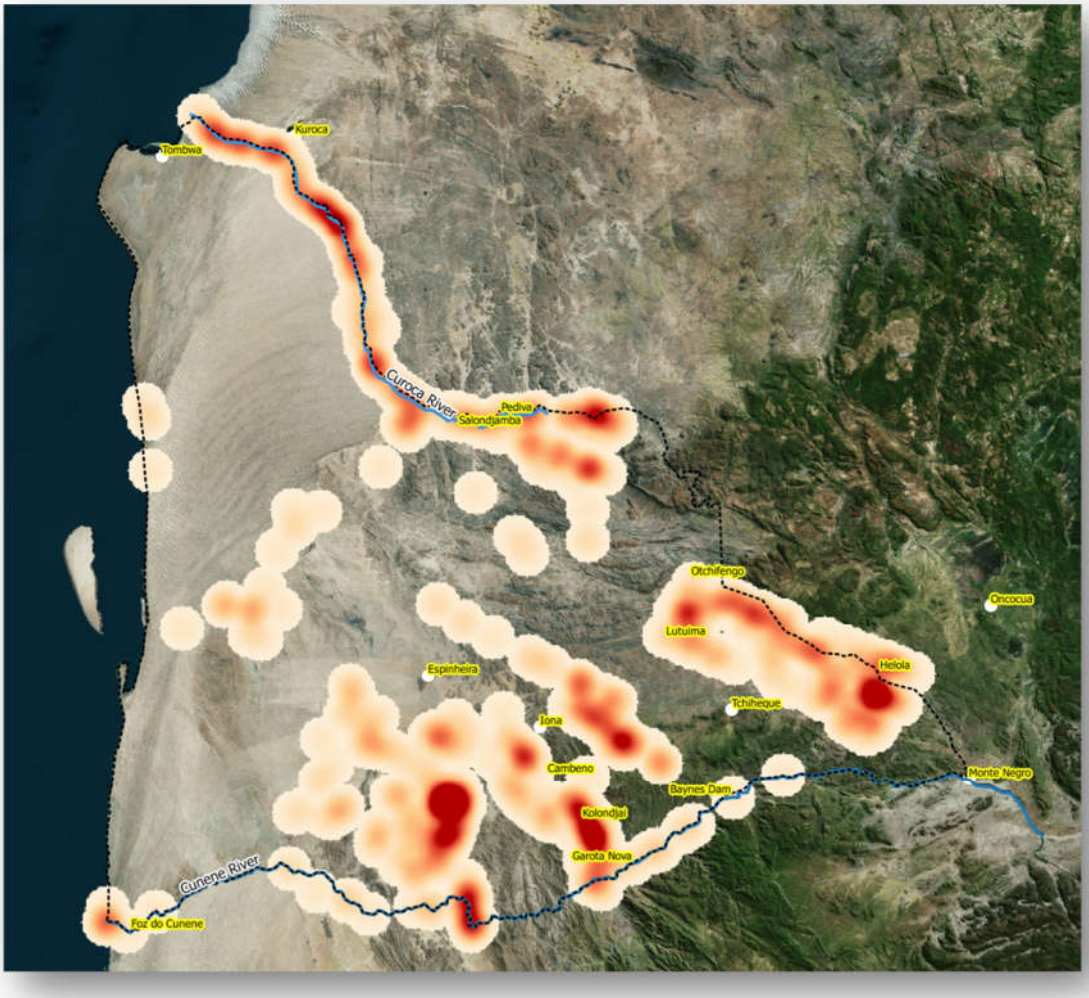
An aerial photographic wildlife survey of the Iona National Park, Angola

November 2016 to February 2017



BUSHSKIES aerial photography

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Acknowledgement

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Bushskies Aerial Photography team

The project coordinator for the Iona National Park aerial photographic survey was Jaco van der Westhuizen. The pilot was Jaco Thomas. Loretha Haraes, a spatial ecologist and MSc student at the Namibia University of Science and Technology, processed the images and did much of the analysis. Dr Morgan Hauptfleisch and Dr Chris Brown helped design the approach and prepared the final report. For more information, please contact jacovdw@bushskies.com.

1. Introduction

The Ministry of Environment with support from the United Nations Development Programme (UNDP) commissioned Bushskies Aerial Photography to conduct a photographic aerial survey of the Iona National Park, Angola. The objective of the survey was to determine the distribution and abundance of terrestrial wildlife (of springbok size and larger) in the park, as well as livestock and structures associated with human activity. In addition, the survey team would opportunistically identify other environmental aspects such as seal colonies, seabird roosts and the distribution of appropriately sized *Welwitschia mirabilis* plants. The survey would also provide a photographic record of high resolution imagery as a baseline for future comparison of factors such as grazing pressure, tree and shrub density and human settlement and impacts.

1.1 Study rationale

There are usually three main objectives set for wildlife surveys:

(a) Estimate the **number** of wildlife of each species, i.e. **how many?** The typical reasons include:
- To estimate stocking rates to manage the veld and grazing conditions
- To provide information to tourists
- To determine the value of the wildlife populations
- To set sustainable off-take quotas (this usually does not apply to national parks)

(b) Understand wildlife **distribution**, i.e. **where are they?** The typical reasons include:
- For park development planning, e.g. tourism and management roads and water points
- For anti-poaching patrols and monitoring
- For monitoring of distribution change over time, e.g. in response to rainfall
- For monitoring veld and rangeland condition

(c) Monitor **population changes**, i.e. **is wildlife increasing or decreasing?** The typical reasons:
- To track changes in population sizes and distribution per species over time
- To provide evidence for management decisions to achieve management goals and objectives
- To track rare and endangered species and assess the impacts of management actions.

There are many ways to count wildlife and estimate their numbers. The most commonly used methods until recently were:

(a) fixed route ground counts using “distance” estimates and statistical software. This works well for plains game in areas with a good road network across all land-forms and habitat types in the target area;

(b) waterhole counts at full moon in the dry months, for at least 48 hours per waterhole. This works well for water dependent species where all watering points can be counted in the target area and the same time;
(c) spoor counts, where transects are walked and all tracks are identified and aged. This method works well in small areas with experienced trackers trained to log information on GPS-linked electronic devises (trackers);
(d) camera traps set at water points or along game trails and field photography, for species with unique markings such as zebra and spotted cats, based on the identification of individual species. This method is applicable to a few species only;
(e) aerial counts, using observers and a recorder in either a fixed wing aircraft flying survey strips or a helicopter, counting blocks. This method relies on good observers seeing and correctly identifying all wildlife as the aircraft flies past.

The selection of a method depends on the terrain, habitat, priority species, objectives of the count, size of area, time-frame and budget. None of these methods give absolute numbers – they all provide estimates with varying levels of accuracy and precision.

With recent advances in aviation navigation and camera technology, it has become feasible to photographically document large areas of land at high image resolution at relatively low cost. An aircraft is equipped with high resolution cameras linked to a GPS logger that photographs the terrain below the aircraft in strips about 600 m wide and at a resolution of less than about 5 cm. A series of geo-referenced digital images is produced comprising each flight strip, from which all wildlife and other subjects of interest can be identified, counted and mapped. There are many advantages to the wildlife aerial photographic survey method, including:

- ✓ accuracy and precision, identifying and counting animals on a high-resolution computer screen slowly and carefully, rather than in flight at speed
- ✓ checking, being able to revisit photographs and review the accuracy of species identifications and numbers recorded
- ✓ retaining a permanent digital, geo-referenced record of the count
- ✓ using the geo-referenced images and data for more detailed analysis, e.g. habitat, terrain and slope selection by different species, herd sizes
- ✓ assessing vegetation condition, woodland cover, change, etc.
- ✓ geo-referenced details of all infrastructure, e.g. roads, tracks, buildings, water points
- ✓ assessing human encroachment, e.g. human settlements, livestock kraals, livestock numbers, areas where livestock is grazed, crop fields
- ✓ option of stitching images together to form photographic maps

- ✓ option of photographing other biological and ecological aspects at different levels of resolution, e.g. coastlines to assess erosion and accretion, seal and seabird colonies and roosts, 3-dimentional modelling and contour mapping
- ✓ safety, as observers do not fly in the aircraft, just a pilot, and the aircraft flies much higher (about 430 m above ground) than for observer-based aerial surveys.

Although still being improved through a growing body of experience, the use of such imagery to estimate wildlife numbers is increasingly being used. *Bushskies Aerial Photography* in collaboration with the Namibia University of Science and Technology (NUST) is, to our knowledge, the only group with experience in using imagery to census southern African wildlife.

1.2 Study area

The Iona National Park covers about 15,200 km^2 or 1.52 million hectares of Angola's Namibe Province in the south-western part of the country (Figure 1). It is the largest national park in Angola. It is bounded by the Atlantic Ocean to the west, an escarpment to the east that marks the beginning of the interior plateau, the Curoca River to the north, and the Cunene River to the south (Figure 2). It is about 200 kilometres south of the town of Namibe. Iona was proclaimed as a reserve in 1937 and upgraded to a national park in 1964. However, as is true for most Angolan national parks, the Angolan Civil War caused considerable disruption to the area and park management, including illegal poaching, encroachment of local people and destruction of infrastructure. In recent years, a number of government and international projects have begun rebuilding the infrastructure of the park and its management.

The topography of Iona is characterised by wild dunes, vast plains, and rough mountains and cliffs. The western part of the park is flat, while the eastern part is very rugged and mountainous, with the highest peaks reaching well over 1,500 m above sea level. Annual average precipitation is approximately 20 mm. The Curoca River is ephemeral but has lagoons, while the Cunene is perennial and has marshy areas at its mouth. Iona National Park is divided into four zones: coastal, desert dune-field, gravel and sandy plains and the mountains, valleys and hills.

Figure 1: Location of Iona National Park in south-western Angola, on the border with north-western Namibia (map by Uwe Dedering)

The park is an import area for conservation, both in Angola and at the regional level. It protects a significant

part of the northern Namib and escarpment zone, protects Angola's southern coast and provides protection to the lower Cunene River, one of only two perennial rivers crossing the Namib Desert and thus providing a linear oasis across this hyper-arid zone.

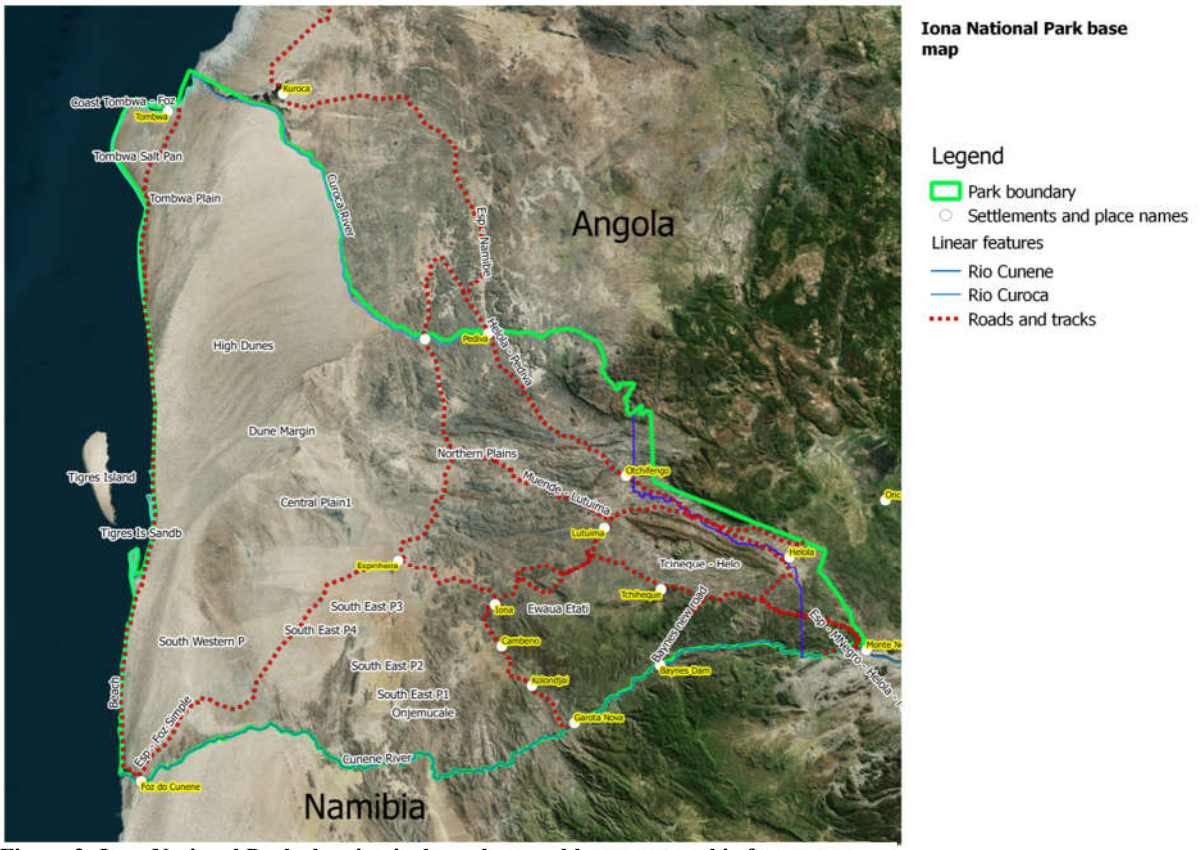

Figure 2: Iona National Park showing its boundary and key topographic features

At the regional level, Iona National Park and the Skeleton Coast Park in Namibia form a transfrontier conservation area (TFCA) agreed by the governments of both countries. In addition, Iona forms part of the largest transboundary conservation area in Africa, and one of the largest contiguous conservation landscapes in the world.

The Iona National Park is linked to the Skeleton Coast National Park which in turn is linked to the Dorob National Park, the Namib-Naukluft Park and the Tsau Khaeb National Park (previously called the Sperrgebiet National Park). This chain of contiguous coastal parks then links via the /Ai-/Ais – Fish River Canyon Park to the Richtersveld National Park in South Africa. This contiguous landscape of national parks covers a combined area of 12.834 million hectares, the 8th largest contiguous conservation area in the world, the 6th largest terrestrial protected area globally and the largest area of contiguous parks in Africa (Table 1).

These parks also border onto private protected areas, to communal and freehold conservancies managed for wildlife and conservation, onto tourism and wildlife concession areas and onto other national Parks

such as Etosha. If all these conservation areas contiguous with the coastal string of parks are added to the total, then the area under the different forms of wildlife management amounts to 25.769 million hectares (Figure 3), of which the Iona National Park contributes about 6% and protects a range of very important coastal, wetland, desert and escarpment habitats and species.

Table 1: The 10 largest protected areas in the world (marine protected areas shaded blue)

No.	Name	Ecosystem	Country	Size (ha)
1	Greenland's National Park	Terrestrial and coastal; Arctic island	Greenland	97,200,000
2	Ar-Rub'al-Khali Wildlife Management Area	Terrestrial; Desert	Saudi Arabia	64,000,000
3	Great Barrier Reef Marine Park	Marine & coastal	Australia	34,500,000
4	North-western Hawaiian Islands' Coral Reef Ecosystem Reserve	Marine & coastal	United States of America	34,000,000
5	Amazonia Forest Reserve	Terrestrial; Tropical rain forest	Colombia	32,000,000
6	Qiang Tang Nature Reserve	Terrestrial; Alpine Tibetan plateau grasslands	China	25,000,000
7	Cape Churchill Wildlife Management Area	Terrestrial; intertidal & marine	Canada	14,000,000
8	**Iona - Skeleton Coast – Namib – Richtersveld National Parks**	**Terrestrial & coastal; Desert ecosystems**	**Angola, Namibia & South Africa**	**12,832,000**
9	Northern Wildlife Management Zone	Terrestrial; Desert	Saudi Arabia	10,000,000
10	Alto Orinoco-Casiquiare Biosphere Reserve	Terrestrial; tropical rain forest	Venezuela and Bolivia	8,000,000

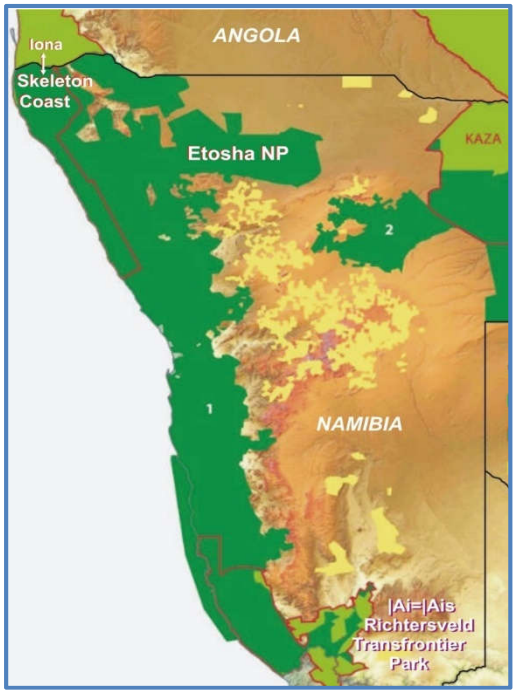

Figure 3: The Iona National Park is part of a contiguous conservation landscape across three countries and covering almost 26 million ha

The TFCAs and the huge contiguous areas under various forms of wildlife and conservation management spanning from Angola to Namibia and South Africa represent one of Africa's greatest conservation achievements. It is therefore important that all units within this greater landscape are monitored on a regular basis. This aerial photographic wildlife survey is an important contribution to this monitoring requirement.

2. Methodology

2.1 Aerial photography

In line with standard aerial wildlife census methodology (Bothma 2010) the photographic survey consisted of strips of approximately 600 m in width, traversing the landscape. Inter-strip width varied according to guidance provided by park management. This ranged from 20% coverage in the high dunes zone to 100% at the Kunene River mouth. Table 2 and Figure 4 below provides details on approximate flight zone coverage. Overall coverage was 599,975 ha, which amounts to 39.99% of the Iona National Park. In addition, specific areas were selected for more detailed surveys, at the request of park management (see Table 3 below).

Table 2: Flight strip zones, coverage and image resolution

Flight Zone	GSD	Area (ha)	Coverage %	Coverage (ha)
South Western Plains	5	177,425	40	70,970
South Eastern Plains 1	5	7,829	50	3,915
South Eastern Plains 2	5	36,682	50	18,341
South Eastern Plains 3	5	8,052	50	4,026
South Eastern Plains 4	5	32,161	50	16,081
Central Plains 1	4	48,963	55	26,930
Central Plains 2	4	77,265	55	42,496
Northern Plains	4	227,284	50	113,642
Dune Margin	4	107,005	55	58,853
High Dunes	4	166,495	20	33,299
Tombwa Plains and Salt Pan	4	93,149	40	37,260
Tchineque Helola	4	148,163	40	59,265
Ewaua Etati	4	5,595	50	2,798
Onjemucale	4	12,236	40	4,894
Kolondjai	4	27,903	40	11,161
Pediva	4	31,889	35	11,161
Tobwa Salt Pans	4	10,319	25	2,580
Tigres Sand Banks	4	14,875	100	14,875
Tigres Island	4	18,170	100	18,170
Cunene Mouth	4	784	100	784
Cunene River	4	12,002	100	12,002
Iona Coastline	4	10,870	100	10,870

Table 3: Areas covered in detail (some overlap with survey areas covered in Table 2)

Flight Zone	GSD	Area (ha)	Coverage %	Coverage (ha)
Road from Esp - Kolondjai	4	4,124	100	4,124
Road from Esp - Monte Negro	4	6,031	100	6,031
Road from Esp - Cunene Mouth	4	5,091	100	5,091
Road from Esp - Curoca River	4	3,547	100	3,547
Curoca River	4	6,278	100	6,278
Iona Town	4	308	100	308
Welwitschia areas	4	225	100	225

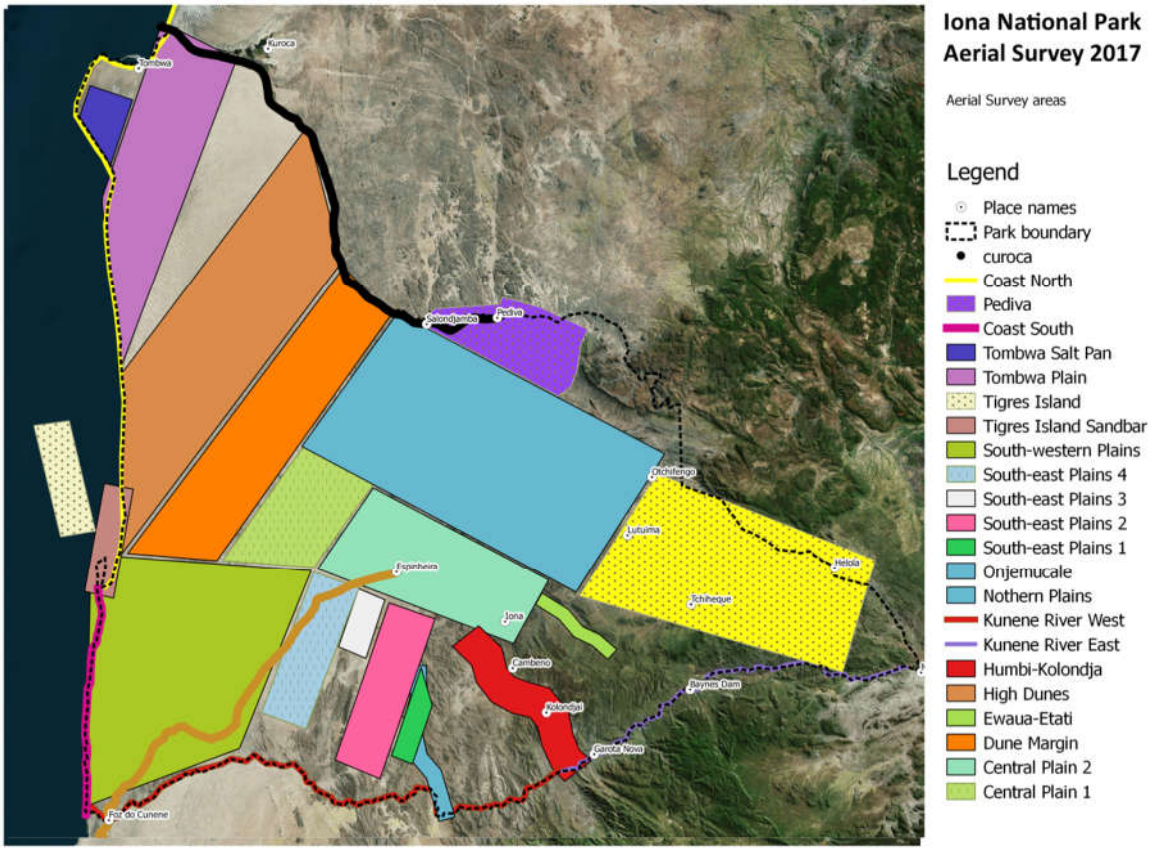

Figure 4: Aerial survey flight zones

Specific flight and photographic specifications are provided in Table 4 below.

2.2 Geo-referencing of wildlife sightings

Windows Photo Viewer on a high definition monitor was used to search the images individually to detect wildlife and other features of interest. An excel sheet was designed to record the GPS coordinates, area, type and number of wildlife, and other features of interest observed on each image. Only images with observations of interest were recorded in the excel sheet. The excel sheet was then converted to csv and used in GIS software for further analysis and mapping.

Table 4: Flight and photographic specifications.

Flight	
Aircraft	Jabiru 430 Standard, with fuselage mounted cameras
Altitude	431m above ground level
Flight times	07h00 to 12h00 and 15h00 to 18h00
Photogrammetry	
Camera	2 x Canon 5Dsr 50mm focal length[1]

2.3 Identification of wildlife species

Ungulates smaller in size than springbok could not be identified with any degree of accuracy and were thus not included in this survey. The dorsal view provided by perpendicular photography revealed limited distinguishing features (see Appendix A) which required initial comparisons with sketches and measurements in literature (Skinner & Chimimba 2005, Apps 2000, Roodt 2015). Shadows were an important feature in detecting and identifying wildlife. The choice of flight times (Table 4) resulted in clear shadows of most animals, which added to the effectiveness of the method. Table 5 below summarises the diagnostic features used for identification of each wildlife species from the imagery. Because of the experience of the Bushskies team, a high level of accuracy is achieved.

Table 5: Wildlife identification features from aerial imagery

Species	Diagnostic characteristics	Possible species confusion
Hartmann's zebra	Posture, head shape of shadow, lighter patch at base of the tail. Impossible to distinguish from Burchell's zebra, stripes not visible. Mountainous habitat locations led to the assumption of Hartmann's zebra and not Burchell's zebra	Burchell's zebra, oryx, horse, donkey
Oryx	dark patch on rump / base of tail	kudu, zebra, donkey
Springbok	horns on shadow, white pronk	sheep, goat
Ostrich	neck on shadow, shape, colour	None
Cape fur seal	Location, shape	None
Humpback whale	Size, white patterns on the underside of flukes and pectoral fins, large pectoral fins	Southern right whale, fin whale

[1] Camera pixel size was 4.89 x 4.89 um, factory calibration was applied.

2.4 Determination of wildlife estimates

Strip extrapolation

As is standard practice with sample counts (Khaemba 2001, Bothma 2010) the wildlife count numbers per landscape unit were extrapolated to represent 100% of each respective landscape unit area. Image coverage was determined by multiplying mean strip width with total strip length. Confidence limits for the survey were determined using the Robson-Whitlock method.

2.5 Spatial analysis

2.5.1 Species distribution and density heat-maps

The wildlife vector file was imported into QGIS version 2.6.1. Heatmaps (QGIS plugin) were produced based on kernel density estimate methodology for the density of overall wildlife and for species specific point vectors.

2.5.2 Graze and browse biomass estimates for terrestrial ungulates

Bothma's (2010) estimates of mean biomass, as well as graze and browse units were used to obtain grazing and browsing biomass per area (ha) for the terrestrial ungulates censused across the park (Table 6).

Table 6: Biomass and graze / browse unit conversions for wildlife.

Species	Biomass (kg)	Graze unit (GU)	Browse unit (BU)
Hartmann's zebra[2]	260	1.32	0.03
Impala	41	0.33	0.40
Oryx	210	1.12	0.19
Springbok	37	0.31	0.37
Ostrich	69	0.49	0.59
Cattle[3]	520	2.21	0.58
Sheep and goat[4]	37	0.31	0.37

[2] No data in literature – Burchell's zebra units applied.
[3] Used buffalo GU and BU estimates.
[4] Used springbok GU and BU estimates. The aerial survey could not distinguish, therefore springbok, as a mixed feeder small ungulate was used.

3. Results and discussion

3.1 Wildlife, livestock and associated infrastructure estimates for Iona National Park

The numbers of wildlife, domestic stock and human infrastructure recorded, the estimated numbers corrected for coverage and the confidence ranges at 90% and 95% are set out in Table 7.

Table 7: Summary of actual numbers of wildlife seen, estimated populations and 90% and 95% confidence ranges in the Iona National Park

Species and infrastructure		Actual individuals counted	Estimated population	90% confidence range	95% confidence range
Terrestrial wildlife					
Mammalian					
Oryx	*Oryx gazelle*	358	951	760-1,142	724-1,211
Springbok	*Antidorcas marsupialis*	627	1,894	1,317-2,472	1,206-2,503
Hartmann's zebra	*Equus zebra*	147	434	280-588	250-618
Avian					
Ostrich	*Strutheo camelus*	137	379	255-485	232-503
Reptilian					
Crocodile	*Crocodylus niloticus*	3	3	Insufficient	samples
Domestic Livestock					
Cattle	*Bos Taurus*	502	1,009	839-1,179	807-1,262
Sheep / goats	*Caprinae*	3,386	7,482	5,965-9,000	5,674-9,742
Donkey	*Equus asinus*	59	82		
Marine wildlife					
Mammalian					
Seal colonies	*Arctocephalus pusillus*	52	52	Insufficient	samples
Unknown whale	*Cetacea*	1	1	Insufficient	samples
Humpback whale	*Megaptera novaeangliae*	2	2	Insufficient	samples
Piscine					
Shark (unidentified)	*Elasmobranchii*	9	9	Insufficient	samples
Reptilian					
Green turtle	*Chelonia mydas*	105	105	Insufficient	samples
Human Infrastructure					
Crop fields		72	98	75-122	72-126
Livestock kraals		1,114	2,630	2,206-3,054	2,125-3,359
Homesteads		440	929	758-1100	726-1203

Table 8 calculates the grazer and browser biomass of wildlife and domestic stock based on the population estimates. The total wildlife biomass in the Iona National Park is about 408,779 kg, which is only an average of 0.27 kg/ha. The total domestic stock biomass is about 822,834 kg, or about 0.54

kg/ha, twice that of the wildlife. Total animal biomass is thus only about 0.81 kg/ha. Even for a hyper-arid zone, thus is at least five times below the carrying capacity of the Park, which would be expected to support about 4-6 kg/ha.

Table 8: Biomass and vegetation (graze and browse) utilization estimates for animals in Iona National Park

Species	Scientific name	Total biomass (kg)	Total graze units	Total browse units	Hectares per graze unit	Hectares per browse unit
Terrestrial wildlife						
Mammalian						
Oryx	*Oryx gazelle*	199,710	1,065	181	1,427	8,413
Springbok	*Antidorcas marsupialis*	70,078	587	701	2,589	2,169
Zebra	*Equus zebra*	112,840	573	13	2,653	116,748
Avian						
Ostrich	*Strutheo camelus*	26,151	186	224	8,185	6,798
Domestic Livestock						
Cattle	*Bos taurus*	524,680	2,230	585	682	2,597
Sheep / goats	*Caprinae*	276,834	2,319	2,768	655	549
Donkey	*Equus asinus*	21,320	108	2	14,043	617,912

The estimated numbers of wildlife, domestic stock and human infrastructure and the confidence ranges at 90% and 95% (where there is sufficient data to support these statistics), per zone, are set out in Table 9.

Table 7: Estimated populations and 90% and 95% confidence ranges of wildlife, domestic stock and human infrastructure, per Zone, in the Iona National Park

Area:	**Zone 1 Coastal**			**Zone 2 Desert Dunes**		
Species and infrastructure	**Estimated total**	Conf: 90%	Conf: 95%	**Estimated total**	Conf: 90%	Conf: 95%
Terrestrial wildlife						
Oryx	0	N/A		7	N/A	
Springbok	0	N/A		0	N/A	
Ostrich	0	N/A		0	N/A	
Zebra	0	N/A		0	N/A	
Crocodile	0	N/A		0	N/A	
Domestic livestock						
Cattle	0	N/A		142	76-209	63-221
Sheep / goats	0	N/A		0	N/A	
Donkey	0	N/A		0	N/A	

Marine wildlife				
Seal colonies	20	N/A	0	N/A
Unknown whale	0	N/A	0	N/A
Humpback whale	0	N/A	0	N/A
Shark	10	N/A	0	N/A
Turtles	105	N/A	0	N/A
Human Infrastructure				
Crop fields	0	N/A	32	N/A
Homesteads	0	N/A	24	N/A
Kraals	0	N/A	68	N/A

Area:	**Zone 3 Arid Plains**			**Zone 4 Communal**		
Species and infrastructure	**Estimated total**	Conf: 90%	Conf: 95%	**Estimated total**	Conf: 90%	Conf: 95%
Terrestrial wildlife						
Oryx	932	711-1152	669-1195	0	N/A	
Springbok	1893	864-2922	667-3119	0	N/A	
Ostrich	379	255-503	231-527	0	N/A	
Zebra	391	N/A		43	N/A	
Crocodile	0	N/A		0	N/A	
Domestic Livestock						
Cattle	209	N/A		481	450-512	444-518
Sheep / goats	413	225-794	189-830	6617	5,991-7,243	5,871-7,363
Donkey	9	N/A		31	N/A	
Marine wildlife						
Seal colonies	0	N/A		0	N/A	
Unknown whale	0	N/A		0	N/A	
Humpback whale	0	N/A		0	N/A	
Shark	0	N/A		0	N/A	
Turtles	0	N/A		0	N/A	
Human Infrastructure						
Crop fields	0	N/A		12	5-19	3-21
Homesteads	32	20-44	18-46	783	710-856	697-869
Kraals	606	418-794	382-830	1881	1,701-2,061	1,667-2,095

Area	Additional areas outside zones (insufficient sample for confidence estimates)		
Species and infrastructure	**Curoco River**	**Kunene River**	**Tigres Island and Sandbank**
Terrestrial wildlife			
Oryx	0	13	0
Springbok	1	0	0
Ostrich	0	0	0
Zebra	0	0	0
Crocodile	0	3	0
Domestic Livestock			
Cattle	66	111	0
Sheep / goats	117	336	0
Donkey	0	38	0
Marine wildlife			
Seal colonies	0	0	40
Unknown whale	0	0	1
Humpback whale	0	0	2
Shark	0	0	7
Turtles	0	0	0
Human Infrastructure			
Crop fields	39	16	0
Homesteads	63	27	0
Kraals	41	33	0

3.2 Comparison with 2003 aerial survey

In June 2003, a joint Angola – Namibia aerial survey of Iona National Park was undertaken (Kolberg & Kilian 2003), confined to an area of 802,200 hectares, or about 53% of the park. Much of the remainder of the park was considered too mountainous to be flown safely in a fixed-wing aircraft (Cessna 206) at low altitude. The survey method used (Jolly 1969) was stratified transects based on expected wildlife distribution and densities, derived from topography and habitat. The park was divided into 11 blocks, eight of which were surveyed at a coverage ranging from 9% to 45%. In total, 174,937 ha were surveyed, representing 21.8% of the surveyed blocks and 11.5% of the whole park. The numbers of wildlife seen, the estimated populations and the 95% confidence range per species are set out in Table 8 and compared to the 2016/17 count. This was the first systematic wildlife survey of Iona National Park. Previous information was from opportunistic counts of small sections of the park and

thus cannot be compared. For example, during a survey in January 1974, 1,050 springbok and 1,650 oryx were seen (Huntley 1974).

Table 8: Estimated populations, numbers seen and 95% confidence ranges of wildlife, domestic stock and human infrastructure during the 2003 and 2016/17 surveys of the Iona National Park

Species	2003 aerial survey			2016/17 aerial photographic survey			Percent change*
	Number seen	Population estimate	95% range	Number seen	Population estimate	95% range	
Oryx	255	1,631	734-2,528	358	951	724-1,211	58%
Springbok	586	2,388	1,062-3,714	627	1,894	1,206-2,503	21%
Hartmann's Zebra	48	263	48-505	147	434	250-618	65%
Ostrich	86	398	111-685	137	379	232-503	5%
Total wildlife	**975**	**4,680**		**1,269**	**3,658**		**22%**
Cattle	5,093	13,962	5,827-22,097	502	1,009	807-1,262	93%
Donkey	69	322	69-794	59	82	-	75%
Goats/sheep	10,430	27,502	12,064-42,940	3,386	7,482	5,674-9,742	73%
Total livestock	**15,592**	**41,786**		**3,947**	**8,573**		**91%**
Homesteads	254	629	511-747	440	929	726-1,203	48%
Livestock kraals	-	-	-	1,114	2,630	2,125-3,359	-
Crop fields	-	-	-	72	98	72-126	-

* Calculated as the 2003 population estimate minus the 2016/17 estimate divided by the 2003 estimate x 100. Figures in red indicate the percent by which the population has declines, those in black show the percent growth.

Because of the increased level of sampling during the 2016/17 aerial photographic survey (over 41% of the park on average compared to 11.5% in 2003), the 95% confidence ranges are considerably narrower than for the 2003 survey, providing greater accuracy and precision.

There is clear evidence of significant declines in wildlife numbers in Iona National Park, from the 1970s through to the 2003 survey and declining further to 2016/17. Between 2003 and 2016/17, wildlife declined by about 22% with the largest decline seen in the oryx population (58%). While the past dry years might be expected to impact on some wildlife species, particularly ostrich, the oryx and, to a lesser extent, springbok have shown the greatest losses. This is unexpected in a large open ecosystem such as Iona. It is thus reasonably to suggest that the main cause of the decline in these species is illegal hunting.

The only species showing an increase was the Hartmann's zebra. This might be related to the fact that the 2003 aerial survey avoided mountainous terrain. However, there has been a significant increase in this species in the Kunene region of Namibia, immediately south of the Cunene River, increasing from fewer than 2,000 zebra in the early 1980s to a current population of about 15,000 zebra. Hartmann's zebra may have expanded their range from the south, across the Cunene River into Iona.

The 2003 survey recorded the presence of small populations of predators (leopard, cheetah, and black-backed jackal) and scavengers (four Lappet-faced Vulture nests). The increased coverage of the 2016/17 survey, by a factor of four, should have revealed evidence of these species, which it did not. This would

suggest that there is anti-predator activity in the park, and perhaps particularly the use of poison, which would explain the absence of both predators and scavengers.

There has also been a dramatic decline (91%) in the number of domestic livestock in the Iona National Park in 2016/17 compared to the 2003 survey. Cattle numbers have declined most (93%) but goats/sheep have also declined by 73%. The past few years have been extremely dry, and it is not known whether these declines result from livestock dying from the drought, or animals being herded eastwards out of the park to higher rainfall areas where there is better grazing, or a combination of these factors.

In 2003 the average wildlife biomass in Iona was about 0.35 kg/ha while the livestock biomass in the park was about 5.50 kg/ha – a ratio of wildlife to livestock biomass of 1:15. This is an extremely unhealthy situation for a national park, with domestic stock dominating to this extent. In 2016/17, the overall animal (wildlife and livestock) biomass had declined from 5.85 kg/ha (2003 situation) to 0.81 kg/ha, reflecting a decline in both wildlife biomass, to 0.27 kg/ha, and livestock biomass, to 0.54 kg/ha. The ratio of wildlife to livestock biomass in 2016/17 was 1:2.

In contrast to the decline in numbers of domestic stock between 2003 and 2016/17, there was a 48% increase in the number of homesteads in the park, from 629 to 929. Groundwork is needed to determine what proportion of these are occupied at any time and the relationship between homesteads and the human population. If a ratio of 5 people per household is assumed, then the human population in the park could be as high as about 4,645 people. In addition, 2,630 livestock kraals were estimates and 98 small crop fields. Livestock kraals and crop fields were not recorded during the 2003 survey.

3.3 Wildlife distribution across the area

Terrestrial wildlife – oryx, springbok, Hartmann's zebra and ostrich - was mostly confined to the Southern Plains (Figure 5). Only small numbers of oryx were found in the dune and dune margin areas. Marine wildlife was mostly confined to Tigres Island and the Cunene River mouth.

Oryx were mostly confined to the central and southern plains (Figure 6), with a few individuals identified in the dunes. The oryx population estimate of 951 animals is lower than the 2003 estimate of 1,631, a population decline of 58%. The largest herd of oryx totalled 69 individuals. There is also a significant reduction in range, mainly from the High Dunes, Dune Margins, South-western Plains and Central Plains areas. In summary, there were virtually no oryx in the northern and central regions of the park.

Springbok were identified only in the southern plains (Figure 7). The population estimate of 1,894 individuals was lower than the 2003 estimate of 2,388 springbok, a population decline of 21%. The largest herd identified totalled 68 individuals. There has been an extensive decline in range of springbok, retreating from the northern and central regions of the park to the Southern Plains area.

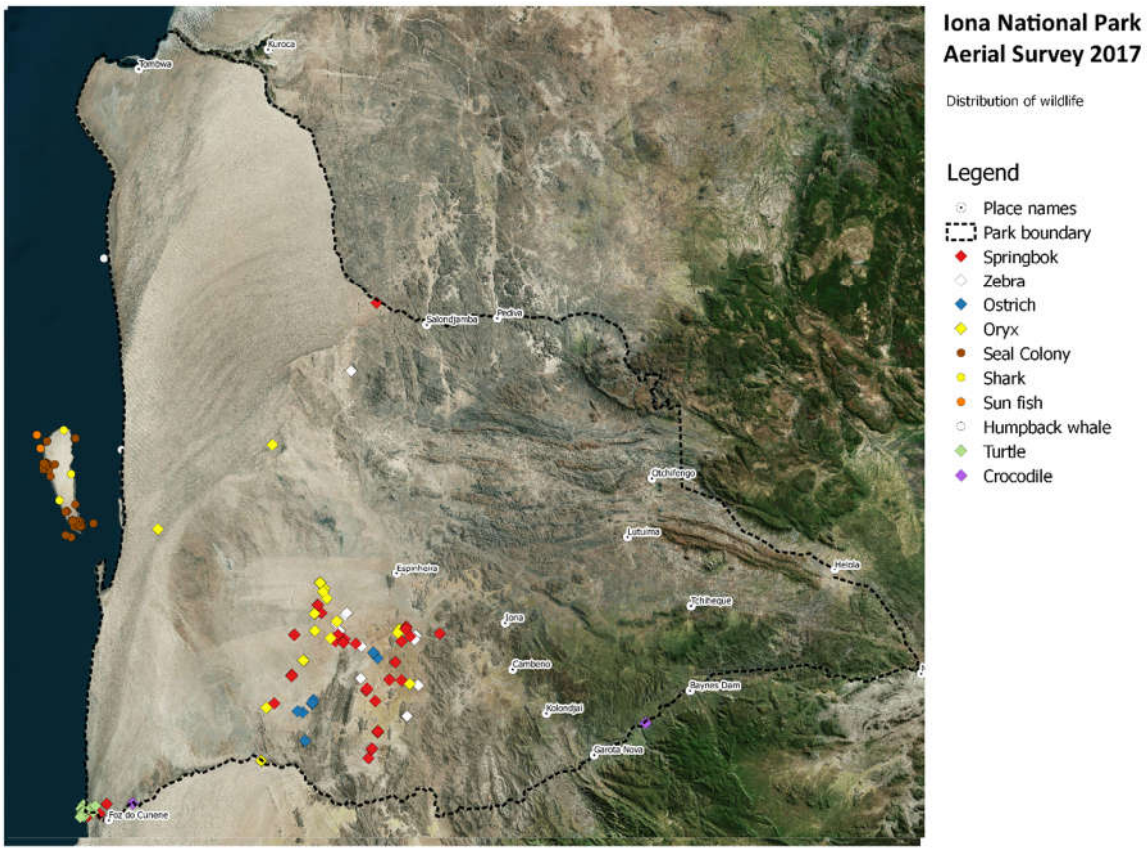

Figure 5: Distribution of wildlife sightings based on the aerial photographic game count in Iona National Park

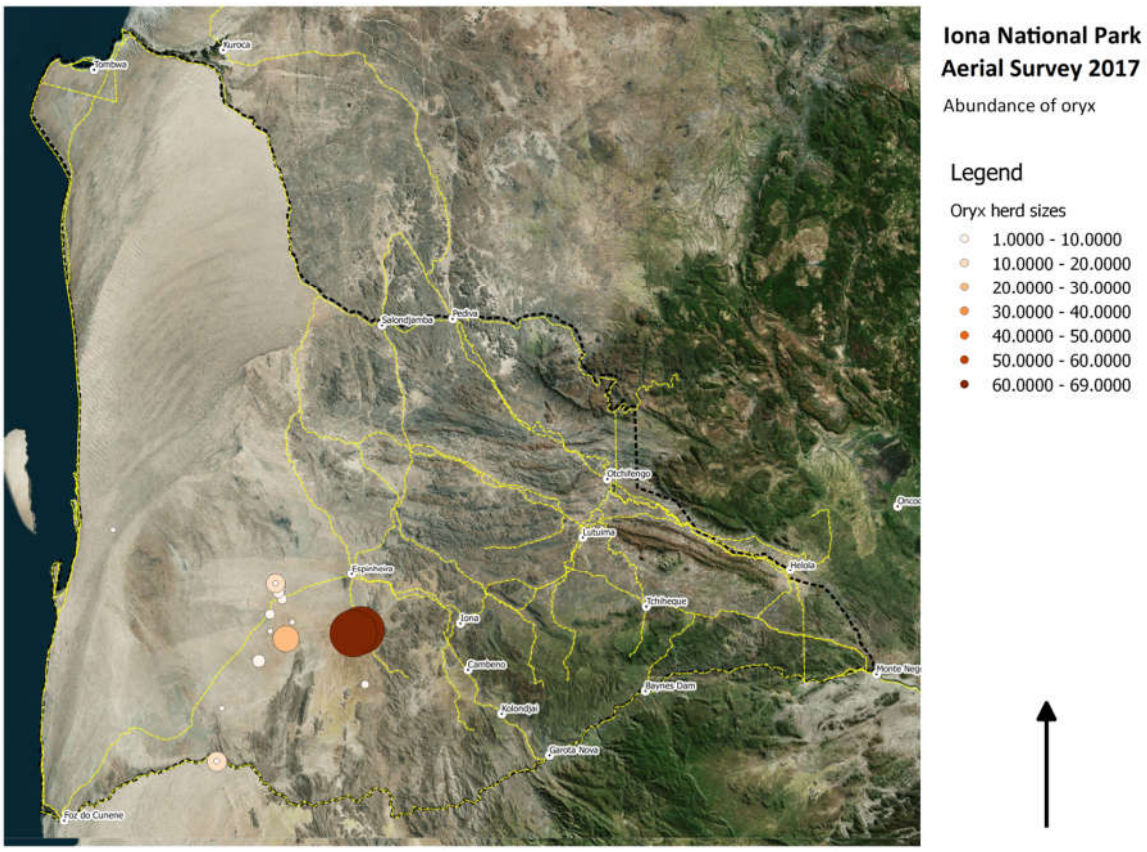

Figure 6: Abundance and distribution of oryx in Iona National Park

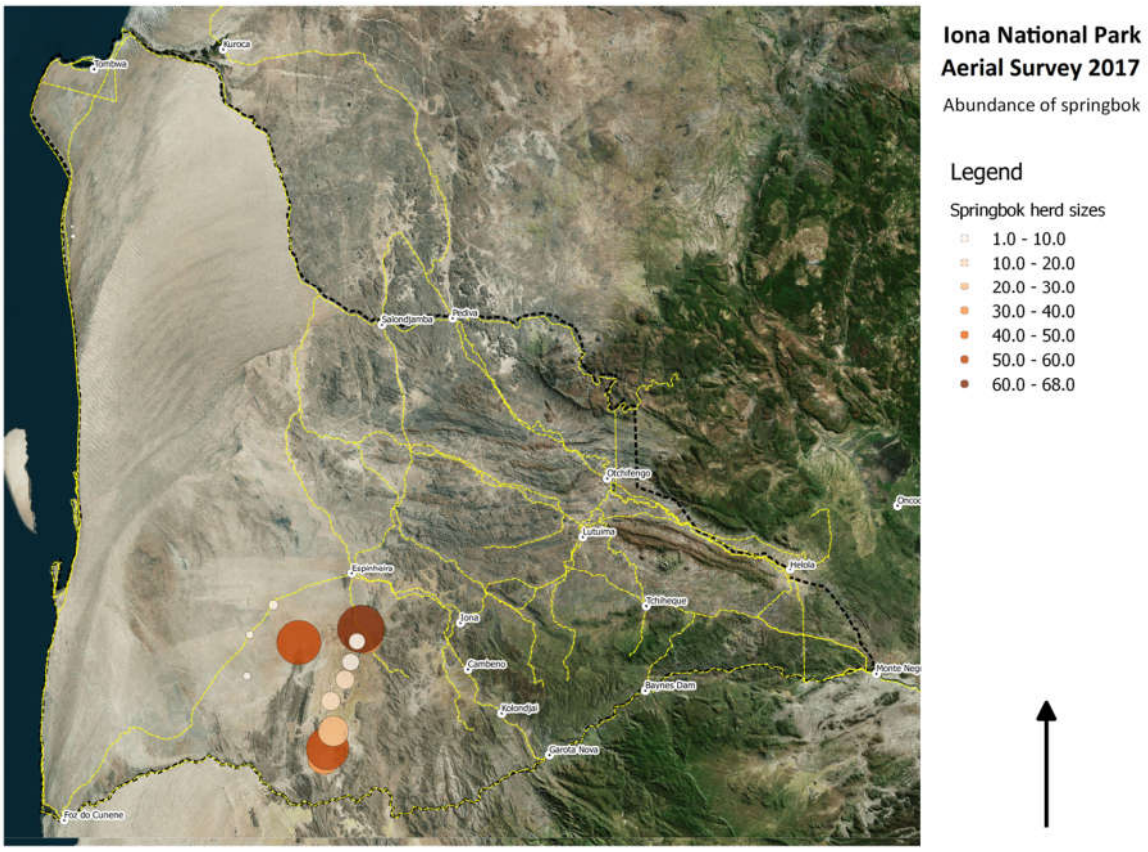

Figure 7: Abundance and distribution of springbok in Iona National Park

Hartmann's mountain zebra numbers seem to have increased since the 2003 survey, from 263 to 434 zebra, an increase of 65%. Their distribution (Figure 8) is currently further south and slightly further east than in 2003, closer to the mountainous terrain where they are more secure from illegal hunting and disturbance. Although the habitat is suitable, no zebras were identified in the eastern mountainous habitat, possibly due to increased human activity in this area and no surface water.

Ostrich numbers declined by just 5%, from 398 to 379. However, their distribution has retreated dramatically, from the northern, central and western regions of the park to the South-East Plains (Figure 9).

3.4 Human impact

Human impact on the Iona National Park includes the numbers and distribution of domestic livestock, livestock kraals, homesteads and crop fields. These are compared to the situation found during the 2003 aerial survey. While the numbers of livestock have declined significantly, the number of homesteads has increased by 48%, from about 629 to 929. In addition, the distribution of homesteads and livestock kraals has expanded considerably, from being confined to the north and east of the park to now extending into the south-central regions (Figures 10 & 11). Stock kraals were also found along the dune margins. These expansions reflect a large incursion into the heart of the Iona National Park.

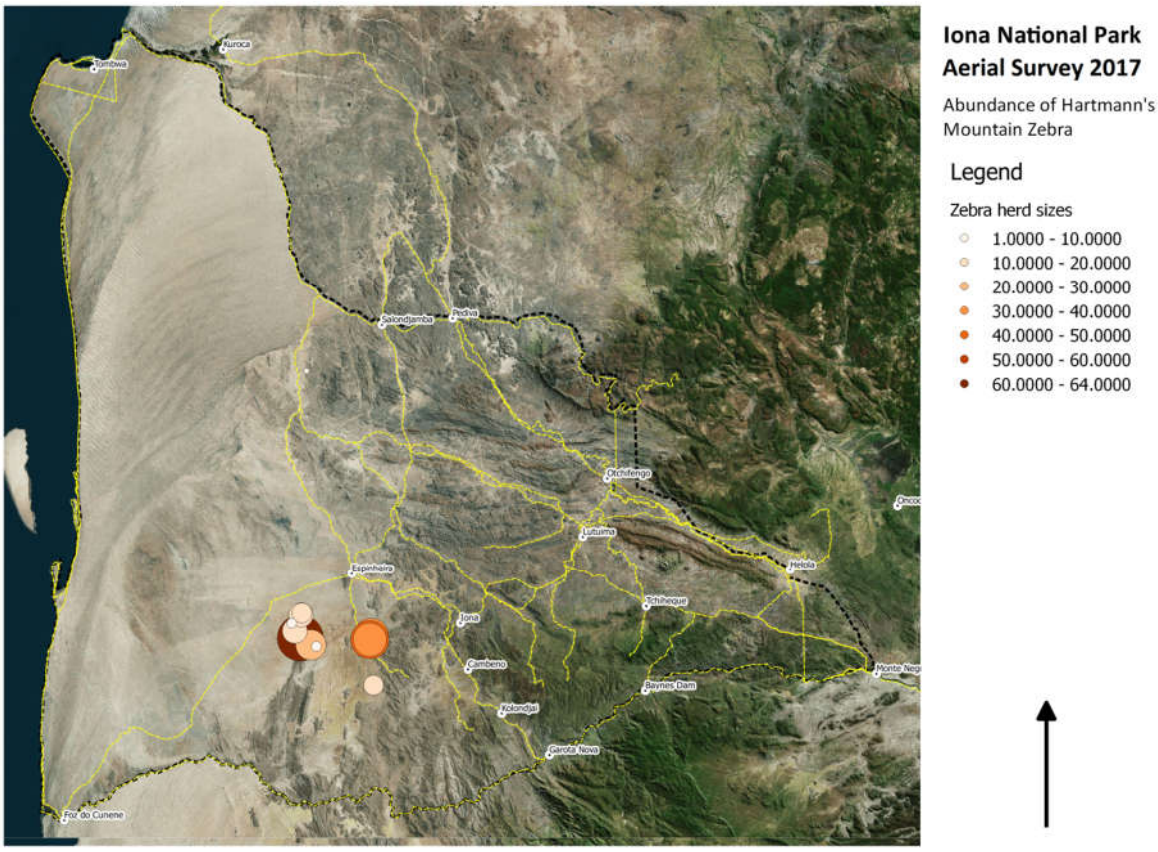

Figure 8: Abundance and distribution of Hartmann's mountain zebra in Iona National Park

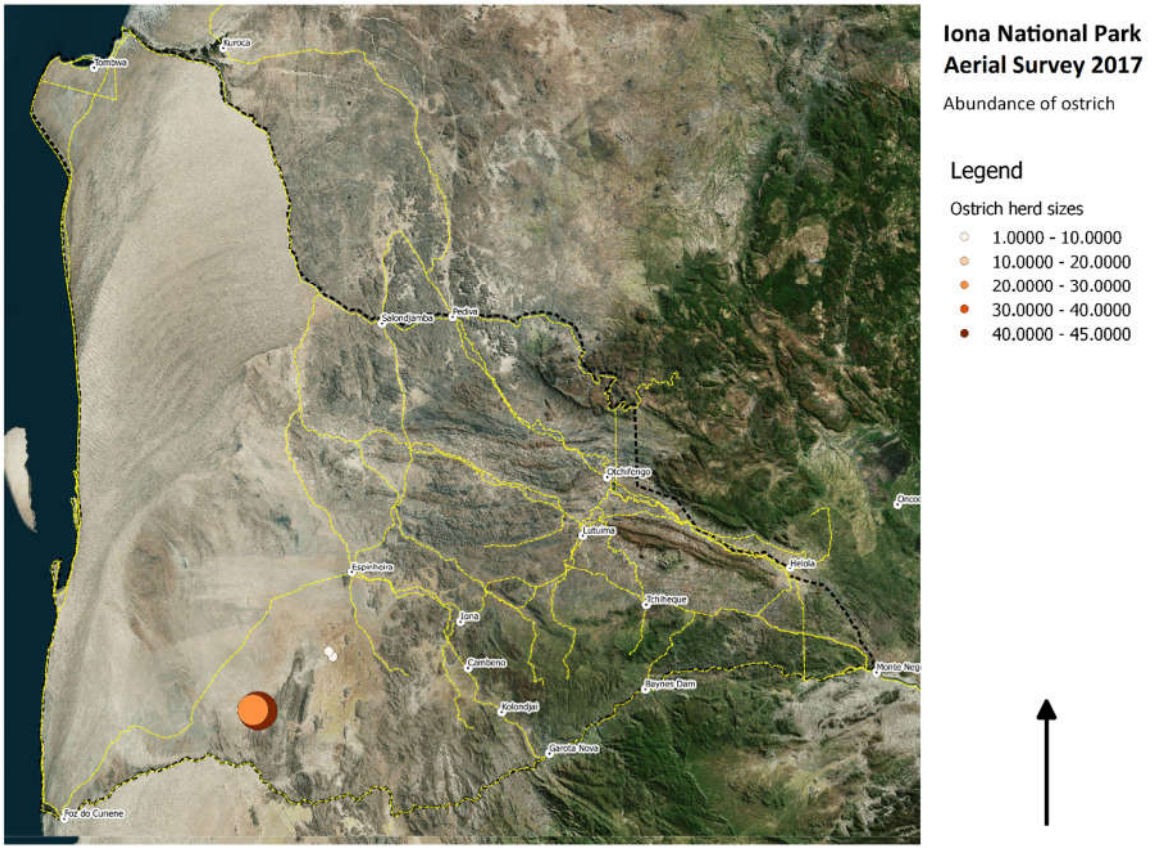

Figure 9: Abundance and distribution of ostrich in Iona National Park

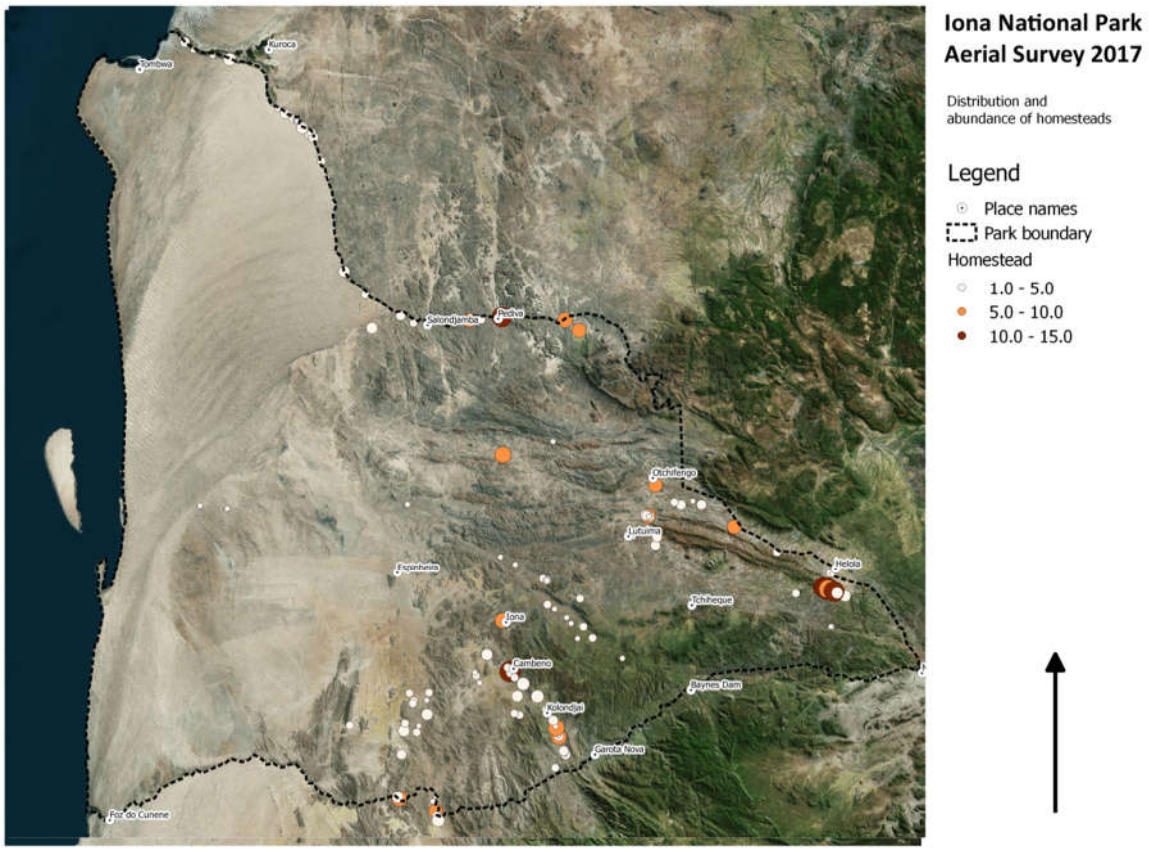

Figure 10: Abundance and distribution of homesteads in Iona National Park

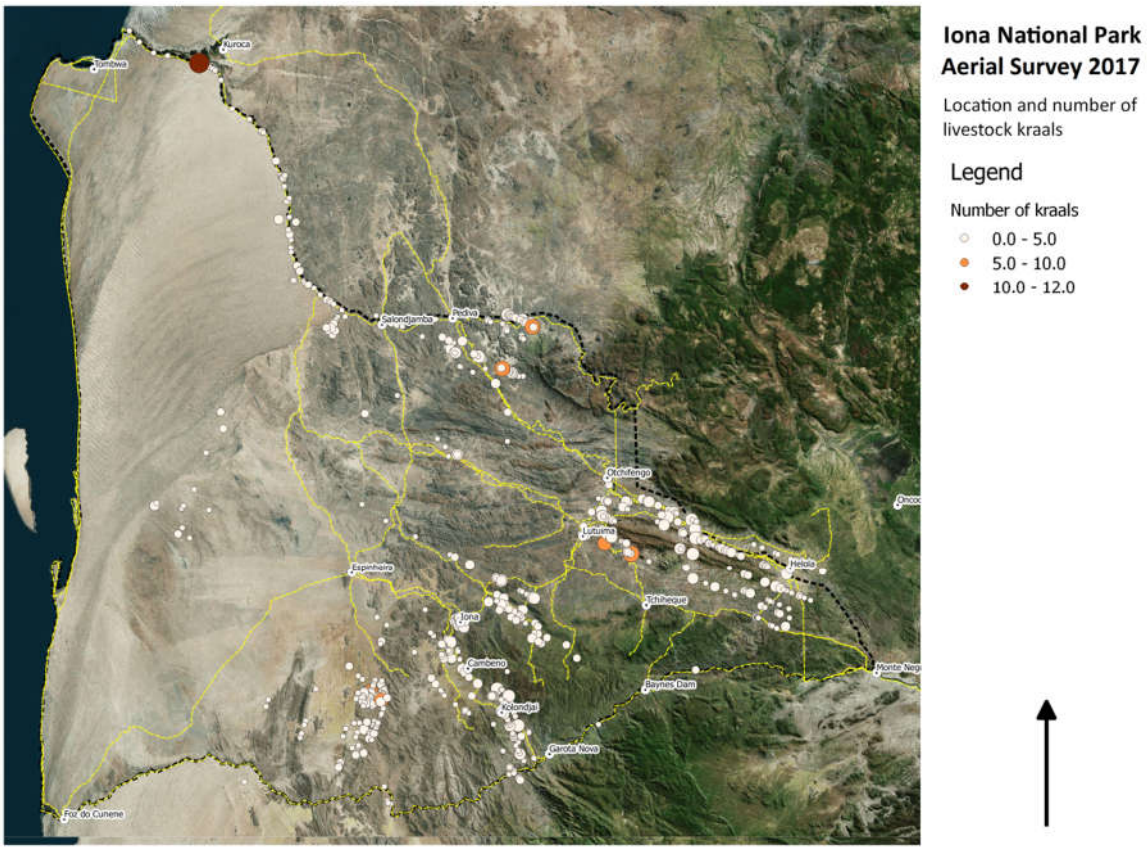

Figure 11: Abundance and distribution of livestock kraals in Iona National Park

While the numbers of domestic stock have declined, their distribution has expanded. Both cattle (Figure 12) and goats (Figure 14) have expanded into the south-central regions and cattle into the dune margins. Evidence of this unexpected incursion of cattle and kraals into the western heart of the Iona National Park is provided in Figures 13a & b.

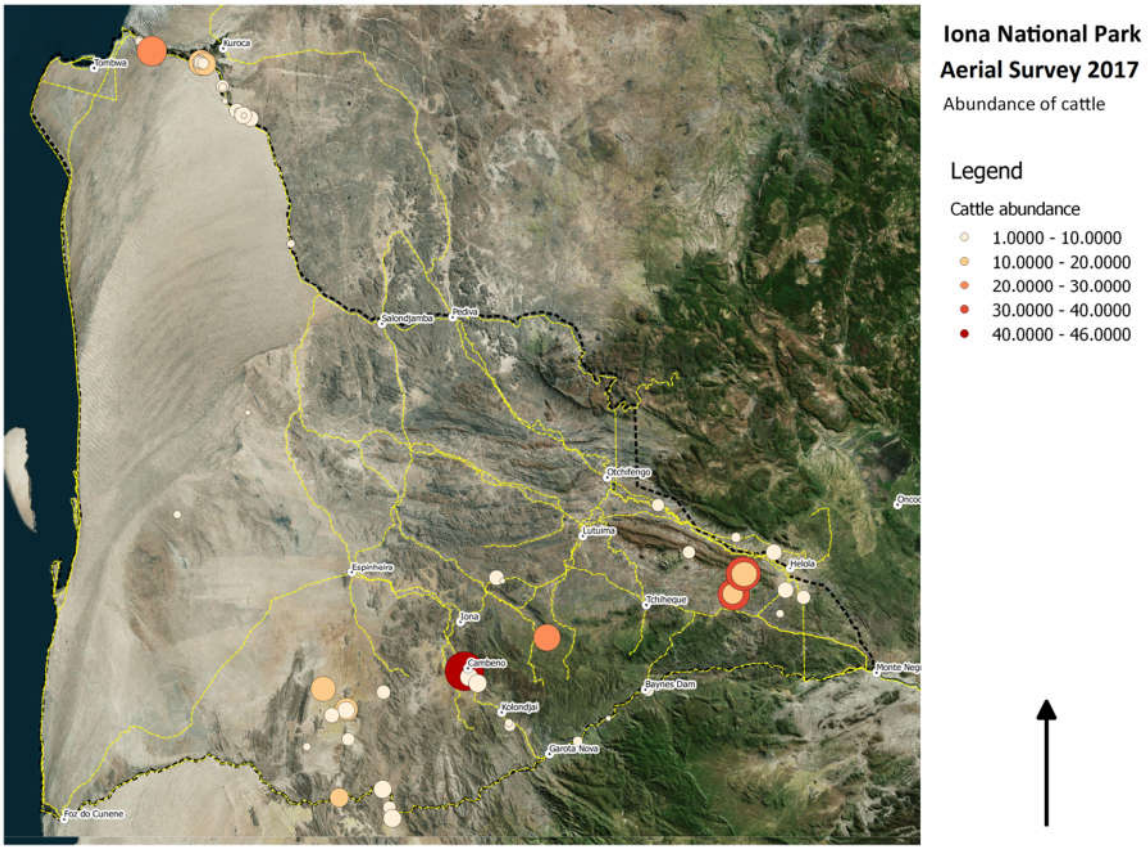

Figure 12: Abundance and distribution of cattle in Iona National Park

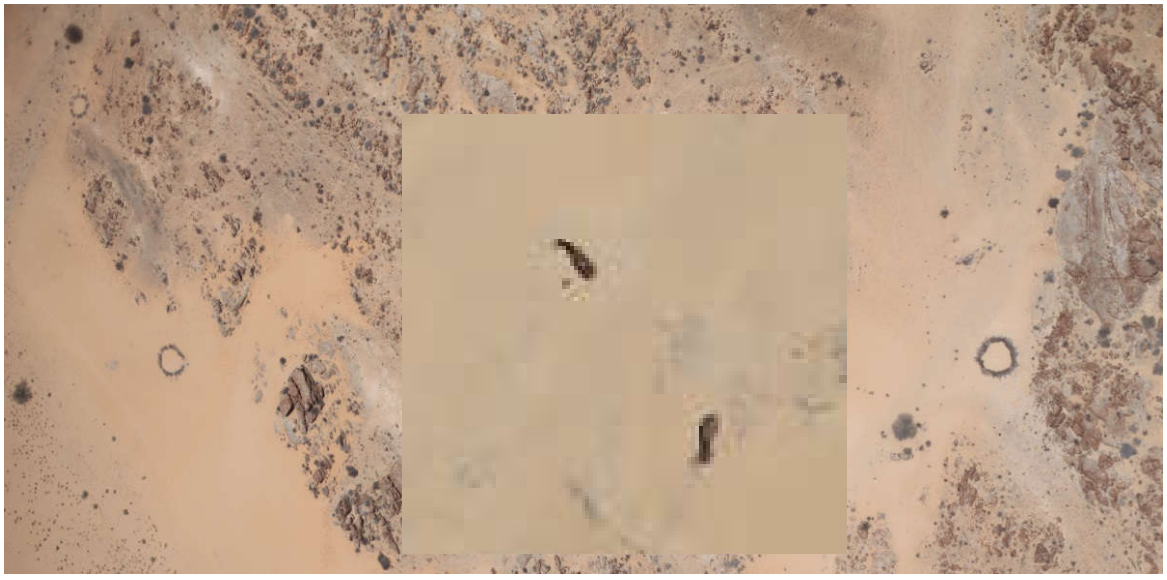

Figure 13a: Cattle within the dune margin at 12º12'51.6"S; 16º01'35.6"E (inset), and b: Brush packed cattle kraals (three in this image at 12º18'58.3"S; 16º18'31.8"E, 19 seen) within the dune margin habitat of the Iona National Park

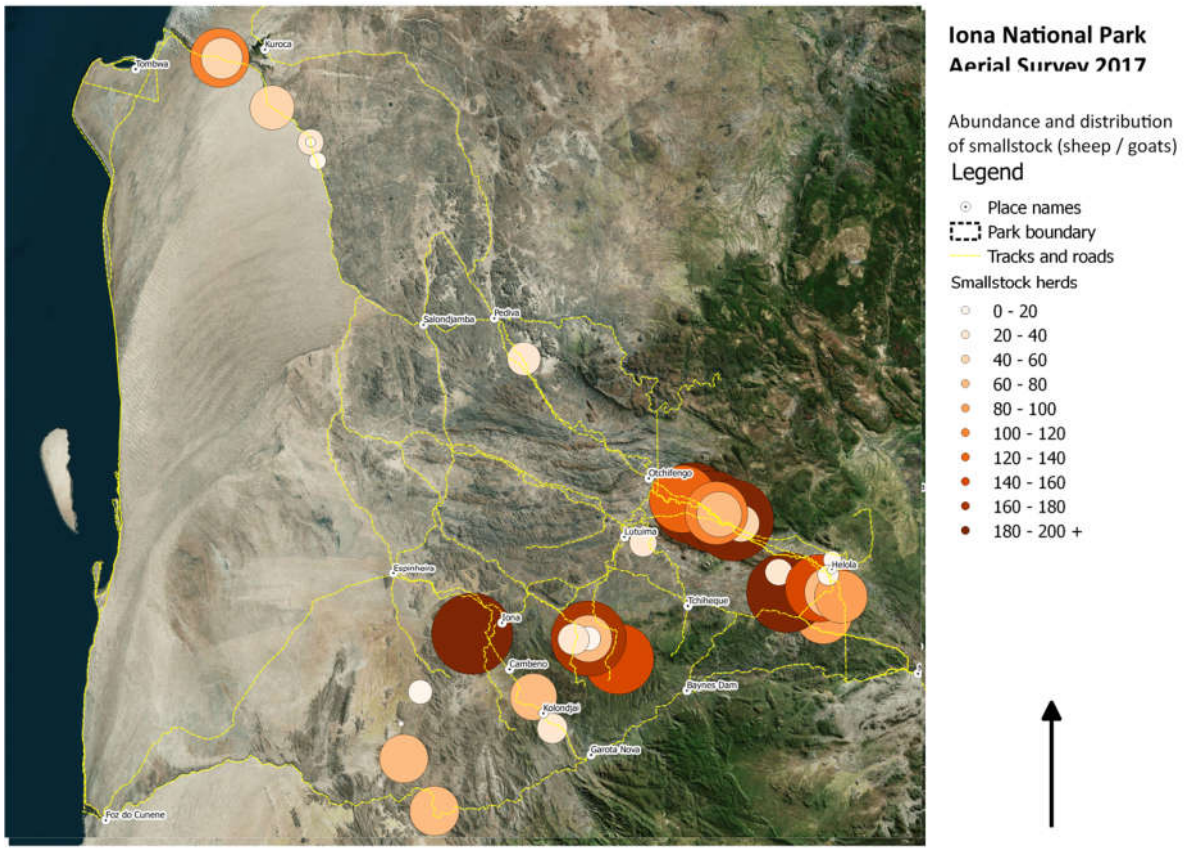

Figure 14: Abundance and distribution of small-stock (goats and sheep) in Iona National Park

All livestock are mapped in Figure 15, and Figure 16 records the distribution of small crop fields. Fields were not recorded during the 2003 survey. As expected, they mirror the distribution of homesteads, and extend along the northern, eastern and south-central regions of the Park.

The combination of increasing numbers of homesteads and domestic livestock kraals, and the expansion of human distribution, crop fields and livestock ever further into the Iona National Park should be of significant concern to the Ministry of Environment in terms of their impact on the biodiversity and integrity of the park and on its future tourism potential.

3.5 Marine wildlife

The aerial photographic survey could identify a variety of marine wildlife. Although the position of Cape fur seal colonies was noted, individuals were not counted. This could be done at a later date. Table 9 provides images of some species of interest.

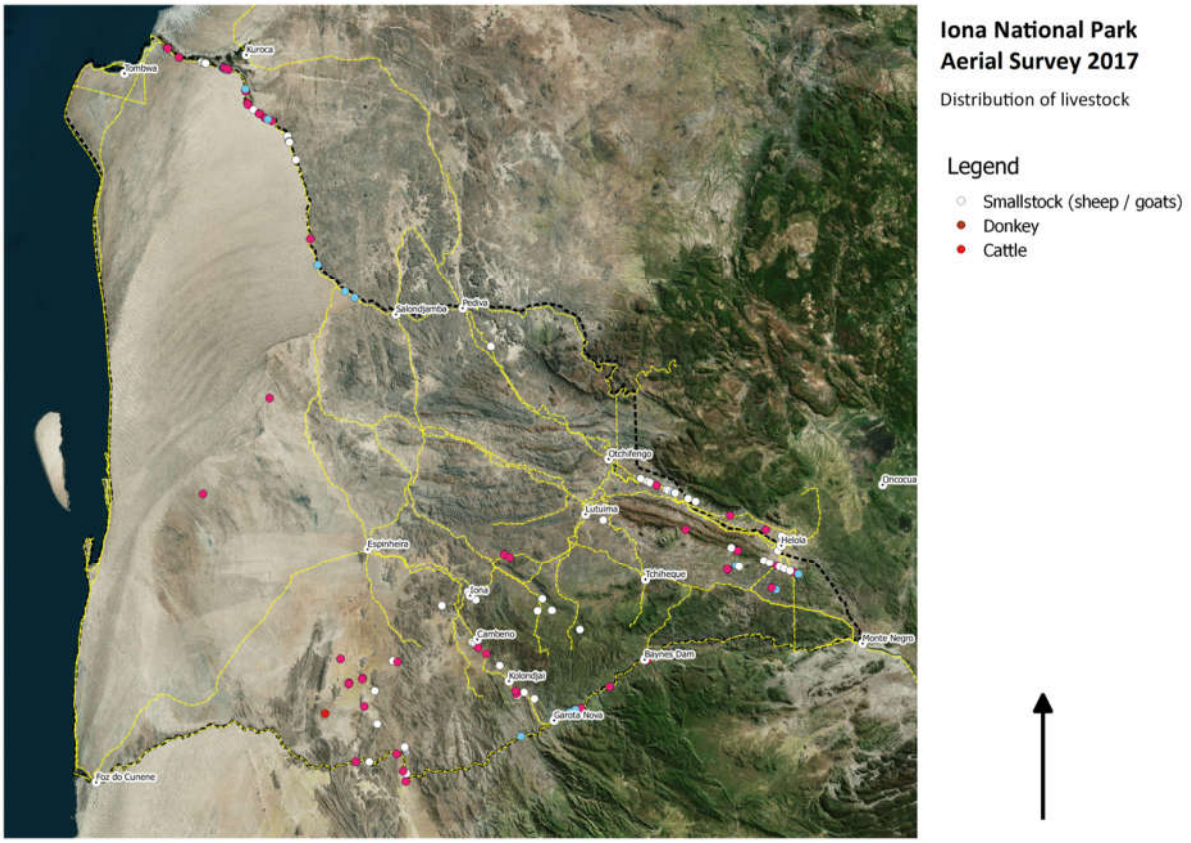

Figure 15: Distribution of all domestic livestock in the Iona National Park

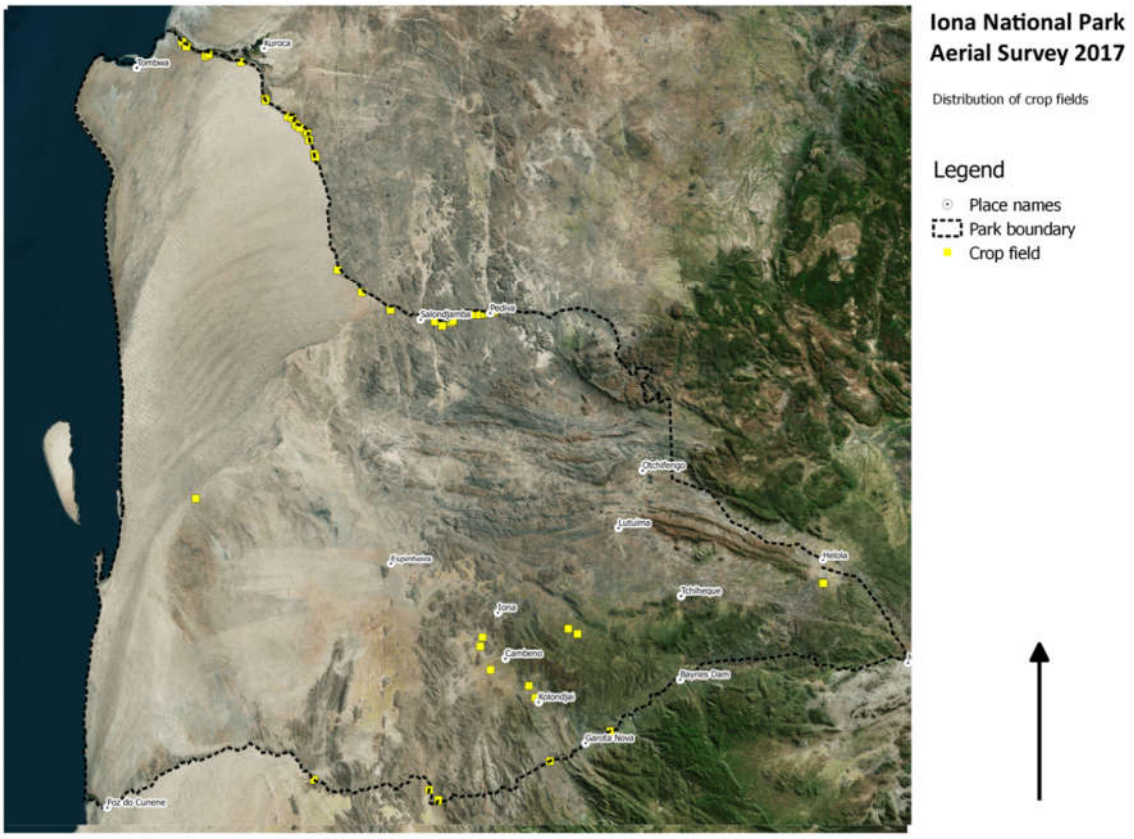

Figure 16: Abundance and distribution of crop fields in Iona National Park. It could not be determined how recently they had been used.

Table 9: Marine wildlife images.

Species	Image
Unidentified shark species (possibly white shark *Carcharodon carcharias*)	
Sunfish *Mola mola*	
Humpback whale *Megaptera novaeangliae*	
Green turtle *Chelonia mydas*	

Species	Image
Cape fur seal colony *Arctocephalus pusillus*	

3.6 Additional features

While analysing the photographs, features of special interest were recorded. These were:

- Additional man-made features (e.g. water-points, kraals, lodges, refuse disposal sites);
- Features of possible archaeological interest (e.g. stone walls, geometric clearings);
- A number of Cape fur seal colonies were found on the Iona coast, reflecting a growing northern movement of this species, perhaps in response to climate change. Techniques are currently being tested to estimate numbers of seals per colony.
- Coastal seabird roosts. Cape Cormorants *Phalacrocorax capensis* where found roosting in large numbers, together with other coastal bird species. The Cape Cormorant is endemic to southern Africa and a Red Data species classed as "Endangered". Techniques are currently being tested to estimate numbers of birds in roosts.
- Colonies of Welwitschia plants, *Welwitschia mirabilis*. At the request of park management, areas known to support populations of Welwitschias were mapped (Figure 17), to facilitate further studies on the conservation of this ancient near-endemic and iconic plant species. These areas were photographed at a higher resolution A student is currently counting individual plants, and classifying them according to size and condition where possible. This will allow for spatial determination of possible impacts of human activity (e.g. groundwater abstraction) and domestic stock (e.g. browse by livestock) on the population. It will further allow for spatial distribution modelling of the species.

The results of these further studies (seal and cormorant population estimates, and Welwitschia assessments) will be forwarded to the Ministry of Environment in Angola and to UNDP as soon as they are completed.

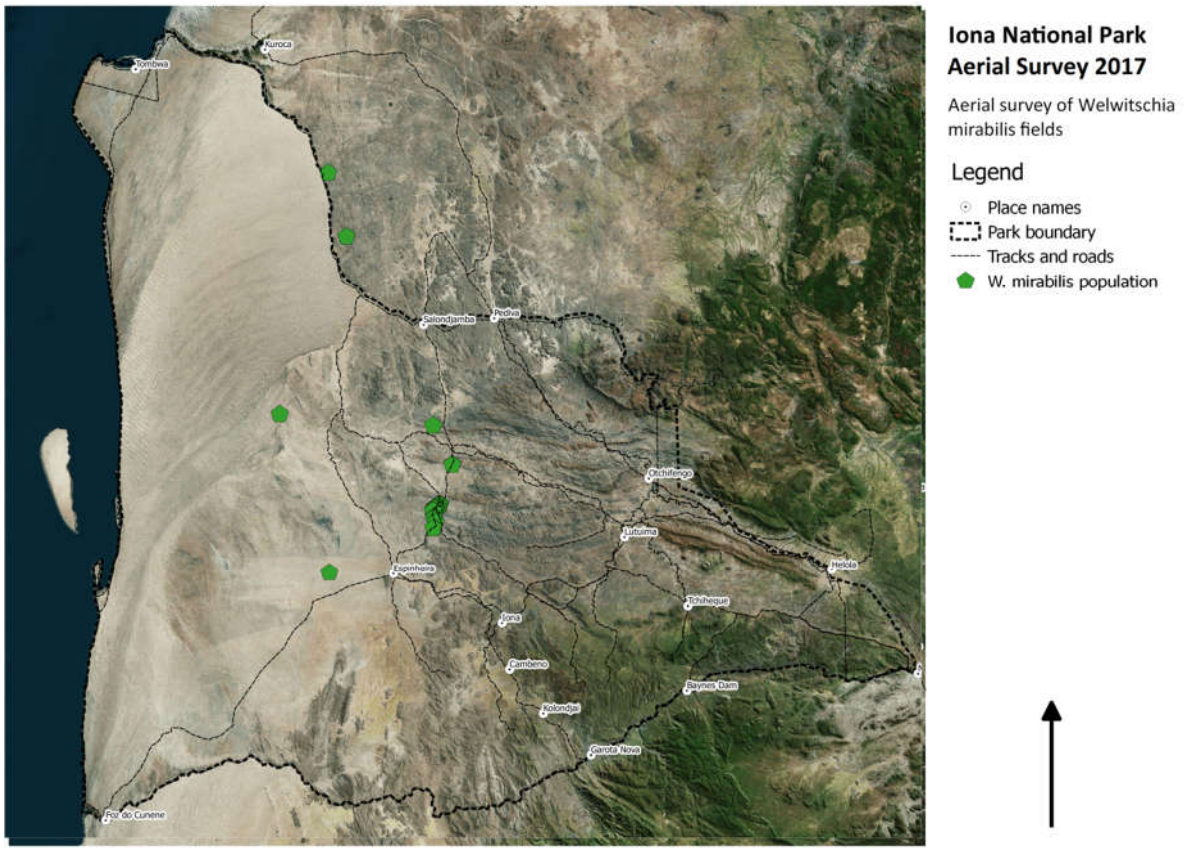

Figure 17: Location of *Welwitschia mirabilis* populations in the Iona National Park

4. Conclusions

The aerial photographic wildlife survey provided high resolution geo-referenced imagery of 41% of the Iona National Park. From the imagery, a baseline count of large and medium sized ungulates within the park was possible. When extrapolated to the whole park, the survey provided population estimates, 90% and 95% confidence ranges and distributions for the following wildlife species: oryx, springbok, Hartmann's zebra and ostrich. The survey also provided information on the numbers and distribution of livestock (cattle, goats/sheep and donkeys), livestock kraals, homesteads and small crop fields. The high-resolution imagery, when viewed on a high-resolution screen, provided reliably identified of all these target species and infrastructure.

The aerial photographic survey was compared to results obtained from an aerial survey in 2003. While the coverage was far lower in 2003, at about 11.5% of the whole park, this is the only other aerial survey undertaken in the Iona National Park. Wildlife populations had declined significantly between the two surveys, by 22%. Oryx showed the largest decline at 58%, springbok 21% and ostrich 5%. This is unexpected, as ostrich are more susceptible to drought than oryx and springbok, and suggests that drought is not the primary cause of the decline. It is suggested that illegal hunting might be the main cause of the declines, with oryx and springbok being more sought-after than ostrich. This decline is also

reflected in changed distribution patterns. Wildlife has retreated from the northern and western parts of the park to the south-central area. This also reflects a response to hunting pressure and disturbance in areas of their former range. Incidental observations in the 1970s suggest that wildlife numbers had already declined significantly by 2003. In addition, he numbers of predators and scavengers appear to have declined. This suggests that predators are being targeted, probably with the use of poison.

By contrast, Hartman zebra appear to have increased. There are two possible explanations. First, the survey in 2003 avoided mountainous terrain for safety reasons, which is the main habitat of this zebra species. Second, there has been a large increase in Hartmann's zebra in northern Namibia, and the animals are able to cross the river in mountainous areas away from human habitation.

Livestock numbers in the Iona National Park have declined significantly between the surveys, by 91%. This is undoubtedly linked to the drought experienced in the past few years. It is not known whether livestock have died or been moved to better pastures to the east – or both. However, the decline in livestock numbers is not mirrored by a decline in homesteads, which have increased by 48%. Also, the distribution and livestock, homesteads, stock kraals and crop fields have expanded significantly, to include the south-central regions. This suggests that, when climatic conditions improve, livestock numbers will increase again and occupy an increasing area of the park, extending far into the western dune margin region.

The impact of human settlement, livestock, presumed illegal hunting and poisoning is having a significant impact on the biodiversity and integrity of the Iona National Park. This will need to be addressed in a pro-active manner, if the Iona National Park is to play its full and important role within the Angolan protected area network, and within one of the largest contiguous protected areas in the world, as part of a three-nation southern African wildlife landscape.

5. Recommendations

Given the pressures on the Iona National Park, the following recommendations are offered:

- An aerial survey, at an average coverage of 40% or more, should be carried out every five years.
- A fixed-route ground count system for the park should be established and carried out at least annually, but preferable twice a year. This approach is used across the Kunene region in Namibia, in both national parks and communal conservancies, covering some 6 million ha, and provides essential wildlife information. Cross-border support, collaboration and coordination for ground counts could be established under the transboundary agreement.
- Effective anti-poaching and anti-poisoning programmes should be implemented, working closely with local communities and establishing an informer network

- The park should be zoned as core conservation areas and multiple use areas. People and livestock should be confined to the multiple use areas.
- The park zonation, and any anti-poaching and anti-poisoning programmes will be ineffective unless a strong community-based approach is adopted. This should involve a socio-ecological survey to initiative the process, to better understand the lifestyles and aspirations of people and their daily challenges, to share information on the park and its objectives, and to discuss a win-win conservation and livelihoods approach for the future management of the area. The park will need to deliver benefits to people in exchange for them delivering conservation and biodiversity protection benefits to the park. This could include benefits from wildlife utilisation and tourism, and job creation. This is the most important recommendation, as most of the other desired outcomes will dependend on a clear and well supported shared vision for the Iona National Park by the Ministry of Environment, their local staff and the local community.
- A Park Management and Development Plan should be developed, with emphasis on key management objectives and outcomes, as well as on development objectives (e.g. tourism) that will start to generate income for the park. Tourism development is typically far better outsourced to the private sector, and this could also be linked to a management contract for running the park if the Ministry of Environment is unable to provide the necessary support in this remote area.
- The Park Management Plan should consider the development of a few key water points, to help distribute the wildlife more effectively. Care should be taken to ensure that people and livestock do not settle at these water points, once again emphasising the need for a strong community-based, consultative approach and the development of a common vision for the park.
- The geo-referenced imagery provides many options for further analysis, research and planning. They could assist the park staff with deciding the location of infrastructure such as water-points, tracks for management and game counts, and tourist roads. The dataset of georeferenced images should be held by the Ministry of Environment in Angola, with a copy at the park coordinator's office. They could also be made available to researchers in the Ministry of Environment, and at university institutions in Angola. The following ideas are offered for further research using the images:
  - Welwitschia plant distribution, population structure and health across the park.
  - Euphorbia distribution and abundance. Larger species of the Euphorbiaceae family are clearly visible in the imagery. Measurements and spatial analyses could be performed.
  - Impact of grazing pressure on vegetation. Woody vegetation composition at gradients from water points could be determined, and to some degree perennial grass cover could also be estimated.
  - Soil erosion hotspots within the landscape could be quantified and mapped.

- Ongoing monitoring of Cape fur seals and coastal seabirds could be undertaken, to better understand the impacts of climate change on the Benguela ecosystem

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Appendix 1. Wildlife, livestock and associated infrastructure identified and extrapolated estimates per area surveyed.

Iona National Park																	
Wildlife and livestock count																	
2017	Zone 1				Zone 2				Zone 3				Zone 4	Rivers		Island	
Area	Salt pan	Sheltered coast	Exposed coast	Estuary	Main dunes	Tombwa plain	Oases	Eastern margin	Northern plains	Central plains	Southeastern plains	Southwestern plains	Communal and peripheral areas	Curoco river	Kunene river	Tigres Island and sandbank	Total
Size of area	22232	3787	7304	564	341470	16391	22138	37908	197608	143860	107036	129559	486867	6278	12002	18170	1553174
Size of area surveyed	18470	2272	7304	564	264326	16119	22138	37738	179796	136066	70387	109943	510668	6278	12002	18170	1412241
% of area surveyed	32	60	100	100	15	38	40	38	46	52	33	43	42	100	100	100	
Terrestrial wildlife																	
Oryx					1					32	205	107			13		358
Springbok											621	5		1			627
Ostrich											86	51					137
Zebra											129		18				147
Crocodile															3		3
Livestock																	0
Cattle						51		3			69		202	66	111		502
Sheep / goats									63		91		2779	117	336		3386
Donkey									4				13	4	38		59
Marine wildlife																	0
Seal colonies		12														40	52
Unknown whale																1	1
Humpback whale																2	2
Shark	2	2														7	11
Turtles				105													105
																	0
Cropfields						12			0		0		5	39	16		72
Homesteads						5		4	5		7		329	63	27		440
Kraals						4		22	84		139	1	790	41	33		1114

	Zone 1				Zone 2				Zone 3				Zone 4	Curoco river	Kunene river	Tigres Island and sandbank	0
Area	Salt pan	Sheltered coast	Exposed coast	Estuary	Main dunes	Tombwa plain	Oases	Eastern margin	Northern plains	Central plains	Southeastern plains	Southwestern plains	Communal area	Curoco river	Kunene river	Tigres Island and sandbank	0
Terrestrial wildlife																	0
Oryx	0	0	0	0	7	0	0	0	0	62	621	249	0	0	13	0	951
Springbok	0	0	0	0	0	0	0	0	0	0	1882	12	0	1	0	0	1894
Ostrich	0	0	0	0	0	0	0	0	0	0	261	119	0	0	0	0	379
Zebra	0	0	0	0	0	0	0	0	0	0	391	0	43	0	0	0	434
Crocodile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
Livestock	0	0	0														
Cattle	0	0	0	0	0	134	0	8	0	0	209	0	481	66	111	0	1009
Sheep / goats	0	0	0	0	0	0	0	0	137	0	276	0	6617	117	336	0	7482
Donkey	0	0	0	0	0	0	0	0	9	0	0	0	31	4	38	0	82
Marine wildlife	0	0	0														
Seal colonies	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	40	60
Unknown whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Humpback whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Shark	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	7	17
Turtles	0	0	0	105	0	0	0	0	0	0	0	0	0	0	0	0	105
Cropfields	0	0	0	0	0	32	0	0	0	0	0	0	12	39	16	0	98
Homesteads	0	0	0	0	0	13	0	11	11	0	21	0	783	63	27	0	929
Kraals	0	0	0	0	0	11	0	58	183	0	421	2	1881	41	33	0	2630

Appendix 2. Areas flown as a percentage of management units (as determined by Park management)

			Actual Area	Central Plains 1	Central Plains 2	Dune Margin	Ewaua Etati	High Dunes	Humbi Kolondjai	Northern Plains	Ondje - mucale	Pediva	South East Plains 1	South East Plains 2	South East Plains 3	South East Plains 4	Southwestern Plains	Tchiheque Helola	Tombwa Plain	Tombwa Saltpan	Cunene Mouth	Tigres Sandbanks	Tigres Island	Iona Town	Cunene River	Atlantic Coast	Curoca River	Road Esp - Sal	Road Esp - Foz	Road Esp Kolondjai	Road Esp M/Negro	Welwitchia Plots		Total	% Sampled
Zone 1		**Coastal**	42385																															
	1A	Salt Pan	22232																8151	10319						3642								22112	99.5
	1B	Sheltered coast	3787														***2272***					***2600***				3026								7898	208.6
	1C	Exposed Coast	7304														7304									2297								9601	131.4
	1D	Estuary	564																		564				171	168								903	160.1
		Tigres Island	8498																				8498											8498	100.0
Zone 2		**Desert Dunes**	417907																															
	2A	High dunes	341470			39998		166495									19856		37977			1080					3722							269128	78.8
	2B	Tombwa Plain	16391																16119								500							16619	101.4
	2C	Oases	22138																22138															22138	100.0
	2D	Eastern Margin	37908			21338											16400																	37738	99.6
Zone 3		**Arid Plains**	578063																															
	3A	Northern Plains	197608	3412	17265	22119				137000		14395															2056	3230				129		199606	101.0
	3B	Central Plains	143860	45551	24405	22422				3788				1988	4870	10423	22619											317	1384	569	569	96		139001	96.6
	3C	Southeastern Plains	107036		7924						***4455***		***5255***	34694	3182	14877									1706				100	584	584			73361	68.5
	3D	Southwestern Plains	129559													6861	103082								2730				3607					116280	89.8
Zone 4		**Communal**	486867		27671		5595		27903	86496	***7164***	11926	***2574***					121717						308	7395					2971	4878			306598	63.0
		Peripheral				1128					617	5568					5892	26446	8764		220	11195	9672			1737								71239	
		Area Sampled	1525222	**48963**	**77265**	**107005**	**5595**	**166495**	**27903**	**227284**	**12236**	**31889**	**7829**	**36682**	**8052**	**32161**	**177425**	**148163**	**93149**	**10319**	**784**	**14875**	**18170**	**308**	**12002**	**10871**	**6278**	**3547**	**5091**	**4124**	**6031**	**225**	1300721	85.3
		Sampling intensity %		55	55	55	50	20	40	50	40	35	50	50	50	50	40	40	40	25	100	100	100	100	100	100	100	100	100	100	100	100			
		Actual coverage		26930	42496	58853	2798	33299	11161	113642	4894	11161	3915	18341	4026	16081	70970	59265	37260	2580	784	14875	18170	308	12002	10871	6278	3547	5091	4124	6031	225	599976	

AREAS ACTUALLY PHOTOGRAPHED

				Central Plains 1	Central Plains 2	Dune Margin	Ewaua Etati	High Dunes	Humbi Kolondjai	Northern Plains	Ondje - mucale	Pediva	South East Plains 1	South East Plains 2	South East Plains 3	South East Plains 4	Southwestern Plains	Tchiheque Helola	Tombwa Plain	Tombwa Saltpan	Cunene Mouth	Tigres Sandbanks	Tigres Island	Iona Town	Cunene River	Atlantic Coast	Curoca River	Road Esp - Sal	Road Esp - Foz	Road Esp Kolondjai	Road Esp M/Negro	Welwitchia Plots	Total	%
Zone 1		**Coastal**	33887																															
	1A	Salt Pan	22232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3260	2580	0	0	0	0	0	3642	0	0	0	0	0	0	9482	42.7
	1B	Sheltered coast	3787	0	0	0	0	0	0	0	0	0	0	0	0	0	***909***	0	0	0	0	***2600***	0	0	0	3026	0	0	0	0	0	0	6535	172.6
	1C	Exposed Coast	7304	0	0	0	0	0	0	0	0	0	0	0	0	0	2922	0	0	0	0	0	0	0	0	2297	0	0	0	0	0	0	5219	71.4
	1D	Estuary	564	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	564	0	0	0	171	168	0	0	0	0	0	0	903	160.1
		Tigres Island	8498	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8498	0	0	0	0	0	0	0	0	0	8498	100.0
Zone 2		**Desert Dunes**	417907																															
	2A	High dunes	341470	0	0	21999	0	33299	0	0	0	0	0	0	0	0	7942	0	15191	0	0	1080	0	0	0	0	3722	0	0	0	0	0	83233	24.4
	2B	Tombwa Plain	16391	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6448	0	0	0	0	0	0	0	500	0	0	0	0	0	6948	42.4
	2C	Oases	22138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8855	0	0	0	0	0	0	0	0	0	0	0	0	0	8855	40.0
	2D	Eastern Margin	37908	0	0	11736	0	0	0	0	0	0	0	0	0	0	6560	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18296	48.3
Zone 3		**Arid Plains**	578063																															
	3A	Northern Plains	197608	1877	9496	12165	0	0	0	68500	0	5038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2056	3230	0	0	0	129	102491	51.9
	3B	Central Plains	143860	25053	13423	12332	0	0	0	1894	0	0	0	994	2435	5212	9048	0	0	0	0	0	0	0	0	0	0	317	1384	569	569	96	73325	51.0
	3C	Southeastern Plains	107036	0	4358	0	0	0	0	0	***1782***	0	***2628***	17347	1591	7439	0	0	0	0	0	0	0	0	1706	0	0	0	100	584	584	0	38118	35.6
	3D	Southwestern Plains	129559	0	0	0	0	0	0	0	0	0	0	0	0	3431	41233	0	0	0	0	0	0	0	2730	0	0	0	3607	0	0	0	51000	39.4
Zone 4		**Communal**	486867	0	15219	0	2798	0	11161	43248	***2866***	4174	***1287***	0	0	0	0	48687	0	0	0	0	0	308	7395	0	0	0	0	2971	4878	0	144991	29.8
		Peripheral		0	0	620	0	0	0	0	247	1949	0	0	0	0	2357	10578	3506	0	220	11195	9672	0	0	1737	0	0	0	0	0	0	42081	
		Actual coverage	1525222	26930	42496	58853	2798	33299	11161	113642	4894	11161	3915	18341	4026	16081	70970	59265	37260	2580	784	14875	18170	308	12002	10870	6278	3547	5091	4124	6031	225	599975	39.3
		Area of flight Block		**48963**	**77265**	**107005**	**5595**	**166495**	**27903**	**227284**	**12236**	**31889**	**7829**	**36682**	**8052**	**32161**	**177425**	**148163**	**93149**	**10319**	**784**	**14875**	**18170**	**308**	**12002**	**10870**	**6278**	**3547**	**5091**	**4124**	**6031**	**225**	1300720	
		% Photographed		55	55	55	50	20	40	50	40	35	50	50	50	50	40	40	40	25	100	100	100	100	100	100	100	100	100	100	100	100	46	