Utilising bycatch camera-trap data for broad-scale occupancy and conservation: a case study of the brown hyaena *Parahyaena brunnea*

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SUPPLEMENTARY MATERIAL 1 Characteristics of sites surveyed using camera traps to assess brown hyaena occupancy in South Africa. Asterisks (*) indicate unfenced or partially unfenced sites.

Atherstone Nature Reserve: Atherstone Nature Reserve is 240 km^2 in size and is located in the Thabazimbi district of Limpopo Province (Marnewick et al., 2008). The fenced nature reserve is used for seasonal commercial sport hunting and some live animal sales also occur (Marnewick et al., 2008). Fifty camera-trap stations covering 156 km^2 (minimum convex polygon) collected data from August 8, 2013 to September 28, 2013.

Barberton Nature Reserve: Barberton Nature Reserve is in Mpumalanga Province. An area of 280 km^2 was surveyed between July 12, 2016 and August 25, 2016 using 33 camera-trap stations. There is widespread illegal activity within the reserve; both illegal mining and cattle (*Bos taurus*) grazing within the reserve were recorded during our survey, and this appeared to be accompanied by subsistence poaching, both through snaring and dog hunts.

Blyde River Canyon Nature Reserve*: Blyde River Canyon is the third largest vegetated canyon in the world. The canyon, which is situated on the northern Drakensberg Escarpment in Mpumalanga Province, extends 21 km between Bourke's Luck at its southern tip to the Blyde Dam in the north. The canyon is in Blyde River Canyon Nature Reserve which is managed by the Mpumalanga Parks Board and is unfenced. Blyde River Canyon Nature Reserve covers 268 km^2 and ranges in elevation from 560 m to 1944 m above sea level (Lötter & Beck, 2004). A grid of 31 camera-trap stations which covered 232 km^2 collected data between September 13, 2016 and October 27, 2016.

Dinokeng Game Reserve: Dinokeng Game Reserve is a 185 km^2 fenced reserve which straddles Gauteng and Limpopo Provinces. Altitude varies between 1100 m and 1200 m (Yiu et al., 2015). The reserve is primarily used for eco-tourism. Lions (*Panthera leo*) were reintroduced to the reserve between 2011 and 2013. Prior to this, the only large carnivores occupying the area were leopards (*Panthera pardus*) and brown hyaenas (*Parahyaena brunnea*) (Yiu et al., 2015). Camera-trap stations were active at 36 sites across 173 km^2 between July 2, 2016 and August 18, 2016.

Hluhluwe-iMfolozi Park is located in KwaZulu-Natal Province. The park, which is managed by Ezemvelo KwaZulu-Natal Wildlife, covers almost 900 km^2 and has altitudes ranging between 60 m and 750 m (Boundja & Midgley, 2010). The area is used for eco-tourism and is entirely fenced. Forty-six camera-trap stations collected data from March 28, 2017 to May 19, 2017 across a 418 km^2 area.

Ithala Game Reserve: Ithala Game Reserve in the province of KwaZulu-Natal has elevations varying from 350 m to 1550 m above sea level (Wiseman et al., 2004). The 296 km^2 reserve is managed by Ezemvelo KwaZulu-Natal Wildlife. Between August 27, 2013 and October 10, 2013, 36 camera stations extending over 236 km^2 collected data.

Khamab Kalahari Reserve: The reserve (955 km^2) is situated in the north-western Kalahari region of South Africa's North West Province. Formerly a livestock farm, the property was converted to a private game reserve in 2008. Forty camera-trap stations spaced over 617 km^2 recorded data between September 1, 2016 and October 15, 2016.

Kwandwe Private Game Reserve: Kwandwe Private Game Reserve is in the Eastern Cape Province's Great Fish River Valley. The 183 km^2 reserve is entirely fenced and is used for eco-tourism (Welch & Parker, 2016). Brown hyaenas were reintroduced at Kwandwe in 2003 (Welch & Parker, 2016). The population has thrived and increased from six individuals in 2003 to a minimum of 28 individuals in 2013 (Welch & Parker, 2016). Cheetah, leopards, lion, serval (*Leptailurus serval*), and wild dog were reintroduced between 2001 and 2005 (Hayward et al., 2007). Between March 3, 2017 and April 23, 2017, forty camera-trap stations covering 135 km^2 were active.

KwaZulu Private Game Reserve and adjacent private properties: This survey, situated in KwaZulu-Natal Province, covered a number of privately owned neighbouring properties namely KwaZulu Private Game Reserve itself and Mahlalela Game Ranch and Amakhosi, Zeekoepan and Mkuze Falls Private Game Reserves. Land use includes ecotourism and game farming/hunting. Data was collected from 62 camera-trap stations spanning 325 km^2 between November 2, 2015 and December 16, 2015.

Lajuma and adjacent private properties*: This site is composed of multiple privately owned properties in the western Soutpansberg Mountains in northern Limpopo Province. The Soutpansberg Mountains range in altitude from 200 m to 1748 m above sea level (Berger et al., 2003). Lajuma and adjacent private properties are a patchwork of land uses including a private nature reserve, ecotourism, cattle farming and wildlife farming (mostly wild ungulates often referred to as game). Some parts of the survey site are fenced, yet still permeable, while other areas are unfenced. Data was collected at 39 camera-trap stations (193 km^2) between August 23, 2014 and October, 8, 2014.

Lapalala Wilderness: Lapalala Wilderness is a game reserve in the Waterberg Biosphere, Limpopo Province. The reserve is privately owned, fenced, and closed to the public. The reserve is home to a wilderness school (Dalerum & Belton, 2015). Occasional guided hunts are also conducted. A 385 km^2 area was surveyed using 40 camera-trap stations from October 29, 2016 to December 20, 2016.

Little Karoo*: The Little Karoo is a semi-arid region in the Western Cape Province. The landscape is comprised of broad valleys surrounded by mountain ranges with deeply incised gorges. The survey area is an unfenced mosaic of farmland, formally protected areas and privately-owned conservancy land. Forty camera-trap stations spaced across a 2,038 km^2 area were active between May 6, 2017 and June 21, 2017.

Loskop Dam Nature Reserve: The Loskop Irrigation Dam is located on the Olifants River in Mpumalanga Province. The dam and its surrounding land are protected within

the Loskop Dam Nature Reserve which is managed by the Mpumalanga Tourism and Parks Agency. The reserve is 232 km^2 in size with water surface covering 23.5 km^2 (Barrett et al., 2010). Thirty-four camera-trap stations spanning 170 km^2 collected data between November 4, 2016 and December 18, 2016.

Madikwe Game Reserve: Madikwe Game Reserve is situated in North West Province and the 600 km^2 area is predominately flat with rocky outcrops and ridges scattered throughout the landscape. The reserve is used for eco-tourism. Camera-trap stations were active between November 3, 2016 and December 17, 2016. The 40 stations covered an area of 327 km^2.

Makalali Private Game Reserve: The Greater Makalali Private Game Reserve spans 220 km^2 in the Central Lowveld region, Limpopo Province (Kettles & Slotow, 2009). Altitude ranges from 300 m to 500 m above sea level (Kettles & Slotow, 2009). The reserve is a partnership between several privately-owned properties. Internal fences have been removed and the area is used for eco-tourism, the sale of live game and low impact hunting (Kettles & Slotow, 2009). An area of 180 km^2 was surveyed using 40 camera-trap stations between September 8, 2015 and November 16, 2015.

Manyoni Private Game Reserve: Situated in KwaZulu-Natal Province, Manyoni Private Game Reserve is 230 km^2 in size. Formerly known as Zululand Rhino Reserve, the reserve contains all of the 'Big Five'. Data was collected between July 29, 2015 and September 11, 2015 at 40 camera-trap stations spanning 200 km^2

Mountain Zebra National Park: The Mountain Zebra National Park is a South African National Park situated in the Eastern Cape Province. The park is 214 km^2 in size and lies in a transition zone between the Nama-Karoo, Grassland and Thicket biomes (Novellie & Gaylard, 2013). Recent carnivore releases include four cheetahs in 2007, three brown hyaenas in 2008 and three lions in 2013. Eleven camera-trap stations covering 73 km^2 were active between April 15, 2014 and April 16, 2015.

Pilanesberg National Park: The site is located in North West Province and spans 550 km^2. Eco-tourism is the primary land use. The park sits within an extinct volcano. Three concentric rings of hills surround a flatter central area (Thorn et al., 2009). An area covering 247 km^2 was monitored using 40 camera-trap stations from March 13, 2016 to April 26, 2016.

Somkhanda Game Reserve and adjacent properties: Somkhanda Game Reserve in KwaZulu-Natal Province is a community owned game reserve spanning 120 km^2. The reserve is used for eco-tourism. A 229 km^2 area including Somkhanda Game Reserve, Zimanga Private Game Reserve, Esikhotheni Private Game Reserve, Nyathi Community Reserve and one station on community land that is not under any formal protection was surveyed using 40 camera-trap stations between February 14, 2014 and March 30, 2014.

Songimvelo Game Reserve: Located in south-eastern Mpumalanga Province, Songimvelo Game Reserve spans 490 km^2. The reserve spreads diagonally over 50 km with elevation varying between 600 m to over 1800 m above sea level (Steyn & Stalmans, 2001). Twenty-seven camera-trap stations set up over 112 km^2 were active from March 8, 2016 to April 21, 2016.

Timbavati Game Reserve: Timbavati Private Nature Reserve in Limpopo Province spans an area of 534 km^2 ranges in altitude between 300 and 500 m above sea level. The fenced reserve is situated on the western boundary of Kruger National Park which it is internally unfenced with Kruger. The area is used for eco-tourism. Between September 1, 2016 and October 22, 2016 an area of 167 km^2 was monitored with 40 camera-trap stations.

Venetia Limpopo Nature Reserve: Situated in Limpopo Province, the De Beers Venetia Limpopo Nature Reserve spans 316 km^2. Altitude ranges between 560 and 790 m above sea level (Davies-Mostert et al., 2013). The fenced reserve is owned by the De Beers Diamond Mining Company. A mine is situated on the site, although the majority of land is used for eco-tourism. An area of 288 km^2 was monitored using 40 camera-trap stations between July 3, 2016 and August 20, 2016.

Welgevonden Private Game Reserve: This privately owned and commercially operating reserve situated on the Waterberg Plateau, Limpopo Province, is 375 km^2 in size (Dalerum & Belton, 2015). Eco-tourism is the main land use. An array of 51 camera-trap stations covering 146 km^2 captured data from April 24, 2013 to June 13, 2013.

Wonderkop Nature Reserve: The Wonderkop Nature Reserve is a 160 km^2 reserve in Limpopo Province. Fifty-two camera-trap stations across 192 km^2 were active between June 19, 2013 and August 6, 2013.

Zingela Nature Reserve: Zingela Nature Reserve is a commercial hunting reserve in northern Limpopo Province. The 219 km^2 area is mostly flat with a scattered rocky outcrops. Monitoring was conducted between May 3, 2016 and June 28, 2016 using 40 camera-trap stations which spanned 186 km^2.

SUPPLEMENTARY TABLE 1 Protected area status for survey sites. Abbreviated IUCN protected area designations: Nature Reserve NR, UNESCO-MAB Biosphere Reserve UBR, World Heritage Site WHS, and National Park NP.

Survey site	IUCN protected area designation
Atherstone Nature Reserve	NR
Barberton Nature Reserve	NR
Blyde River Canyon Nature Reserve	NR, UBR
Dinokeng Game Reserve	NR*
Hluhluwe-iMfolozi Park	NR
Ithala Game Reserve	NR
Khamab Kalahari Reserve	None
Kwandwe Private Game Reserve	None
KwaZulu Private Game Reserve and adjacent private properties	None
Lajuma and adjacent private properties	NR*, UBR
Lapalala Wilderness	NR*, UBR
Little Karoo	NR*, WHS*, UBR
Loskop Dam Nature Reserve	NR
Madikwe Game Reserve	NR
Makalali Private Game Reserve	UBR
Manyoni Private Game Reserve	NR
Mountain Zebra National Park	NP
Pilanesberg National Park	NR
Somkhanda Game Reserve and adjacent properties	NR*
Songimvelo Game Reserve	NR
Timbavati Game Reserve	NR, UBR
Venetia Limpopo Nature Reserve	NR*, UBR
Welgevonden Private Game Reserve	NR, UBR
Wonderkop Nature Reserve	NR, UBR
Zingela Nature Reserve	None

*Partial coverage.

SUPPLEMENTARY TABLE 2 Goodness-of-fit results from the chi-square probability (χ^2p) and overdispersion statistic (ĉ) for the global model using different collapsing day periods. Cheetah, spotted hyaena, leopard, lion, wild dog, human, vehicle, habitat and prey were the occupancy covariates. The sample period was limited to 40 or 42 days depending on whether it was a multiple of the sampling occasion length and 984 camera-trap stations were included.

Collapsing period	No. of periods	χ^2p	ĉ
4 day sampling occasions	10	0	1.47
5 day sampling occasions	8	0	1.39
6 day sampling occasions	7	0.01	1.45
7 day sampling occasions	6	0	2.22

SUPPLEMENTARY TABLE 3 Estimated home range size of collared brown hyaenas in South Africa.

Home range size (km^2)	Location	Source
28	Pilanesberg National Park	Richmond-Coggan, 2014
43	Kwandwe Private Game Reserve	Welch *et al.*, 2016
72	Kwandwe Private Game Reserve	Welch *et al.*, 2016
80	Kwandwe Private Game Reserve	Welch *et al.*, 2016
95	Lajuma and adjacent private properties	Williams, 2017
95	Pilanesberg National Park	Richmond-Coggan, 2014
98	Pilanesberg National Park	Richmond-Coggan, 2014
121	Madikwe Game Reserve	Richmond-Coggan, 2014
170	Lajuma and adjacent private properties	Williams, 2017
172	Mountain Zebra National Park	Welch *et al.*, 2016
177	Madikwe Game Reserve	Richmond-Coggan, 2014
192	Mountain Zebra National Park	Welch *et al.*, 2016
205	Mountain Zebra National Park	Welch *et al.*, 2016
119.08	*Average home range for all sites*	

SUPPLEMENTARY TABLE 4 Goodness-of-fit chi-square test of brown hyaena occupancy analysis using the global model. Detection histories recorded from five-day sampling periods. The observed value is the number of times each detection history was observed and the expected value is the number of times each detection history was expected. Detection histories that recorded brown hyaenas across every occasion and were removed from the analysis are denoted with *.

Detection histories	Observed	Expected	Chi-square
00000000	222	245.19	2.19
00000001	8	5.29	1.39
00000010	20	5.29	40.91
00000011	1	3.73	2.00
00000100	13	5.29	11.24
00000110	2	3.73	0.80
00001000	5	5.29	0.02
00001001	1	3.73	2.00
00001010	2	3.73	0.80
00001011	1	2.63	1.01
00001100	1	3.73	2.00
00001101	1	2.63	1.01
00001110	3	2.63	0.05
00001111	1	1.85	0.39
00010000	12	5.29	8.51
00010001	5	3.73	0.43
00010010	3	3.73	0.14

00010011	1	2.63	1.01
00010100	1	3.73	2.00
00011000	2	3.73	0.80
00011000	2	2.63	0.15
00011110	2	1.85	0.01
00011111	3	1.30	2.20
00100000	14	5.29	14.34
00100010	3	3.73	0.14
00100011	1	2.63	1.01
00100100	6	3.73	1.39
00100101	1	2.63	1.01
00100110	1	2.63	1.01
00101000	5	3.73	0.43
00101001	1	2.63	1.01
00101100	4	2.63	0.72
00110000	2	3.73	0.80
00110001	2	2.63	0.15
00110010	2	2.63	0.15
00110100	2	2.63	0.15
00110101	1	1.85	0.39
00110110	1	1.85	0.39
00111000	1	2.63	1.01
00111001	3	1.85	0.71
00111111	1	0.92	0.01
01000000	22	5.29	52.79
01000001	2	3.73	0.80
01000010	6	3.73	1.39
01000100	3	3.73	0.14
01000101	1	2.63	1.01
01000110	1	2.63	1.01
01001000	3	3.73	0.14
01001010	1	2.63	1.01
01001100	1	2.63	1.01
01001110	1	1.85	0.39
01010000	1	3.73	2.00
01010010	1	2.63	1.01
01010100	2	2.63	0.15
01010110	2	1.85	0.01
01011000	2	2.63	0.15
01011100	1	1.85	0.39
01011101	1	1.30	0.07
01100000	5	3.73	0.43
01100001	1	2.63	1.01
01100010	3	2.63	0.05
01100111	1	1.30	0.07
01101000	1	2.63	1.01

01101001	1	1.85	0.39
01101011	1	1.30	0.07
01101100	1	1.85	0.39
01110000	2	2.63	0.15
01110001	3	1.85	0.71
01110010	2	1.85	0.01
01110011	1	1.30	0.07
01110110	1	1.30	0.07
01111011	1	0.92	0.01
01111100	1	1.30	0.07
01111101	1	0.92	0.01
01111110	1	0.92	0.01
01111111	3	0.65	8.54
10000000	22	5.29	52.79
10000001	4	3.73	0.02
10000010	10	3.73	10.55
10000011	3	2.63	0.05
10000100	5	3.73	0.43
10000101	1	2.63	1.01
10000110	1	2.63	1.01
10000111	2	1.85	0.01
10001000	9	3.73	7.46
10001001	3	2.63	0.05
10001010	2	2.63	0.15
10001011	2	1.85	0.01
10001100	2	2.63	0.15
10001101	1	1.85	0.39
10010000	7	3.73	2.87
10010100	3	2.63	0.05
10010101	2	1.85	0.01
10011000	3	2.63	0.05
10011001	1	1.85	0.39
10011100	1	1.85	0.39
10011111	1	0.92	0.01
10100000	7	3.73	2.87
10100001	4	2.63	0.72
10100010	1	2.63	1.01
10100011	1	1.85	0.39
10100100	1	2.63	1.01
10100101	1	1.85	0.39
10101000	4	2.63	0.72
10101011	1	1.30	0.07
10101100	1	1.85	0.39
10101110	1	1.30	0.07
10101111	1	0.92	0.01
10110000	6	2.63	4.33

10110010	2	1.85	0.01
10110101	1	1.30	0.07
10110111	3	0.92	4.71
10111000	2	1.85	0.01
10111001	2	1.30	0.37
10111010	3	1.30	2.20
10111011	1	0.92	0.01
10111100	2	1.30	0.37
10111101	4	0.92	10.32
10111110	1	0.92	0.01
10111111	1	0.65	0.19
11000000	12	3.73	18.36
11000010	3	2.63	0.05
11000011	2	1.85	0.01
11000100	4	2.63	0.72
11000101	1	1.85	0.39
11000110	2	1.85	0.01
11000111	1	1.30	0.07
11001000	2	2.63	0.15
11001001	3	1.85	0.71
11001011	1	1.30	0.07
11001100	1	1.85	0.39
11001101	1	1.30	0.07
11001110	4	1.30	5.57
11010000	5	2.63	2.14
11010001	1	1.85	0.39
11010010	2	1.85	0.01
11010100	3	1.85	0.71
11010101	2	1.30	0.37
11010110	4	1.30	5.57
11010111	1	0.92	0.01
11011000	1	1.85	0.39
11011001	2	1.30	0.37
11011010	2	1.30	0.37
11011011	3	0.92	4.71
11011100	2	1.30	0.37
11011101	2	0.92	1.27
11011110	3	0.92	4.71
11011111	3	0.65	8.54
11100000	8	2.63	10.99
11100001	1	1.85	0.39
11100010	6	1.85	9.30
11100011	1	1.30	0.07
11100100	3	1.85	0.71
11100101	2	1.30	0.37
11100110	2	1.30	0.37

11101000	7	1.85	14.32
11101001	1	1.30	0.07
11101010	2	1.30	0.37
11101011	1	0.92	0.01
11101100	3	1.30	2.20
11101101	3	0.92	4.71
11101110	3	0.92	4.71
11101111	5	0.65	29.24
11110000	7	1.85	14.32
11110001	3	1.30	2.20
11110010	3	1.30	2.20
11110011	2	0.92	1.27
11110100	3	1.30	2.20
11110101	1	0.92	0.01
11110110	1	0.92	0.01
11110111	3	0.65	8.54
11111000	3	1.30	2.20
11111001	2	0.92	1.27
11111010	1	0.92	0.01
11111011	2	0.65	2.82
11111100	7	0.92	40.22
11111101	3	0.65	8.54
11111110	12	0.65	198.91
11111111*	19	0.46	753.14
0000000-	3	3.61	0.10
0000001-	1	0.14	5.05
0001001-	1	0.10	7.91
0010110-	1	0.07	11.98
1000000-	1	0.14	5.05
1000010-	1	0.10	7.91
1010000-	1	0.10	7.91
1011111-	1	0.03	37.78
1110111-	1	0.03	37.78
1111000-	1	0.05	17.79
000000-0	4	3.60	0.04
001000-0	1	0.11	7.16
001011-1	1	0.04	23.91
010011-0	1	0.05	16.29
100000-0	1	0.11	7.16
101000-0	1	0.08	10.93
111000-1	1	0.04	23.91
000000--	6	3.47	1.84
000001--	1	0.23	2.66
011100--	1	0.11	7.05
011110--	1	0.08	10.76
100000--	1	0.23	2.66

110000--	1	0.16	4.46
00000-00	2	1.19	0.55
10001-10	1	0.02	62.46
00000--0	4	4.73	0.11
00101--0	1	0.13	5.70
01001--0	1	0.13	5.70
01110--0	1	0.09	8.83
10000--0	1	0.19	3.52
10110--0	1	0.09	8.83
11100--0	1	0.09	8.83
11111--0	1	0.05	19.67
0000-000	2	2.97	0.32
0011-000	1	0.07	11.70
0100-101	1	0.05	17.40
0111-100	1	0.04	25.49
1011-100	1	0.04	25.49
1100-000	1	0.07	11.70
1101-110	1	0.03	36.98
1111-000	1	0.04	25.49
0000--00	2	3.75	0.82
0000--01	1	0.19	3.53
0001--01	1	0.13	5.72
0001--10	1	0.13	5.72
0111--11	1	0.05	19.71
1000--00	1	0.19	3.53
1000--11	1	0.09	8.85
1100--00	2	0.13	26.47
1000---1	1	0.03	31.52
0000----	1	0.47	0.59
000-0000	7	3.64	3.10
101-1010	1	0.03	36.00
000-000-	1	0.74	0.09
000-010-	1	0.04	24.64
010-1-0-	1	0.03	37.92
000--000	1	0.40	0.91
000---00	2	1.17	0.58
111---00	1	0.05	19.00
100----0	1	0.08	10.41
101-----	1	0.05	17.43
00-00000	1	2.34	0.77
00-01101	1	0.03	29.92
01-01000	1	0.04	20.52
01-11111	1	0.01	89.13
11-10101	1	0.02	62.23
11-11101	1	0.01	89.13
00-0000-	1	0.74	0.09

10-0000-	1	0.04	24.53
00--0000	1	0.74	0.09
11--1100	1	0.02	40.35
11--1101	1	0.02	58.07
00----00	1	2.89	1.24
00----10	1	0.48	0.55
01----00	1	0.48	0.55
10----10	1	0.34	1.28
11----00	2	0.34	8.08
11----10	2	0.24	12.90
00-----0	1	0.71	0.12
11-----1	2	0.20	15.94
00------	6	4.32	0.65
10------	1	0.99	0.00
0-000000	1	1.89	0.42
0-000001	1	0.07	12.18
1-011000	1	0.04	26.45
1-100000	2	0.05	76.15
1-111111	1	0.01	113.23
1-0010-0	1	0.01	75.75
0--00000	1	1.31	0.07
1--01000	1	0.01	66.87
0--0--00	1	0.71	0.12
0---000-	1	0.26	2.07
0---00--	1	0.60	0.26
1-----11	1	0.06	13.54
0-------	1	1.63	0.25
1--------	1	0.37	1.10
-0000000	27	14.27	11.37
-0010000	1	0.39	0.94
-0010001	1	0.28	1.89
-0100000	2	0.39	6.59
-0101111	1	0.10	8.43
-1000000	1	0.39	0.94
-1000100	1	0.28	1.89
-1001010	1	0.19	3.33
-1100000	1	0.28	1.89
-1100101	1	0.14	5.42
-00000--	2	1.04	0.89
-1000-01	1	0.01	83.64
-0000--0	1	0.60	0.27
-000-0-0	1	0.45	0.68
-000--00	1	0.30	1.60
-00--000	3	1.35	2.03
-0-00000	1	0.42	0.81
-0---000	2	0.83	1.64

-0---00-	1	0.54	0.39
-0----10	1	0.09	9.06
--000000	5	3.72	0.44
--000001	1	0.19	3.50
--000100	1	0.19	3.50
--001000	1	0.19	3.50
--010000	1	0.19	3.50
--010001	1	0.13	5.68
--00010-	1	0.04	26.11
--0000-0	2	0.80	1.79
--000-00	1	0.90	0.01
--110-00	1	0.04	22.61
---00000	4	1.81	2.63
---0000-	3	1.15	2.99
---0----	1	0.75	0.08
----0000	2	0.89	1.37
----0-00	1	0.59	0.29
------00	1	0.09	9.64
------11	2	1.88	0.01

SUPPLEMENTARY TABLE 5 Predicted average brown hyaena occupancy estimates at each survey site. Names of sites are abbreviated. Full names are listed in Supplementary Table 1. Predicted average occupancy and SE were calculated from spatially corrected estimates for each camera station within the surveillance area.

Survey site	**Predicted occupancy**	**SE**
Somkhanda	0.12	0.11
Hluhluwe-iMfolozi	0.13	0.07
Mountain Zebra	0.36	0.08
Little Karoo	0.38	0.09
Blyde River	0.42	0.09
Barberton	0.42	0.08
Songimvelo	0.45	0.08
Manyoni	0.49	0.23
Makalali	0.56	0.09
Timbavati	0.56	0.09
Lajuma	0.60	0.08
Ithala	0.69	0.07
Loskop Dam	0.71	0.15
KwaZulu	0.73	0.12
Kwandwe	0.75	0.10
Lapalala	0.83	0.06
Dinokeng	0.87	0.05
Wonderkop	0.87	0.04
Pilanesberg	0.90	0.04
Venetia	0.90	0.09
Atherstone	0.90	0.12
Welgevonden	0.91	0.03
Madikwe	0.94	0.11
Zingela	0.97	0.04
Khamab	0.98	0.05

References

BARRETT, A.S., BROWN, L.R., BARRETT, L. & HENZI, P. (2010) A floristic description and utilisation of two home ranges by vervet monkeys in Loskop Dam Nature Reserve, South Africa. *Koedoe,* 52, 1-12.

BERGER, K., CRAFFORD, J.E., GAIGHER, I., GAIGHER, M.J., HAHN, N. & MACDONALD, I. (2003) Introduction. In *A first synthesis of the environmental, biological and cultural assets of the Soutpansberg* (eds K. Berger, J.E. Crafford, I. Gaigher, M.J. Gaigher, N. Hahn & I. Macdonald), pp. 1. Leach Printers & Signs, Louis Trichardt.

BOUNDJA, R.P. & MIDGLEY, J.J. (2010) Patterns of elephant impact on woody plants in the Hluhluwe-Imfolozi park, Kwazulu-Natal, South Africa. *African Journal of Ecology*, 48, 206-214.

DALERUM, F. & BELTON, L. (2015) African ungulates recognize a locally extinct native predator. *Behavioral Ecology,* 26, 215-222.

DAVIES-MOSTERT, H.T., MILLS, M.G.L. & MACDONALD, D.W. (2013) Hard boundaries influence African wild dogs' diet and prey selection. *Journal of Applied Ecology,* 50, 1358-1366.

HAYWARD, M.W., ADENDORFF, J., O'BRIEN, J., SHOLTO-DOUGLAS, A., BISSETT, C., MOOLMAN, L.C. et al. (2007) Practical considerations for the reintroduction of large, terrestrial, mammalian predators based on reintroductions to South Africa's Eastern Cape Province. *The Open Conservation Biology Journal,* 1, 1-11.

KETTLES, R. & SLOTOW, R. (2009) Management of free-ranging lions on an enclosed game reserve. *South African Journal of Wildlife Research,* 39, 23-33.

LÖTTER, M.C. & BECK, H.T. (2004) Preliminary inventory and classification of indigenous afromontane forests on the Blyde River Canyon Nature Reserve, Mpumalanga, South Africa. *BMC Ecology,* 4, 9.

MARNEWICK, K., FUNSTON, P.J. & KARANTH, K.U. (2008) Evaluating camera trapping as a method for estimating cheetah abundance in ranching areas. *South African Journal of Wildlife Research,* 38, 59-65.

NOVELLIE, P. & GAYLARD, A. (2013) Long-term stability of grazing lawns in a small protected area, the Mountain Zebra National Park. *Koedoe,* 55, 1-7.

RICHMOND-COGGAN, L. (2014). *Comparative abundance and ranging behaviour of brown hyaena (Parahyaena brunnea) inside and outside protected areas in South Africa.* PhD thesis. Nottingham Trent University, Nottingham, UK.

STEYN, A. & STALMANS, M. (2001) Selective habitat utilisation and impact on vegetation by African elephant within a heterogeneous landscape. *Koedoe,* 44, 95-103.

THORN, M., SCOTT, D.M., GREEN, M., BATEMAN, P.W. & CAMERON, E.Z. (2009) Estimating brown hyaena occupancy using baited camera traps. *South African Journal of Wildlife Research,* 39, 1–10.

WELCH, R.J. & PARKER, D.M. (2016) Brown hyaena population explosion: rapid population growth in a small, fenced system. *Wildlife Research,* 43, 178-187.

WELCH, R.J., TAMBLING, C.J., BISSETT, C., GAYLARD, A., MULLER, K., SLATER, K. et al. (2016) Brown hyena habitat selection varies among sites in a semi-arid region of southern Africa. *Journal of Mammalogy*, 97, 473–482.

WILLIAMS, K.S. (2017) *Human-Brown Hyaena Relationships and the Role of Mountainous Environments as Refuges in A Postcolonial Landscape*. PhD thesis. Durham University, Durham, UK.

WISEMAN, R., PAGE, B.R. & O'CONNOR, T.G. (2004) Woody vegetation change in response to browsing in Ithala Game Reserve, South Africa. *South African Journal of Wildlife Research,* 34, 25-37.

YIU, S.-W., KEITH, M., KARCZMARSKI, L. & PARRINI, F. (2015) Early post-release movement of reintroduced lions (*Panthera leo*) in Dinokeng Game Reserve, Gauteng, South Africa. *European Journal of Wildlife Research,* 61, 861-870.