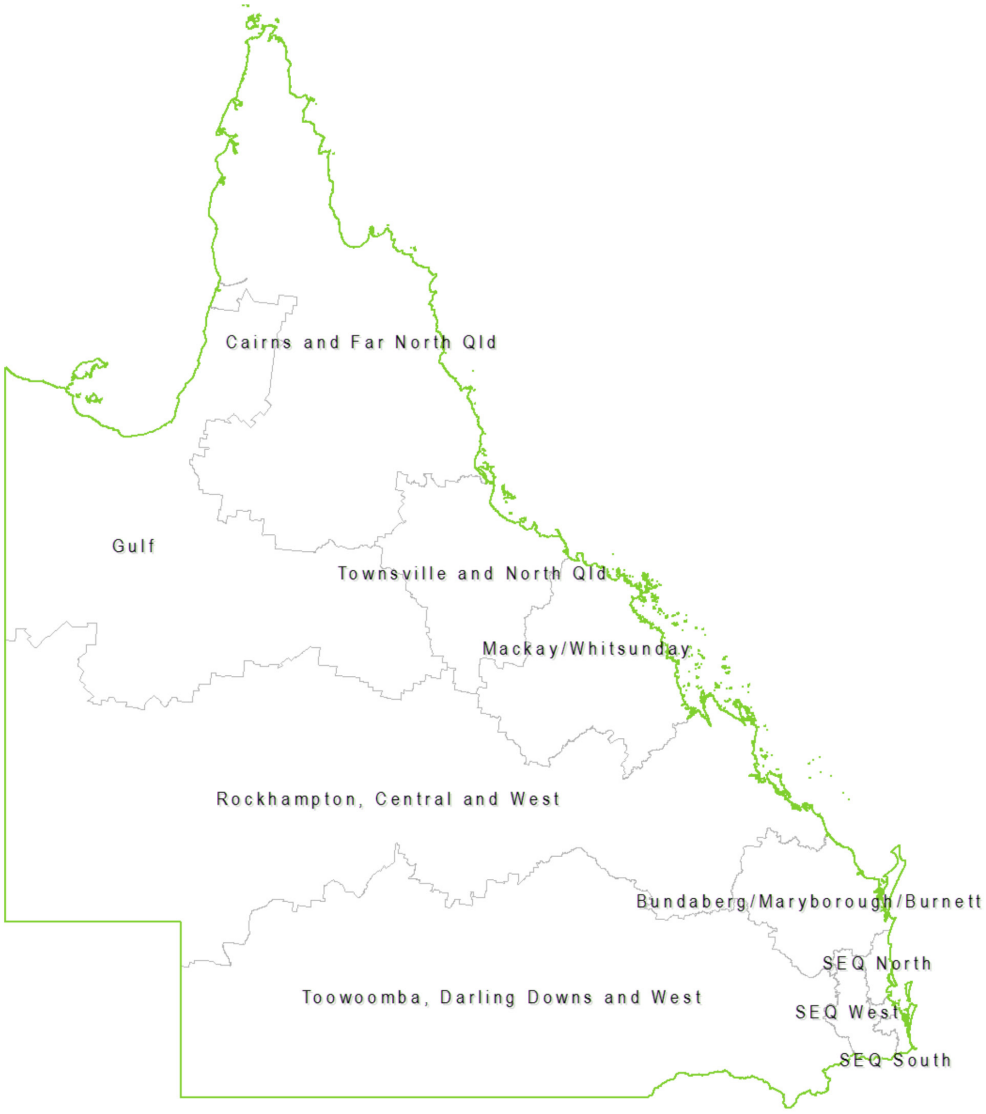

Figure 1. State development administrative regions of Queensland.

2 https://www.statedevelopment.qld.gov.au/contact-us/regional-contacts.html

GOLDEN-TAILED GECKO © NATHAN BIGNELL

EXECUTIVE SUMMARY

In 2003, leading zoologists estimated the numbers of Australian animals losing habitat to, and killed by, tree-clearing in Queensland in the late 1990s. For a reported 446,000 ha of remnant, mature or intact bushland being cleared annually, an estimated 100 million native vertebrates died, including over two million mammals (such as koalas, gliders, possums, bandicoots and native rodents), 8.5 million forest and woodland birds and 89 million reptiles (such as goannas, geckos and skinks).

Following this 2003 report much stronger protections, including a ban on large-scale clearing of remnant bushland, were legislated in Queensland and tree-clearing rates declined sharply.

These protections were greatly weakened in 2012-13 by the former Newman-LNP state government. Tree-clearing rates in Queensland have since resurged to almost 300,000 ha per annum.[1]

In this update, we apply the same methods employed in the 2003 report to clearing data for 2013-15, the most recent available. These updated estimates include the effects on wildlife of clearing not just of remnant but also advanced age regrowth bushland. We estimate that about 34 million vertebrates are losing their habitats to bulldozers every year and presumed killed, including 0.9 million mammals, 2.6 million birds and 30.6 million reptiles.

These estimates are likely to be underestimates because they do not account for clearing of younger forests, or aquatic and marine animals killed as a result of clearing and resulting water pollution in the catchment. Nor do they account for the ongoing higher mortality rates of wildlife due to the delayed effects of habitat fragmentation and degradation that follow from clearing.

1 Taylor, M., 2015. *Bushland destruction rapidly increasing in Queensland.* WWF-Australia briefing. http://awsassets.wwf.org.au/downloads/fl024_bushland_destruction_rapidly_increasing_in_queensland_16sep15.pdf

PUBLICATION DETAILS

The report is an update of the earlier WWF report: Cogger HJ, Ford H, Johnson C, Holman J & Butler D, 2003, *Impacts of Land Clearing on Australian Wildlife in Queensland*. Report for WWF-Australia, Sydney.

Suggested citation

Cogger H, Dickman C, Ford H, Johnson C and Taylor MFJ, 2017. *Australian animals lost to bulldozers in Queensland 2013-15*. WWF-Australia technical report.

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Author contributions

Authors are listed alphabetically.

Martin Taylor was the principal analyst and author for this update to the earlier Cogger *et al*, 2003 report.

Acknowledgements

WWF-Australia also gratefully acknowledges Don Butler, Carol Booth and Jon Hanger for their contributions.

FRONT COVER: KOALA (*PHASCOLARCTOS CINEREUS*) PAW RESTING ON A TREE TRUNK. RETURN TO THE WILD INC. TOOWOOMBA, QUEENSLAND. APRIL 2017 © DOUG GIMESY / WWF-AUS

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DEAD KOALA FOUND IN COLLINGWOOD PARK, QUEENSLAND, JANUARY 2017 © MITCH & JIM DODRILL

INTRODUCTION

Habitat destruction is the greatest threat to native wildlife in Australia and worldwide, resulting in mass loss of life for animals and plants, ecosystem and food chain disruption, and if carried far enough, population or species extinctions.

Rates of forest and woodland destruction were alarmingly high in Queensland last century until laws were enacted over a decade ago to regulate what was largely unrestricted bulldozing of natural bushland.

Legislation limiting the destruction of natural bushland was weakened recently. This has led to an increase in clearing rates. In this report, we update earlier estimates from 2003 of the numbers of Australian land vertebrates - mammals, birds and reptiles - killed as a result of the destruction of their forest, woodland or bushland habitat, also known as deforestation, land clearing or tree-clearing.

THE IMPORTANCE OF CONSIDERING ALL ANIMALS AFFECTED BY CLEARING

Conservation is not only concerned with saving endangered species. Common species dominate resource flows in food webs and are vital to the maintenance of ecosystem complexity and resilience. As such, they too are an important issue for conservation.[2] Large-scale killing of forest and woodland-dependent native animals through destruction of their habitats, whether they are common species or not, cannot fail to have adverse conservation consequences. These include disrupting natural food chains and natural ecosystems' services and bringing species and ecosystems closer to depletion, dysfunction or extinction.

Although this report estimates the numbers of animals lost from the footprint of areas destroyed, wild animals continue to suffer elevated mortalities in the remaining islands of forest by virtue of the legacy effects of fragmentation and degradation of their habitat. Fragmentation of once continuous habitat creates archipelagos of islands surrounded by a landscape hostile to the movement of forest-dependent wildlife while their edges may be invaded by weeds and aggressive or predatory animals.[3]

This habitat degradation effect can continue to result in excessive deaths of wild animals over many decades, ultimately resulting in loss or local extinctions of entire populations, and if enough populations are affected, the loss of entire species.

The phenomenon of ongoing decline in degraded habitats due to elevated mortalities (or reduced reproduction) leading to extinction is called the 'extinction debt'. Populations and species are at increased risk of extinction due to the legacy effects of clearing in the past, even if clearing has been halted for some time.[4]

This appears to be happening now to the koala in southeast Queensland. Recent analysis shows that koalas have been in continuous decline in the Brisbane outer suburbs for decades. Over the period 1996-2015, koala populations declined 80% in the Koala Coast (Redlands) area and 54% in the Pine Rivers area, although most clearing for urban or commercial/industrial development happened decades ago.[5] Continuous, substantial population decline led to the koala populations of NSW, ACT and Queensland being listed as vulnerable to extinction in 2012.[6] The plight of the koala illustrates what can happen to a species, once considered widespread, common and safe, that suffers extensive habitat loss and fragmentation.

2 Gaston KJ, 2010, Valuing common species. *Science*, 327, 154-155; Dickman CR & Steeves TE, 2004, Use of habitat by mammals in eastern Australian forests: are common species important in forest management. pp.761-73 in D Lunney (ed) *The Conservation of Australia's Forest Fauna* (2nd edition) 2004, Royal Zoological Society of New South Wales, Australia.

3 Saunders DA, Hobbs RJ & Margules CR, 1991, Biological consequences of ecosystem fragmentation: a review. *Conservation Biology*, 5, 18-32.

4 Kuussaari M *et al*, 2009, Extinction debt: a challenge for biodiversity conservation. *Trends in ecology & evolution*, 24, 564-571.

5 Rhodes J *et al*,. 2015, *South East Queensland Koala Population Modelling Study.* UniQuest, Brisbane, Australia.

6 http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=85104

The conservation impacts of habitat destruction on animal populations are likely to be greater now than they were in the late 1990s because of the cumulative effect of past habitat loss and fragmentation. For Australian mammals in particular, there has been a general decline in health and resilience of many populations over the intervening period from the late 1990s to the present. A recent comprehensive review of the conservation status of mammals shows that over the last 20 years, 52 species and subspecies of land mammals on mainland Australia have undergone a worsening of conservation status, and only 15 have improved. [7]

There are also significant animal welfare concerns about the injury, suffering and death of Australian animals that are an inevitable result of so much habitat destruction. [8]

ANIMALS LOST TO TREE-CLEARING PRIOR TO EFFECTIVE CONTROLS

In the late 1990s, about 100 million individual vertebrate animals died annually, based on an estimated 446,000 ha clearing of remnant [9] bushland (including both forests and woodlands). These numbers were primarily composed of 89 million reptiles (such as goannas, skinks and geckos), 8.5 million woodland birds and 2.1 million mammals (including monotremes, marsupials and placentals like rodents and bats) (Cogger *et al,* 2003, referred to as 'the 2003 report' below). [10]

The 2003 report assumed that all, or virtually all, animals die when their habitat is destroyed. Animals do not necessarily die during the bulldozing itself. Those that survive the bulldozing may be unable to escape, often because they are too small to travel the distances needed to reach new habitat, or because of high attachment to their homes and nest sites, or because they are trapped, die on site from starvation or exposure, or die hiding in woodpiles that are burned.

For the larger, more mobile animals like birds and macropods that may escape to remnants of habitat, death still awaits, because of over-crowding in those remnants, which are most likely already occupied with no excess capacity to absorb immigrants. Immigrants end up in conflict with residents over resources, territories and mates, and are pushed out to poorer marginal habitat, or may even push residents out.

With increased displacement comes increased exposure to predation and pathogens or collisions with cars, fences and powerlines in developed areas. Increased injuries and stress from conflict and displacement may also lead to disease. [11]

7 Woinarski JCZ, Burbidge AA & Harrison PL, 2014, *The action plan for Australian mammals 2012.* CSIRO Publishing, Collingwood, Vic.
8 Finn HC & Stephens NS, 2017, The invisible harm: tree-clearing is an issue of animal welfare. *Wildlife Research* DOI: 10.1071/WR17018
9 Meaning intact, primary or never cleared, or if cleared has since grown back to maturity.
10 Cogger HJ, Ford H, Johnson C, Holman J & Butler D, 2003, *Impacts of Land Clearing on Australian Wildlife in Queensland.* Report for WWF-Australia, Sydney.
11 Ibid.

BULLDOZING OF CYPRESS/ EUCALYPT FOREST IN PROGRESS UNDER THE "THINNING" CODE, WESTERN DARLING DOWNS, QUEENSLAND, MAY 2017 © WWF-AUSTRALIA

RESURGENCE OF TREE-CLEARING IN QUEENSLAND

Following the 2003 report, significant protections against excessive tree-clearing were legislated in Queensland in 2004 and 2009, and tree-clearing rates declined sharply as a result (Fig 1).

These protections were drastically weakened in 2012-13 by the former Newman-LNP state government, firstly by relaxing enforcement and then by changing the laws and codes governing tree-clearing. Tree-clearing rates in Queensland have since more than tripled to almost 300,000 ha per annum in 2014-15 from the historic low point of 78,000 ha in 2009-10. Clearing of remnant bushland has also quadrupled from 24,000 ha to 114,000 ha over the same period (Fig 1). [12]

The present government attempted to restore tree-clearing controls in 2016, but unfortunately were blocked in the state parliament. The weakened laws and codes introduced by the previous government continue to apply.

The trend in recent remnant clearing is increasing sharply upward (Fig 1). In addition, notifications of nearly 400,000 ha for clearing of remnant bushland under self-assessable codes (for which no permit is required) have been made from 20 July 2016 to 2 July 2017. [13] Therefore, when they are released, the 2015/16 estimates of clearing and consequently numbers of animals killed, are expected to significantly exceed those in 2014/15.

The resurgence of tree-clearing in Queensland, along with recent repeal of the *Native Vegetation Act* in NSW, has led to the listing of Eastern Australia as one of 11 'global deforestation fronts' by WWF International. Australia is the only developed country on this ignominious list. [14]

12 Taylor MFJ, 2015, *Bushland destruction rapidly increasing in Queensland.* WWF-Australia briefing. http://awsassets.wwf.org.au/downloads/fl024_bushland_destruction_rapidly_increasing_in_queensland_16sep15.pdf

13 WWF analysis of register of self-assessable code notifications, corrected for apparently duplicated notifications on the same property. https://data.qld.gov.au/dataset/vegetation-management-register-of-self-assessable-code-notifications Prior to 20 July 2016, no areas were provided for notifications.

14 http://wwf.panda.org/about_our_earth/deforestation/deforestation_fronts/

Figure 1:
History of tree-clearing in Queensland.

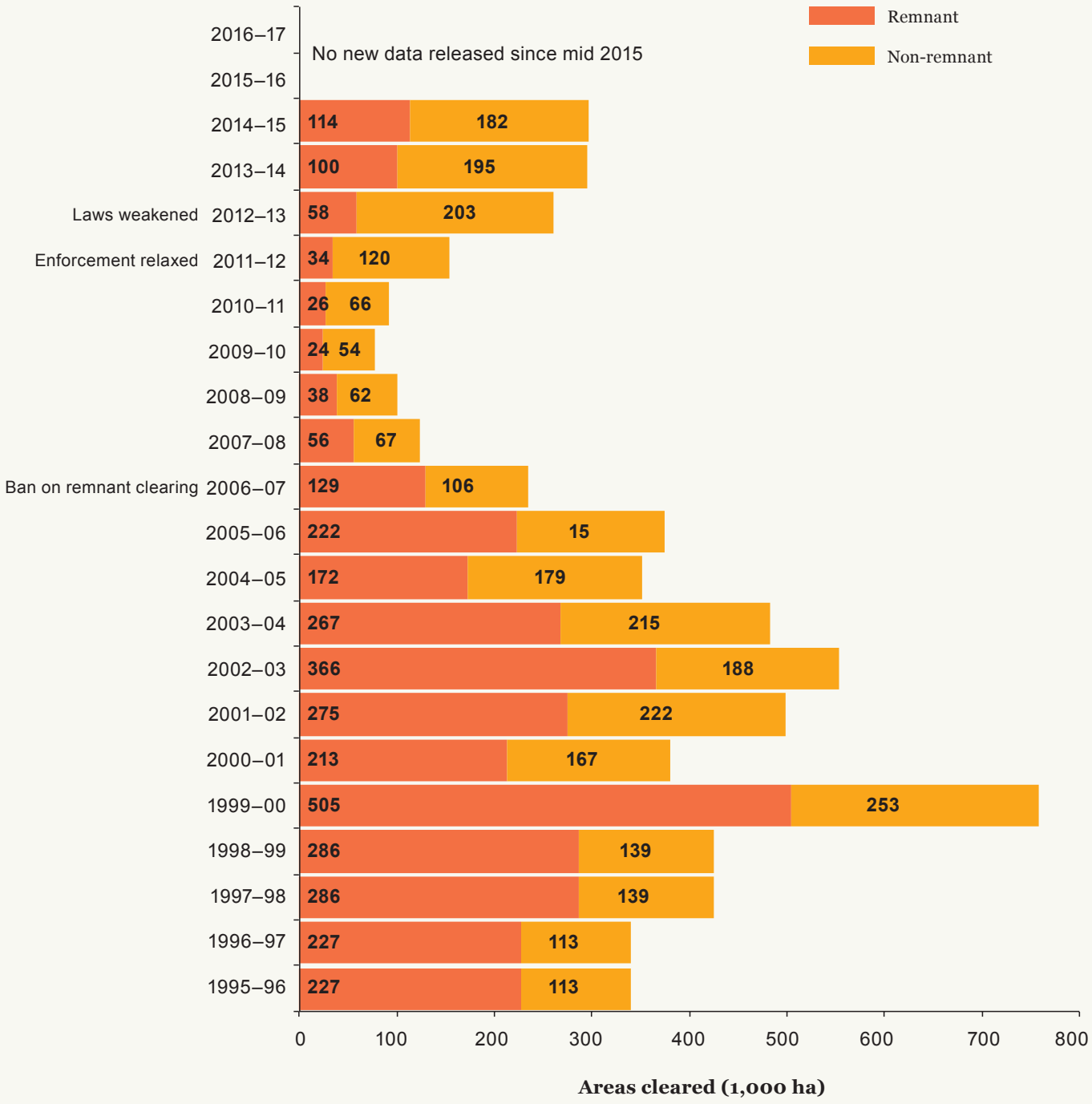


Table 1. Animals lost annually to tree-clearing in the late 1990s (1997-99)[15] and updates for recent clearing (2013-15) of remnant and advanced regrowth bushland (Summary of data in Tables 2-4 below).

		No. animals lost per annum (millions)			
Period	**Bushland type**	**Mammals**	**Birds**	**Reptiles**	**Total**
Late 1990s	Remnant only[16]	2.2	8.6	89.2	100.0
Recent (2013-2015)	Remnant only	0.5	1.8	20.9	23.1
	Remnant & advanced regrowth[17]	0.9	2.6	30.6	34.1

UPDATED ESTIMATES OF ANIMALS LOST TO CLEARING IN QUEENSLAND

Based on the levels of remnant clearing following weakening of protections in 2012-13, at least 23 million mammals, birds and reptiles are killed every year by bulldozing of their remnant bushland habitats in Queensland (Table 1).

However, this greatly underestimates the loss of life due to clearing because it ignores the clearing of advanced regrowth habitat, which has largely been exempted from the provisions of Queensland's *Vegetation Management Act*. As of April 2017, the regulated vegetation map had approximately 33.8 million ha mapped as exempt from all tree-clearing controls. In contrast to the late 1990s, the majority of clearing in 2013-15 was of non-remnant or regrowing bushland (Fig. 1).

Advanced age non-remnant bushland may already have grown back to remnant status and will already have been recolonised by some of its original community of animals, but Queensland lacks any systematic process for assessing the extent to which this has happened. Previously cleared but regenerating bushland remains largely unaccounted for and is still classified as non-remnant.[18]

Accordingly, we include in areas of habitat lost, areas of non-remnant bushland that had not been cleared since at least 1988 (at least 25 years old) and that had also attained at least 11% foliage projective cover (equivalent to the Kyoto Protocol definition of a forest) prior to being cleared in 2013-15.

Applying the same density estimates to these areas, we estimated at least 0.9 million mammals, 2.6 million birds and 30.6 million reptiles would have inhabited remnant and advanced regrowth forests cleared annually, a total of 34.1 million animals annually or 68.2 million animals over the two years studied 2013-15 (Tables 1-4, Fig 2).

This is a more credible estimate of terrestrial vertebrates killed than that for clearing of remnant habitats alone.

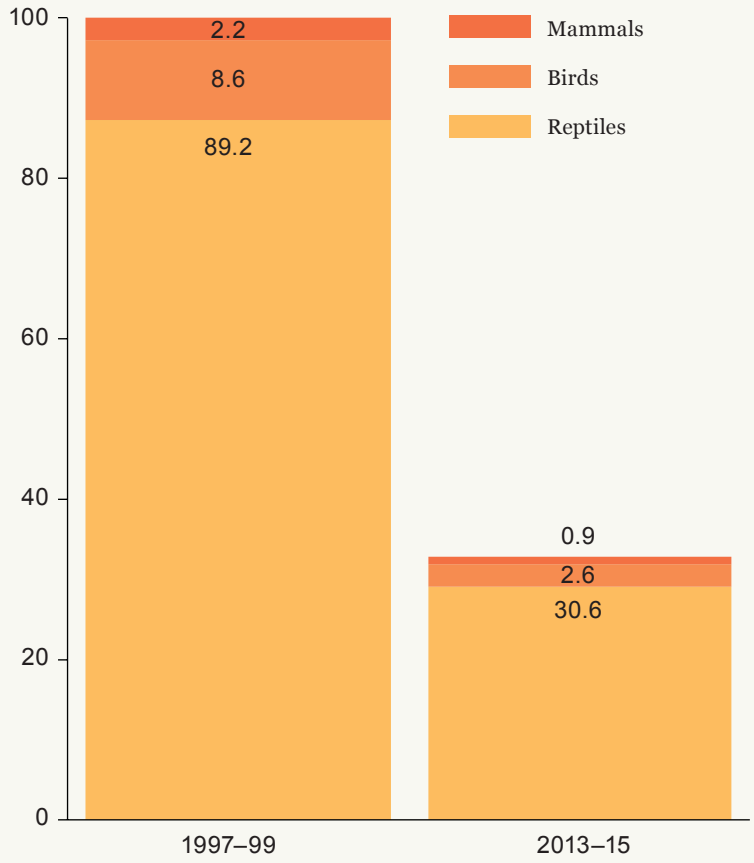
15 Cogger *et al*,. 2003 cited above.

16 *Remnant* in Queensland does not mean never cleared old-growth. It includes bushland previously cleared that has regrown above thresholds of at least 70% of average mature height and 50% of mature average canopy cover.

17 Advanced regrowth means that prior to clearing in 2013-15, it had not been cleared since at least 1988 and had a foliage projective cover of at least 11%.

18 The thresholds for non-remnant to be reclassified into remnant status in Queensland are at least 70% of the typical mature or never-cleared height and at least 50% of the typical mature or never-cleared canopy cover.

Figure 2: Animals lost annually to tree-clearing in the late 1990s (1997-99)[19] and updates for recent clearing (2013-15) of remnant and advanced regrowth bushland (From Table 1 above).



This is still an underestimate however, because it does not include:

- animals lost due to clearing of forests and woodlands younger than 25 years;
- invertebrates;
- semi-aquatic and aquatic animals such as frogs, turtles and fish, or marine mammals such as dugongs dying due to water pollution and habitat degradation caused by clearing in the catchment; and
- animals dying due to the legacy impacts of habitat fragmentation.

Sources of over and underestimation are discussed in more detail below.

Finn and Stephens (2017)[20] recently proposed a rough estimate of 50 million animals killed annually in Queensland for 2014-15 and NSW for 2012-13 combined, based on the Cogger *et al,* (2003) report for Queensland and also Johnson *et al,* (2007) for NSW.[21] The updated estimates developed here are broadly consistent with that given by Finn and Stephens (2017).

Animal numbers losing habitat are dominated by small reptiles, due to the fact that niche space of smaller organisms is generally greater than for larger organisms and so more can occupy the same area (Tables 3, 4).

19 Cogger *et al*, 2003 cited above.

20 Finn HC & Stephens NS, 2017,The invisible harm: tree-clearing is an issue of animal welfare. *Wildlife Research* DOI: 10.1071/WR17018

21 Cogger *et al*, 2003 cited above; Johnson C, Cogger H, Dickman C & Ford H, 2007, *Impacts of Land clearing; The Impacts of Approved Clearing of Native Vegetation on Australian Wildlife in New South Wales*. WWF-Australia Report, WWF-Australia, Sydney

PATTERNS OF CLEARING AND ANIMAL LOSSES

The current pattern of clearing, and losses due to clearing, has changed since the late 1990s.

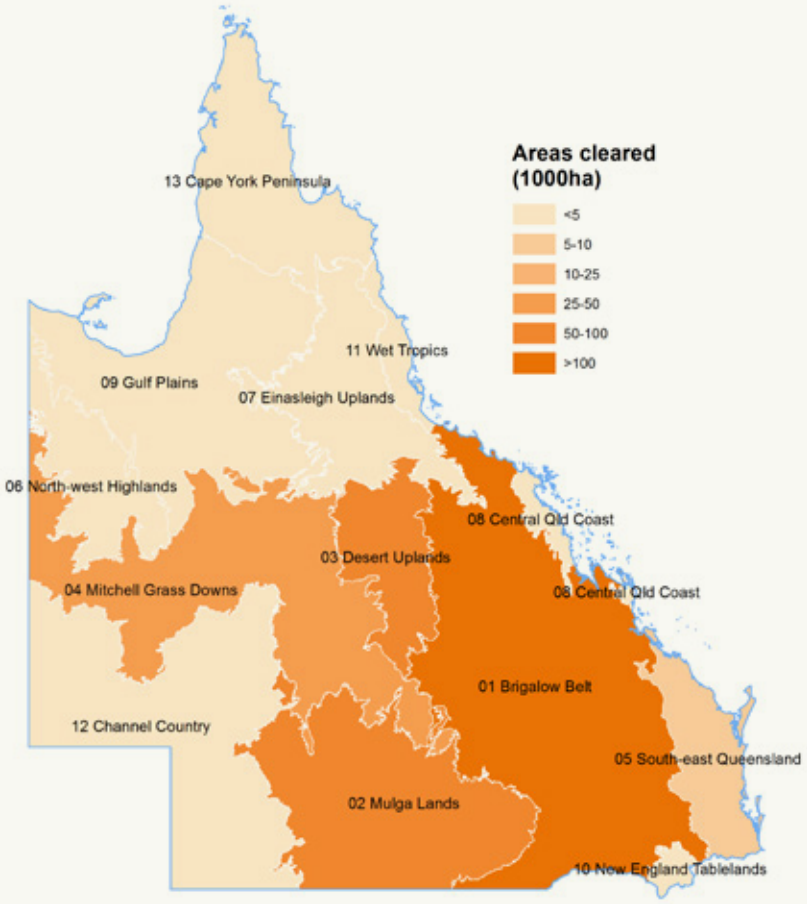
In the late 1990s, the four top ranked bioregions for remnant clearing were in order: Brigalow Belt, Mulga Lands, Desert Uplands and Mitchell Grass Downs (Table 2, Fig 3). This order has changed somewhat to: Brigalow Belt, Mulga Lands, Mitchell Grass Downs and Gulf Plains respectively, when also including advanced regrowth (Table 2, Fig 3).

In the late 1990s, the four top ranked bioregions for mammals losing habitat to clearing were in order: Brigalow Belt, Southeast Queensland, Mulga Lands and Desert Uplands (Table 2, Fig 4). Now this order has changed significantly to: southeast Queensland, Brigalow Belt, Mulga Lands and New England Tableland respectively (Table 2, Fig 4).

It may seem paradoxical that southeast Queensland ranks so highly for mammal losses, but not for areas cleared (Figs 3-4), considering that roughly ten times more clearing by area happens in the Brigalow Belt than in southeast Queensland (Table 2). However, southeast Queensland still features as the hot spot for mammals losing habitat to clearing because mammal densities are so much higher there at 51.24 per hectare of native vegetation, compared with an estimated 3.93 mammals per hectare in the Brigalow Belt, due to the higher rainfall and productivity of the environment (Table 2).

AERIAL IMAGE OF CLEARING TREES FOR AN URBAN EXPANSION NEAR IPSWICH, SOUTHEAST QUEENSLAND, APRIL 2017 © WWF-AUSTRALIA

Figure 3: Queensland bioregions ranked by clearing of remnant in 1997-99 (top) and by recent clearing of remnant and advanced regrowth 2013-15 (bottom) (see Table 2 for areas)



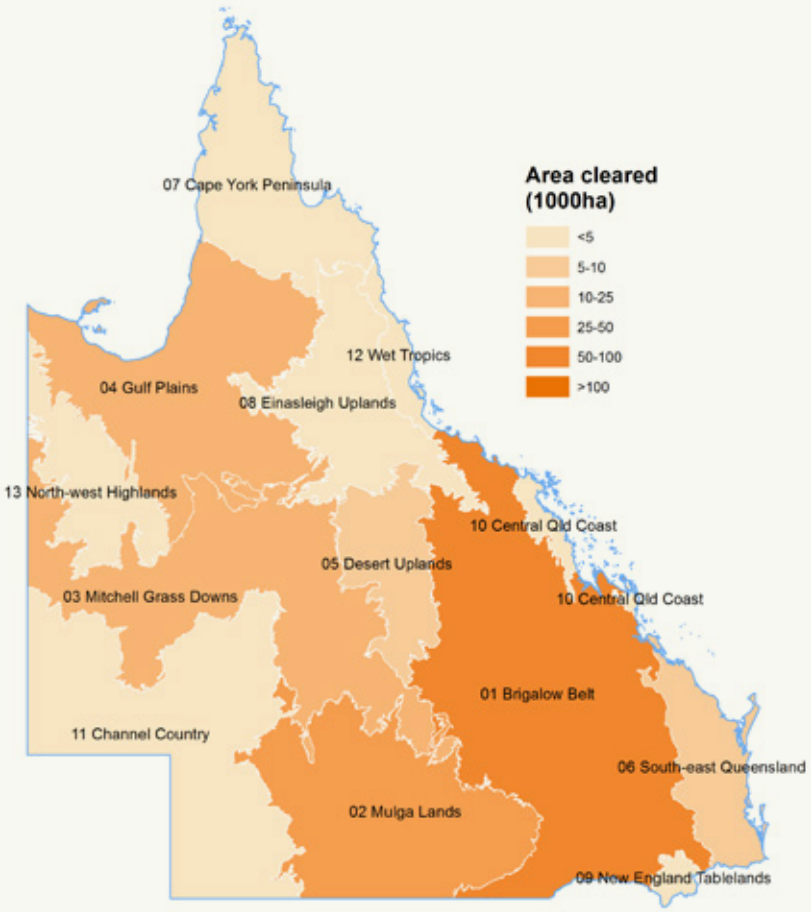
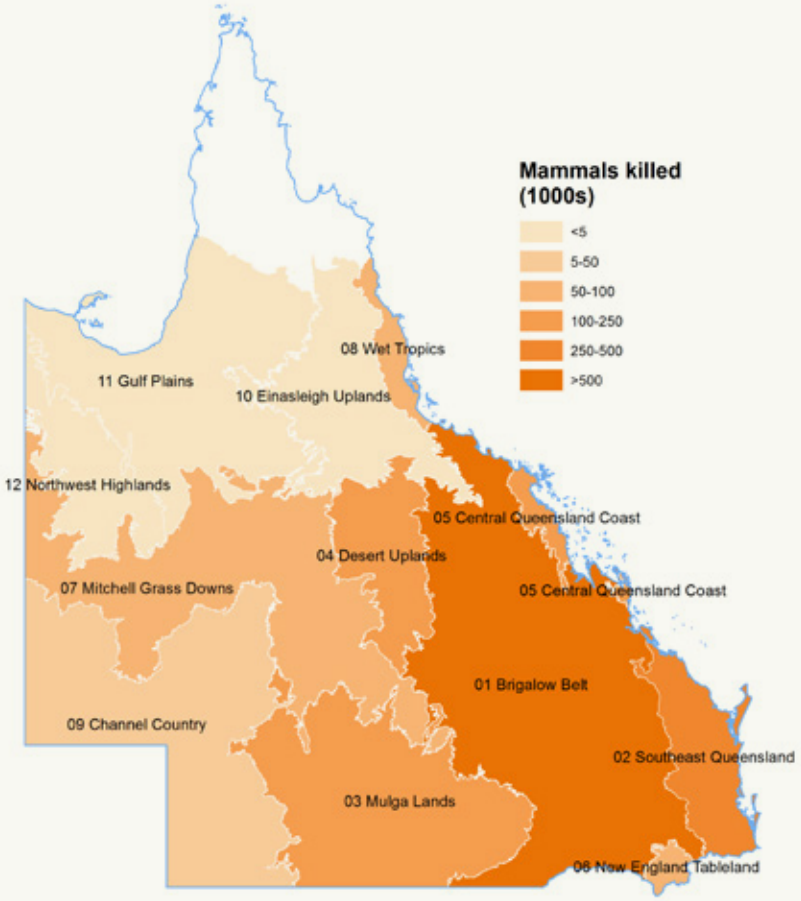
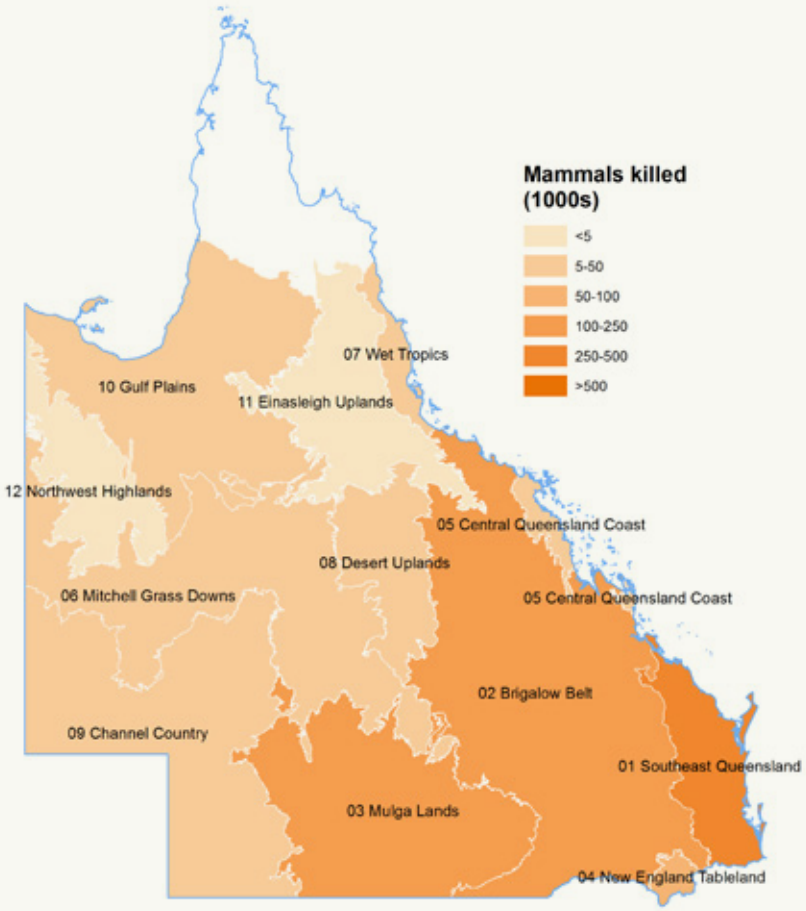


Figure 4: Queensland bioregions ranked by numbers of mammals lost to clearing of remnant in the late 1990s (top) and by recent clearing of remnant and advanced regrowth, 2013-15 (bottom) (see Table 2 for areas).





MAJOR MITCHELL'S COCKATOO (LOPHOCHROA LEADBEATERI) © MOLLY GRACE PHOTOGRAPHY

In the late 1990s, there was no significant clearing of Cape York savannahs. Hence, in the 2003 report, no effort was made to estimate animal numbers affected on Cape York.

Areas cleared have since risen considerably on Cape York and on the neighbouring Gulf Plains due in large part to just three very large High Value Agriculture clearing permits for Strathmore (Gulf Plains), Kingvale and Olive Vale stations (Cape York). [22] This explains the changes in ranks of these two bioregions between the late 1990s and the present in regard to areas cleared (Fig 3).

The animals lost due to recent clearing on Cape York are not estimated in this update report, following the methods of the 2003 report. However, this only adds to the already considerable underestimation of actual losses as discussed below.

In this report, we did not attempt to update estimates of koalas, possums and gliders and bandicoots lost due to tree-clearing (Table 2). We recently estimated koalas lost in southeast Queensland at approx. 90 per annum, based on density estimates recently developed by University of Queensland researchers for the Queensland Government. [23] Statewide estimates of densities and losses of koalas due to tree-clearing are still in development.

22 Taylor MFJ, 2017, *Pervasive inaction on national conservation law over tree-clearing in Queensland.* WWF-Australia briefing paper.

23 Rhodes JR, Beyer HL, Preece HJ & McAlpine CA, 2015, *South East Queensland Koala Population Modelling Study.* UniQuest, Brisbane, Australia.

24 Tables 3 and 5 in Cogger *et al*, 2003, Impacts of Tree-clearing on Australian Wildlife in Queensland. Report for WWF-Australia, Sydney.

Table 2. Mammals losing habitat to tree-clearing annually in the late 1990s (1997-99) [24] in respective bioregions, and updates for recent clearing (2013-15) by application of same density estimates.

		1997-99 estimates						2013-15 updates			
			Mammals lost					Areas cleared (ha/yr)		Mammals lost	
Bioregion	Area (million ha)	Remnant cleared (ha/yr)	Density Nos/ha	Total no.	Koalas	Possums & gliders	Bandi-coots	Remnant only	Remnant & advanced regrowth	Remnant only	Remnant & advanced regrowth
Brigalow Belt	36.4	260,200	3.93	1,022,586	18,000	110,000	-	27,520	59,493	108,155	233,807
Channel Country	23.2	500	10.26	5,130	-	-	-	944	946	9,689	9,707
Central Qld Coast	1.5	2,600	42.12	109,512	200	40,000	6,000	704	1,147	29,666	48,298
Cape York Peninsula	12.1	-	-	-	-	-	-	2,417	2,642	-	-
Desert Uplands	6.9	51,100	3.48	177,828	-	27,000	-	4,229	5,210	14,718	18,130
Einasleigh Uplands	11.9	2,800	1.42	3,976	-	1,500	-	1,571	1,740	2,231	2,470
Gulf Plains	21.8	2,100	0.58	1,218	-	-	-	10,773	10,842	6,248	6,288
Mitchell Grass Downs	24.3	26,900	2.86	76,934	-	-	-	12,563	14,440	35,931	41,299
Mulga Lands	18.7	85,400	2.87	245,098	-	-	-	40,515	49,410	116,279	141,807
New England Tablelands	0.8	1,800	45.11	81,198	-	28,000	3,000	682	1,462	30,744	65,928
North-west Highlands	7.2	3,800	0.16	608	-	-	-	153	157	24	25
South-east Queensland	6.2	7,400	51.24	379,176	600	115,000	17,000	2,075	5,203	106,346	266,616
Wet Tropics	2.0	1,300	50.46	65,598	-	20,000	3,000	245	407	12,371	20,546
Total	173.0	445,900		2,168,862	18,800	341,500	29,000	104,393	153,098	472,403	854,923

* At least 11% FPC in 2013, and not cleared previously in SLATS record 1988-2013, and so regrowing since at least 1988.

Table 3. Birds losing habitat to tree-clearing annually in the late 1990s (1997-99) in different general vegetation types and updates for recent clearing (2013-15) by application of same density estimates to different types of bushland.

General vegetation type	Broad Veg. Types	1997-99 estimates			2013-15 updates			
		Birds lost			Areas cleared (ha/yr)		Birds lost	
		Remnant cleared (ha/yr)	Densities Nos/ha	Total no.	Remnant only	Remnant & advanced regrowth	Remnant only	Remnant & advanced regrowth
Acacia woodlands	10,11,12	133,900	10.2	1,365,780	48,817	70,381	497,930	717,882
Eucalypt woodlands	3,4,5,6,7,8,9	239,200	26.0	6,219,200	39,770	56,022	1,034,019	1,456,572
Grassland	13,14	25,200	1.3	32,760	4,230	4,811	5,500	6,254
Heath/ shrublands	18	1,600			223	257	-	-
Mangroves	17	800			50	79	-	-
Open forest	2	9,100	31.0	282,100	1,515	3,706	46,953	114,893
Rainforests	15	4,400	33.0	145,200	332	1,935	10,945	63,850
Tablelands woodlands	1	29,800	18.9	563,220	8,346	14,522	157,749	274,473
Wetlands	16	2,500			1,110	1,385	-	-
TOTAL		446,500		8,608,260	104,393	153,098	1,753,095	2,633,925

Table 4. Reptiles losing habitat to tree-clearing annually in the late 1990s (1997-99) in different bioregions and updates for recent clearing (2013-15) by application of same density estimates.

Bioregion	1997-99 estimates		2013-15 updates			
			Areas cleared (ha/yr)		Reptiles affected (millions)	
	Remnant cleared (ha/ yr)	Reptiles affected (millions)	Remnant only	Remnant & advanced regrowth	Remnant only	Remnant & advanced regrowth
Brigalow Belt	260,200	52.0	27,520	59,493	5.5	11.9
Desert Uplands	51,100	10.2	4,229	5,210	0.8	1.0
Mitchell Grass Downs	26,900	5.4	12,563	14,440	2.5	2.9
Mulga Lands	85,400	17.1	40,515	49,410	8.1	9.9
South-east Queensland	7,400	1.5	2,075	5,203	0.4	1.0
All others	14,900	3.0	17,489	19,342	3.5	3.9
TOTAL	445,900	89.2	104,393	153,098	20.9	30.6

HOW GOOD ARE THE ESTIMATES?

Some assumptions of these analyses lead to overestimation while others lead to underestimation. We consider however, that the assumptions leading to underestimation greatly outweigh those leading to overestimation, with the net effect of a substantial underestimate of actual animal deaths.

OVERESTIMATION SOURCES

The main assumption leading to overestimation is that death rates following clearing are 100%. They may not be 100% in practice if remaining habitats into which some animals may escape happen to be below carrying capacity. Habitats are thought to be generally at carrying capacity for most species and therefore cannot accommodate any significant influx of new immigrants. In the classic study of rainforest deforestation in the Amazon, bird densities increased rapidly in the remaining islands of forest following clearing of surrounding forest, but then progressively 'self-thinned' back down to previous densities as animals died or were displaced further afield. [25]

In the case of koalas however, chlamydial disease has greatly reduced koala numbers even in largely untouched habitats. [26] Therefore, active translocations of koalas to large forest tracts have been unexpectedly successful. [27] However, koalas are likely to be an atypical case due to the history of disease in reducing populations below capacity.

Even in close-to-ideal conditions where vertebrates are actively translocated (rather than having to make their own way) into habitat known to be unoccupied or below capacity, the success rate is still only about 50% on average over time frames of three to five years typically. [28] Success rate varies greatly depending on type of translocation. [29]

As a group, most reptiles are substantially much less motile than mammals and especially birds and so their ability to escape the impacts of land clearing by migrating to adjacent or nearby blocks of suitable habitat is greatly limited.

For almost all bulldozing of habitat in Queensland there is no active effort required or made to assist animals in relocating to habitats known to have excess capacity to receive them. Hence, this source of overestimation can in most cases be considered minor and greatly outweighed by the underestimation sources discussed below.

25 Lovejoy TE *et al*, 1986, Edge and other effects of isolation on Amazon forest fragments. pp 257-285 in Soule ME (ed.) *Conservation Biology: the science of scarcity and diversity*. Sinauer Associates, Sunderland Mass.

26 Polkinghorne A, Hanger J & Timms P, 2013. Recent advances in understanding the biology, epidemiology and control of chlamydial infections in koalas. *Veterinary microbiology*, 165, 214-223.

27 Nottidge B, Tribe A, Hanger J, Green L, & Parkway D, 2003. Monitoring rehabilitated koalas at two release sites on the Gold Coast. In *National Conference on Wildlife Rehabilitation Victoria 2003* (pp. 26-26). Victoria University.

28 In some cases, persistence was assessed over longer time frames and *"at least 16 of 77 translocations (21%) where species persisted for greater than five years have subsequently failed"*: Short J. 2009, *The Characteristics and Success of Vertebrate Translocations within Australia.* Department of Agriculture, Fisheries and Forestry.

29 Ibid.

An additional problem arises if there is long-term decline in population densities. In which case density estimates taken in the past will be overestimates of current actual densities. For example, bird abundances were greatly reduced by a decadal drought in Victoria from about 2006 to 2011, and did not recover during subsequent normal periods to the extent expected.[30] Similarly, koala densities were greatly reduced by drought in the mulga country of southwest Queensland, although no study has yet determined if numbers have since recovered.[31] There has been long-term decline in koala populations in southeast Queensland, perhaps due to the legacy effects of past tree-clearing, forest fragmentation and development as discussed above.[32] However, we lack the evidence with which to evaluate the extent to which densities may have declined across many taxa since they were collated and used in the 2003 report. We assume that while some taxa may have suffered density declines, this is not a general phenomenon.

SOURCES OF EITHER OVER- OR UNDERESTIMATION

Mean estimates of density are necessarily subject to a high level of natural variability. For example, estimates of bird densities used in the 2003 report for broad vegetation group 1, ranged from 9.7 to 32.7 per hectare with an average of 18.9 (Table 3, and Table 6 in the 2003 report). Densities naturally vary in space and time depending on local conditions (whether data are gathered from large and continuous or already fragmented habitats, whether on fertile or infertile soil) and on climate (whether data are gathered from higher rainfall places or during higher rainfall periods, or from lower rainfall environments or during drought).

A key assumption is that density estimates taken in the past will remain applicable now. If the density estimates were taken from periods of abundance, but the current period is one of drought, then losses will be overestimated, as discussed above.

However, this potential source of overestimation is cancelled out and indeed turned to one of underestimation to the extent that the losses due to the population decline itself represent the legacy effects of past clearing, as discussed further below, effects that are not quantified in this or in the 2003 report.

Conversely, if density estimates were derived from periods of drought, but the current period is one of abundance, then losses will be underestimated. Likewise, if density estimates were taken from less fertile habitats, whereas current clearing tended toward more fertile habitats, losses may be underestimated.

To the extent possible, this concern has been minimised by averaging out a number of density estimates taken from different periods for a given habitat type, as described in the 2003 report.

30 Bennett JM *et al*, 2014, Resistance and resilience: can the abrupt end of extreme drought reverse avifaunal collapse? *Diversity and Distributions*, 20, 1321-1332.
Mac Nally R *et al*, 2009, Collapse of an avifauna: climate change appears to exacerbate habitat loss and degradation. *Diversity and Distributions*, 15, 720-730.
Selwood KE *et al*, 2015, A bust but no boom: responses of floodplain bird assemblages during and after prolonged drought. *Journal of Animal Ecology*, 84, 1700-1710.

31 Seabrook L *et al*, 2011, Drought-driven change in wildlife distribution and numbers: a case study of koalas in south west Queensland. *Wildlife Research*, 38, 509-524.

32 Rhodes *et al*, 2015 cited above.

UNDERESTIMATION SOURCES

The estimation methods of the 2003 report do not include other population segments that are also impacted by tree-clearing. These are expected to be very sizeable, and hence overall losses are very likely to be underestimated.

a) **Non-remnant bushland:** Only the clearing of remnant (also known as intact, mature or primary) forest or bushland was considered in the 2003 report. Excluded from that analysis were the large areas of regrowing forest and bushland that are also cleared. While mature forests are expected to retain the highest natural densities of wildlife,[33] regrowth habitats are also important for woodland birds[34] and reptiles[35], and this is particularly true the more advanced the age of forest. Forest age brings more structure in the form of furrowed bark, knotholes and hollows, fallen timber and foliage debris, as well as a richer resource base of foliage, nectar, pollen, exudates, and invertebrate prey that can support a higher density of vertebrates.[36] Areas of active replanting improve most in value for birds when they are large, wide, structurally complex, old and located near remnant vegetation.[37] Nonetheless, there is little difference between regrowth and remnant brigalow in reptile species richness, diversity, dominance and community composition.[38]

   In this updated analysis, we extend the methods of the 2003 report by also including clearing of advanced (25 years or older) regrowth bushland, bushland that is likely to have re-attained but has not been formally assessed for remnant status.

   Based on the studies above, we believe that the same densities can be applied to advanced regrowth forests as can be applied to remnant. This may overestimate losses to the extent that advanced regrowth cannot support the same animal densities as remnant forests. However, this is likely to be more than offset by the underestimation caused by continuing to exclude from the estimates animals killed during the much larger scale of clearing of younger regrowth. It can also be further offset by differences in species composition rather than a decline in number of individuals.

b) **Off-site, indirect deaths**. Aquatic wildlife such as fish, turtles and frogs in streams and wetlands downstream of, or adjacent to, areas cleared may also die due to increased runoff and erosion,[39] and water pollution due to agrichemicals or sediments, or increased exposure due to loss of streambank shading.[40]

33 Gibson L *et al*, 2011, Primary forests are irreplaceable for sustaining tropical biodiversity. *Nature*, 478, 378-381.

34 Bowen MR *et al*, 2009, The age and amount of regrowth forest in fragmented brigalow landscapes are both important for woodland dependent birds. *Biological Conservation* 142, 3051-3059.

35 Bruton MJ *et al*, 2013, Regrowth woodlands are valuable habitat for reptile communities. *Biological Conservation*, 165, 95-103.

36 McElhinny C *et al*, 2006, Fauna-habitat relationships: a basis for identifying key stand structural attributes in temperate Australian eucalypt forests and woodlands. *Pacific Conservation Biology* 12, 89-110.

37 Monro NT *et al*, 2007, Faunal response to revegetation in agricultural areas of Australia: A review. *Ecological Management & Restoration* 8, 199-207.

38 Bruton MJ *et al*, 2013, cited above.

39 Siriwardena *L et al*, 2006, The impact of land use change on catchment hydrology in large catchments: The Comet River, Central Queensland, Australia. *Journal of Hydrology* 326, 199-214.

40 Sweeney BW & Newbold JD, 2014, Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: a literature review. *Journal of the American Water Resources Association*, 50, 560-584.

Tree-clearing in the catchments is also recognised as a major threat to the Great Barrier Reef and the marine animals that live there such as dugongs and marine turtles, due primarily to increased runoff, erosion and sediment pollution. [41]

Tree-clearing also generates carbon pollution contributing to global warming which may adversely affect many more individual animals on longer time scales. In 2013-14, there were 35.8 million tonnes of CO_2 emissions from tree-clearing in Queensland, representing 6.7% of Australia's greenhouse gas emissions in that year. [42] The impact of climate change on native vertebrates is still poorly understood, but it is predicted that many native species will be adversely affected. [43] Mass deaths of flying foxes in heatwaves are a reminder that tree-clearing also makes a contribution, albeit small, to the rising risk of animal suffering and death due to global warming. [44]

c) **Legacy deaths.** Ongoing losses due to the legacy effects of fragmentation [45] and degradation of the habitat remaining after clearing, are also not included. Losses of animals are not confined just to the sum of all areas of habitat bulldozed. Losses are elevated in the remaining habitats due to edge effects and fragmentation. The type of fragmentation is also very important, depending on the animal species involved. For instance, it is critically important for animals that move along the ground like wallabies, bandicoots or koalas, whether tree-clearing is for a firebreak or a busy road. [46] However, even a firebreak or little used road removes protective cover for native animals and provides avenues for incursions of exotic weeds and feral predators such as cats and foxes. We are unable at this stage to quantify this potentially large segment of wildlife loss due to clearing.

d) **Undetected animals:** Density estimates in the literature are necessarily underestimates of actual animal densities since they are derived from field surveys which can never detect all animals actually present. There is always an undetected and undetectable fraction of animals that are not observed and counted in field surveys. [47] Even large animals can go undetected in surveys. A recent study of radio tagged koalas found that even trained koala experts only detected 50-74% of koalas known to be present, and detectability depended greatly on forest density. We are unable at this stage to quantify this segment of wildlife loss due to clearing. [48]

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41 *"In addition, the Queensland Government will: • strengthen vegetation management laws to protect remnant and high value regrowth native vegetation (including in riparian zones)"* from *Great Barrier Reef 2050 Long-Term Sustainability Plan* http://www.environment.gov.au/marine/gbr/publications/reef-2050-long-term-sustainability-plan

42 Queensland Department of Natural Resources and Mines, 2015, Vegetation clearing rates in Queensland: Supplementary report to the Statewide Landcover and Trees Study Report 2012–14, November 2015. National total emissions of 530.7 million tonnes in 2014, were taken from the National Greenhouse Gas Inventory http://ageis.climatechange.gov.au/.

43 Garnett S & Franklin D (eds) 2014, *Climate change adaptation plan for Australian birds.* CSIRO publishing; Lee JR *et al*, 2015, Mapping the drivers of climate change vulnerability for Australia's threatened species. PloS one, 10, p.e0124766.

44 http://theconversation.com/killer-climate-tens-of-thousands-of-flying-foxes-dead-in-a-day-23227

45 Haddad NM *et al*, 2015, Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances*, 1, p.e1500052.

46 Polak T *et al*, 2014, Optimal planning for mitigating the impacts of roads on wildlife. *Journal of applied ecology*, 51, 726-734.

47 Wintle BA *et al*, 2004, Precision and bias of methods for estimating point survey detection probabilities. *Ecological Applications*, 14, 703-712.

48 Endeavour Veterinary Ecology 2017, *Final technical report, Moreton Bay Rail Koala Management Program.*

NORTHERN BETTONG (BETTONGIA TROPICA) AT A WILDLIFE CARE HOUSE IN RAVENSHOE, QUEENSLAND - JUNE 2016 © STEPHANIE TODD / JCU / WWF-AUS

CURRENCY OF DENSITY ESTIMATES

The density estimates used in the 2003 report were based on a suite of studies which are summarised in that report. Little new information has come to hand in the past decade which would alter those earlier estimates. Reptile density estimates in particular are conservative underestimates, particularly considering they include all reptiles of any size in the soil, on the ground, in bark and in the foliage.

Young male koala (*Phascolarctos cinereus*) eating Eucalyptus leaves at Return to the Wild Inc. Toowoomba, Queensland.

METHODS

Spatial Data Sources:

- Statewide Land and Tree Study (SLATS) woody cover loss (Queensland Government, 2013-14 and 2014-15 releases)
- Foliage Projective Cover (Queensland Government, 2013 release)
- Regional Ecosystems of Queensland (Queensland Government, version 9, current for 2013)
- Bioregions of Queensland (Queensland Government, 2012)
- Look up table of broad vegetation groups in the above regional ecosystems version 9, matched to the broad vegetation types used in Cogger et al, (2003) (Queensland Herbarium Don Butler pers. comm.)

SLATS tree-clearing layers were combined into one layer for 2013-15. Woody cover loss due natural causes or of non-native vegetation was excluded where indicated as such (plantation harvest, storm damage, drought death).

Tree-clearing polygons were clipped to two different masks:

a) remnant vegetation in 2013 on the basis of the version 9 regional ecosystems layers current for that year; or

b) remnant as above, but also including non-remnant that showed no earlier evidence of clearing in the entire SLATS record since 1988 (that is, had not be cleared in at least 25 years), and which also had 11% or greater foliage projective cover in 2013, the level considered by Queensland to be equivalent to the Kyoto definition of a forest.[49] This advanced regrowth was filtered further to remove small isolated fragments of 0.75ha or less with doubtful value as wildlife habitat.

These two masked extents of areas cleared were then intersected with bioregions and with regional ecosystems respectively and areas cleared within each bioregion or broad vegetation type (as used by Cogger *et al*, 2003) were calculated using the Albers Equal Area Projection on the GDA94 datum.

Areas so calculated were then multiplied by the density estimates as shown in Tables 3, 5 and 8 of Cogger *et al*, (2003) to update the estimates of animals lost due to tree-clearing.

49 Scarth P, Armston J & Danaher T, 2008, On the Relationship between Crown Cover, Foliage Cover and Leaf Area Index. *Proceedings of the 14th Australasian Remote Sensing and Photogrammetry Conference, Darwin, Australia, October 2008.*

APPENDIX

Breakdown of recent areas cleared and animal losses by Queensland Department of State Development regions

	Remnant and advanced regrowth	Nearest 1000 killed			
State Dev. Regions*	**Cleared (ha)**	**Mammals**	**Birds**	**Reptiles**	**Total**
Bundaberg/Maryborough/Burnett	5,997	138	148	1,199	1,486
Rockhampton, Central and West	38,426	174	680	7,685	8,539
Toowoomba, Darling Downs and West	75,525	312	1,106	15,105	16,523
Cairns and Far North Qld	13,351	19	314	2,670	3,003
Gulf	2,715	4	41	543	588
Mackay/Whitsunday	12,823	93	241	2,565	2,898
Townsville and North Qld	2,317	15	46	463	525
SEQ Brisbane	168	9	3	34	45
SEQ North	429	22	12	86	119
SEQ South	552	28	18	110	157
SEQ West	796	41	24	159	224
TOTAL	153,098	855	2,634	30,620	34,108

* https://www.statedevelopment.qld.gov.au/resources/map/dsd-regions-offices-map.pdf

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