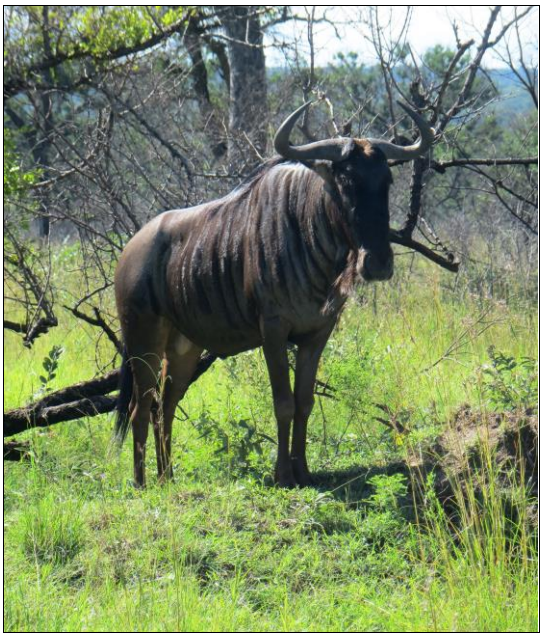
Ecological Monitoring:

Association of Private Nature Reserves

(Timbavati, Umbabat, Klaserie and Balule)



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Thirteenth Joint Report: 2015

TABLE OF CONTENTS

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The ARC-API project team that completed all of the field work in the APNR included:
Mike Peel
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EXPANDED SUMMARY

This report is the thirteenth joint “annual ecological audit” for the landowners of the APNR (Association of Private Nature Reserves). The general background to the study, methods used, and initial results and discussion can be obtained from the ARC-API reports dating back to 1990 and all of the reserves making up the APNR have been a part of this ecological programme since its inception in 1989/90 (see reference list in this document).

To recap, the objective of the monitoring programme is to ascertain the current situation and trends in the resources of the Lowveld (some 450 000ha). This includes the measurement and description of plant species composition and structure, and the quantification of the relations between various aspects of the vegetation, management practices (e.g. stocking rates, fire and bush clearing), soils, rainfall, other climatic variables, the woody/herbaceous ratio and the faecal analysis programme. This report is presented as an expanded summary.

As discussed in the previous report, the process of Adaptive Planning as laid down by the Department of Environmental Affairs and Tourism for setting norms and standards for National Protected Area has been integrated into a comprehensive management plan for the APNR. Besides the legal requirements in terms of the National Environment Management: Protected Areas Act No. 57 of 2003 (NEM: PAA), such a Management Plan serves several important purposes.

This includes the following:

1. It adds value to the reserve and its individual constituent properties as an integrated concept with clearly defined objectives and approaches. This guarantees continuity;
2. A well-articulated plan assists with obtaining the necessary permits and authorisations from the relevant Nature Conservation and Environmental authorities;
3. The Management Plan assists in the yearly planning (and budgeting) of veld management tasks.

In addition to the **APNR** Management Plan, we have now completed such Management Plans for the Kapama Game Reserve, Fleur de Lys Game Reserve, Blue Canyon Game Conservancy, Sabi Sand Wildtuin, MalaMala Game Reserve, joint SSW-MalaMala plan, Eden

Nature Reserve (Nelspruit), Penryn College (Nelspruit/White River), Hans Merensky Estate (Phalaborwa), Raptors View, Thornybush Game Reserve, and Longmere Estate and these are now lodged with the Limpopo Department of Economic Development Environment and Tourism (LEDET) and the Mpumalanga Parks and Tourism Authority (MTPA).

We are also specifically involved in advising on updated plans for the KPNR and TPNR as well as for portions of the Umbabat and BNR in a manner aimed at integrating management actions within the APNR.

RAINFALL

The importance of extreme rainfall seasons (particularly very dry or very wet), are important in driving these systems. Note that with the changes in weather/climate patterns that are predicted (and indeed appear to be happening) the prediction is that rainfall in these semi-arid savannas will become less predictable and more variable. It could be that we are going to experience greater variability and extremes in rainfall with ‘wetter wet seasons’ and ‘drier dry seasons’.

The observed effect of rainfall on the vegetation is discussed under the vegetation section of this report. The importance of careful management is emphasised as this allows for hazards (normally drought related-current) to be avoided and opportunities (following favourable seasons) to be grasped. A drought is defined as being a rainfall season in which less than 75% of the mean rainfall is received. From the latter it can be said that the KPNR, UPNR and BNR (marginal) suffered drought conditions in 2014/15 while the TPNR can be said to have been dry (Table 1 and Figure 1a). The previous six years were favourable in the APNR as a whole, dominated by close to mean and wet years (2011/12 to 2013/14 very wet) (Figure 1a and Figure 1b) and this has had an important lag effect on the current condition of the APNR rangelands.

Up to February 2016 the KPNR (Rowles pers. comm.), UPNR (Shaw *pers. comm.*), TPNR (Bosch *pers. comm.*) and BNR (Clarke and Spencer *pers. comm.*) had received only 161mm, 154mm, 156mm and 159mm respectively since June 2015. The early rains in September (27mm, 40mm and 27mm for the KPNR, TPNR, BNR and UPNR respectively) were in effect ‘too early’ and the heat and dry period following these rains caused the grasses that flushed in September (after the rain) to die back again thus exhausting their energy reserves and depleting the available grazing. The poor follow up rainfall means that we have effectively entered a second season of drought.

Table 1 - Summary of annual rainfall for the APNR.

Year	KPNR Mn 36y 449mm *	% of mean	Comment	UPNR Mn 33y 438mm *	% of mean	Comment	TPNR Mn 36y 537mm *	% of mean	Comment	BNR Mn 30y 454mm *	% of mean	Comment
1979/80	561	125	Wet				658	123	Wet			
80/81	816	182	Very wet				710	132	Very wet			
81/82	524	117	Wet				401	75	Dry			
82/83	182	41	Severe drought	229	52	Drought	340	63	Drought			
83/84	448	100	Close to mean	460	105	Close to mean	664	124	Wet			
84/85	735	164	Very wet	813	186	Very wet	867	162	Very wet			
85/86	323	72	Drought	498	114	Wet	351	65	Drought	403	89	Dry
86/87	293	65	Drought	272	62	Drought	524	98	Close to mean	357	79	Dry
87/88	450	100	Close to mean	559	128	Very wet	551	103	Close to mean	441	97	Close to mean
88/89	304	68	Drought	225	51	Drought	358	67	Drought	318	70	Drought
89/90	435	97	Close to mean	439	100	Close to mean	512	95	Close to mean	443	98	Close to mean
90/91	309	69	Drought	433	99	Close to mean	513	96	Close to mean	428	94	Dry
91/92	258	57	Drought	166	38	Severe drought	263	49	Severe drought	164	36	Severe drought
92/93	313	70	Drought	516	118	Wet	585	109	Wet	415	91	Dry
93/94	304	68	Drought	233	53	Drought	406	76	Dry	356	78	Dry
94/95	372	83	Dry	495	113	Wet	350	65	Drought	437	96	Close to mean
95/96	632	141	Very wet	597	136	Very wet	873	163	Very wet	765	168	Very wet
96/97	383	85	Dry	357	82	Dry	511	95	Close to mean	229	50	Drought
97/98	253	56	Severe drought	269	61	Drought	361	67	Drought	235	52	Drought
98/99	670	149	Very wet	552	126	Very wet	718	134	Very wet	516	114	Wet
99/00	880	196	Very wet	829	189	Very wet	1062	198	Very wet	741	163	Very wet

Year	KPNR Mn 36y 449mm *	% of mean	Comment	UPNR Mn 33y 438mm *	% of mean	Comment	TPNR Mn 36y 537mm *	% of mean	Comment	BNR Mn 30y 454mm *	% of mean	Comment
00/01	458	102	Close to mean	349	80	Dry	537	100	Close to mean	433	95	Close to mean
01/02	349	78	Dry	225	51	Drought	452	84	Dry	411	90	Dry
02/03	251	56	Drought	297	68	Drought	345	64	Drought	254	56	Drought
03/04	403	90	Dry	558	127	Very wet	583	109	Wet	452	100	Close to mean
04/05	274	61	Drought	363	83	Dry	377	70	Drought	330	73	Drought
05/06	594	132	Very wet	450	103	Close to mean	592	110	Wet	649	143	Very wet
06/07	370	82	Dry	395	90	Dry	443	83	Dry	364	80	Dry
07/08	367	82	Dry	343	78	Dry	384	72	Drought	391	86	Dry
08/09	446	99	Close to Mean	461	105	Close to mean	492	92	Dry	598	132	Very wet
09/10	414	92	Dry	439	100	Close to mean	451	84	Dry	597	131	Very wet
10/11	463	103	Close to Mean	491	112	Wet	578	108	Wet	456	100	Close to mean
11/12	871	194	Very wet	605	138	Very wet	686	128	Very wet	740	163	Very wet
12/13	586	130	Very wet	620	142	Very wet	619	115	Wet	649	143	Very wet
13/14	581	129	Very wet	619	141	Very wet	738	138	Very wet	665	146	Very wet
14/15	302	67	Drought	292	67	Drought	460	86	Dry	337	74	Drought

* The mean is updated annually so the previous year's % figures will vary slightly as the mean changes. As new stations are added they are also included in the data set.

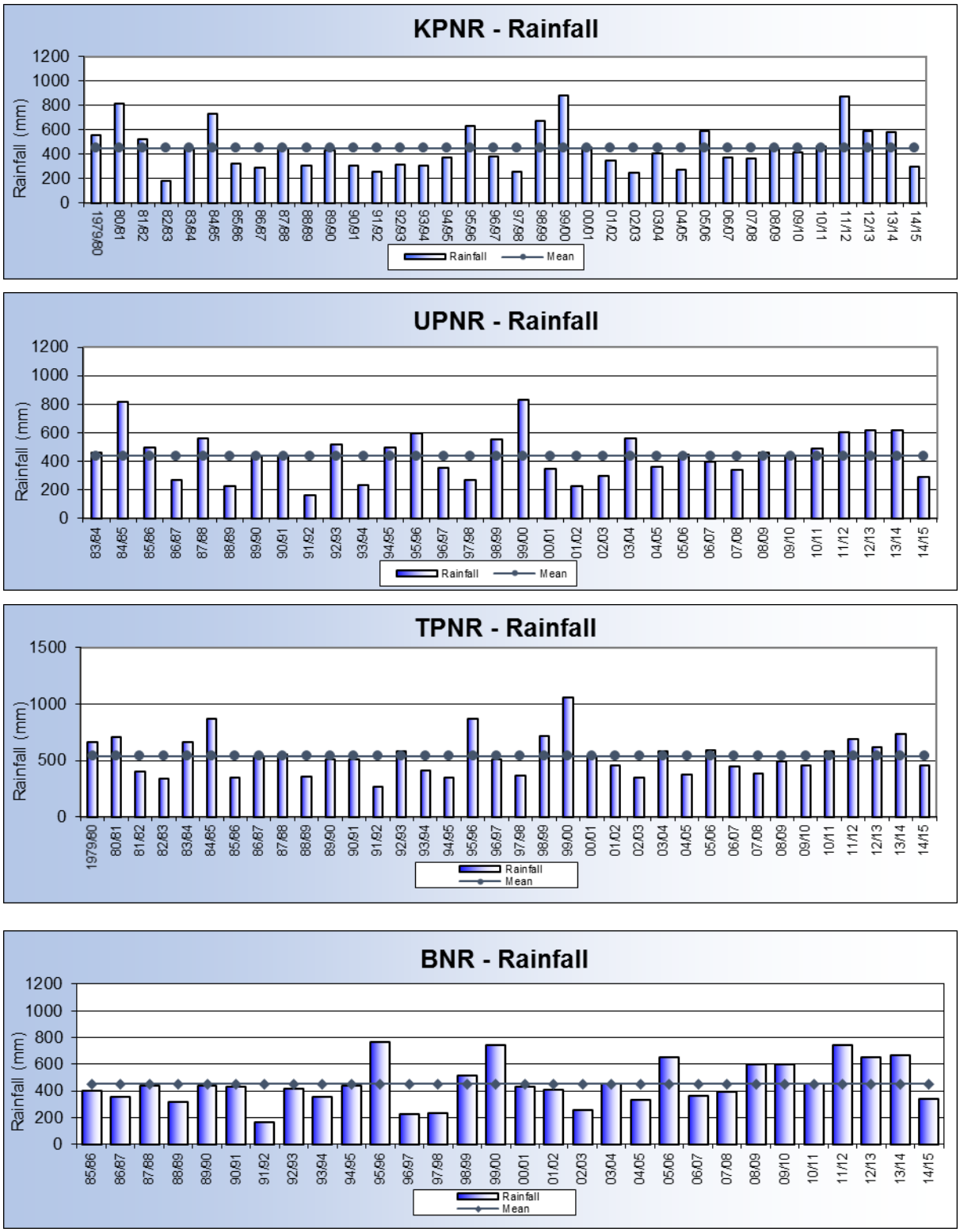

Figure 1 Annual rainfall for APNR and mean.

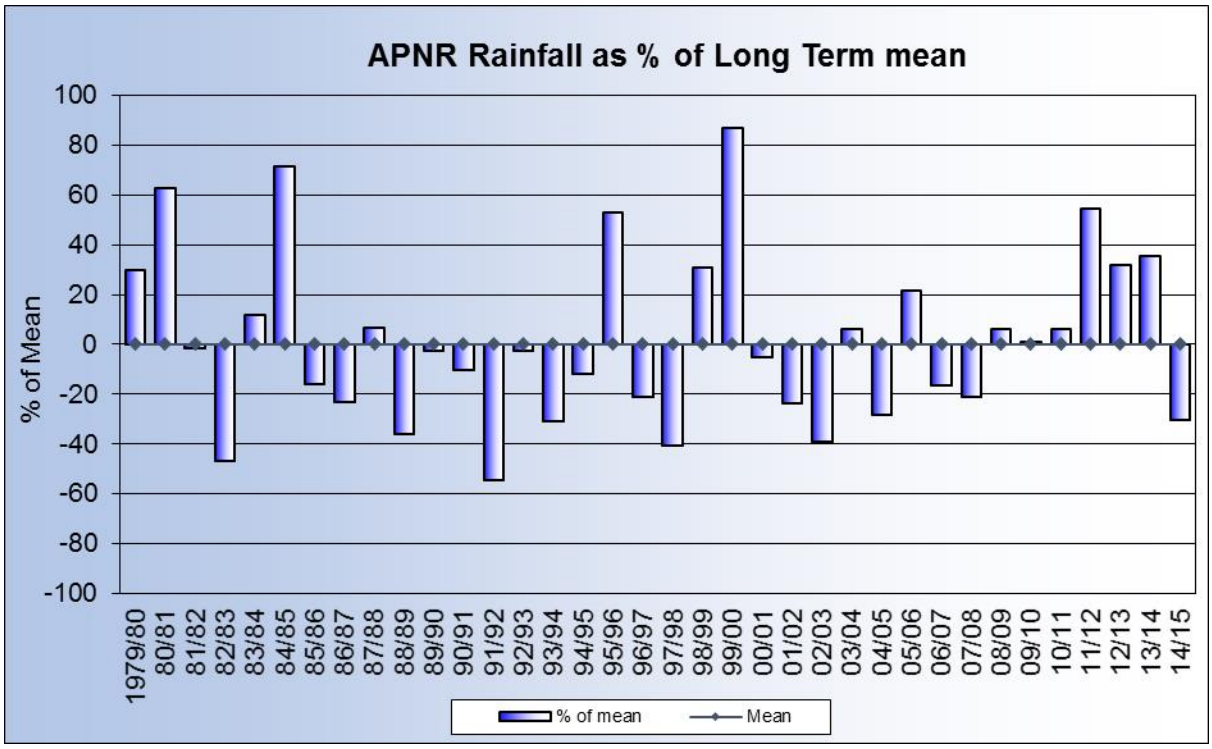

Figure 1a Annual rainfall as a percentage of the long term mean for the APNR.

THE VEGETATION

The monitoring results are discussed and presented graphically in Figures 2 to 12 and in tables 2 to 6. A discussion of the results follows in the text. Vegetation changes on APNR are thus tracked and a further strength of the monitoring programme is the capacity to also compare vegetation condition with other reserves in the area. We compare important vegetation parameters among APNR and four other reserves in the area.

Grass

Figures 2 to 4 illustrate the trends in important grass parameters. As predicted the perennial composition and cover (tuft) was maintained across all reserves and in the light of the dry 2014/15 the statement relating to a potential decline due to the poor early 2014/15 season held with a decline in cover (distance). There is currently a high proportion of perennial grasses in the TPNR, KPNR and UPNR and moderate-high in the BNR. The general lack of steep declines in these three parameters highlights the importance of the previous (three in particular) favourable rainfall seasons. Interestingly the BNR showed most stability (albeit generally lower than the other three reserves) in terms of composition and cover.

The prevailing drought conditions suggest that the perennial composition and cover will in all probability decline in the APNR (the degree depending on the 2015/16 season which as reported earlier has been poor). While driven by rainfall, an active hands-on adaptive management programme influences the degree to which rainfall modifies parameters such as the annual/perennial ratio and cover. This is particularly relevant in the light of the fact that the neighbouring Kruger National Park (KNP) closed artificial water points thus potentially precipitating an influx of animals into the areas adjacent to the KNP (**NNB see Appendix C for further discussion in this regard**).

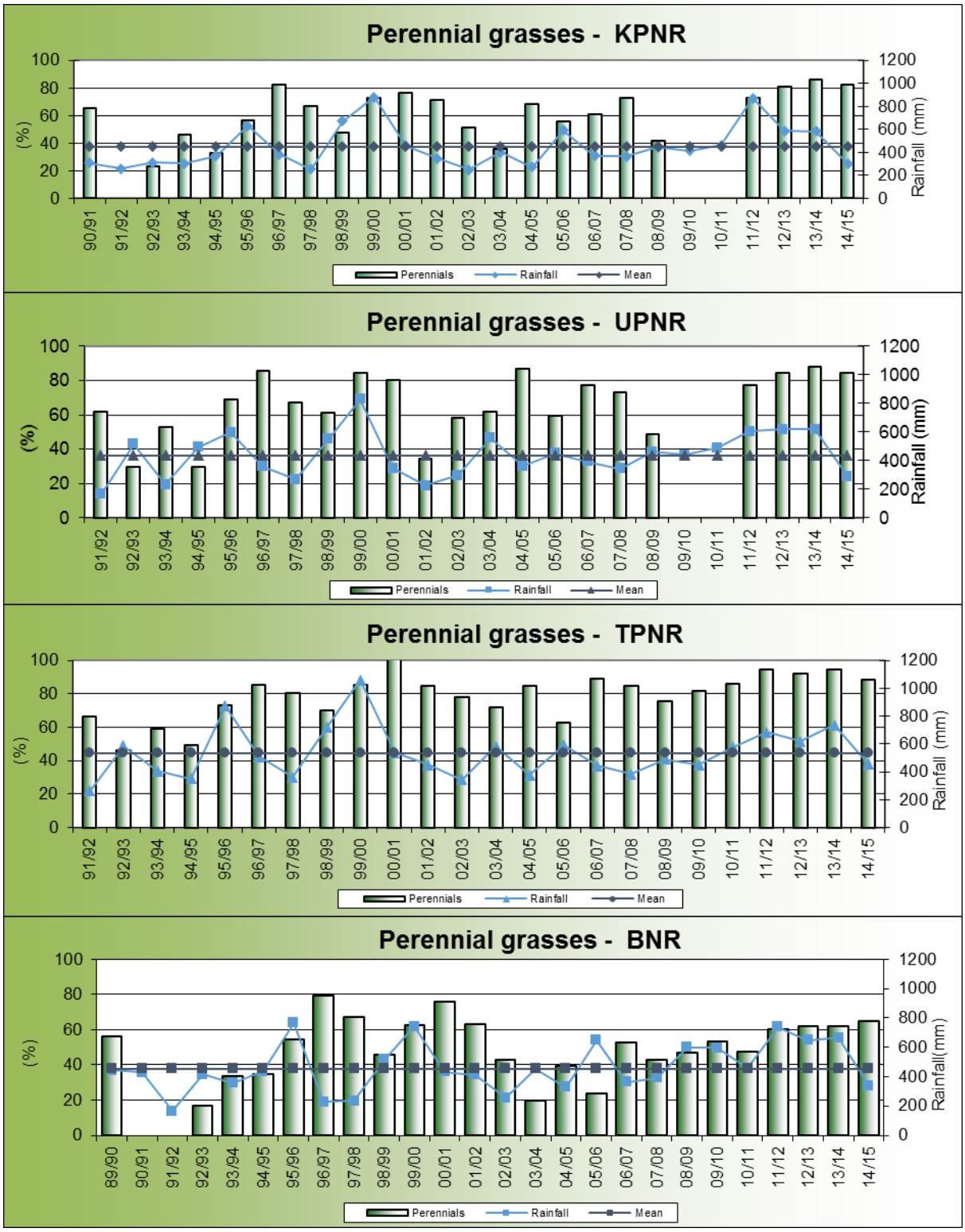

Figure 2 Percentage perennial grasses present on APNR and rainfall.

Table 2 Perennial grass composition trends within the APNR (refer Figure 2).

APNR overall	General Comment **2014/15**; and Comment **Long term**
	Stable - High proportion of perennial grasses; **moderate-high**
KPNR 22y	**Stable** - High proportion of perennial grasses; **moderate-low**
UPNR 22y	**Stable** - High proportion of perennial grasses; **moderate-high**
TPNR 24y	**Decline** – High proportion of perennial grasses; **High**
BNR 24y	**Stable** – Moderate-high proportion of perennial grasses; **Low**

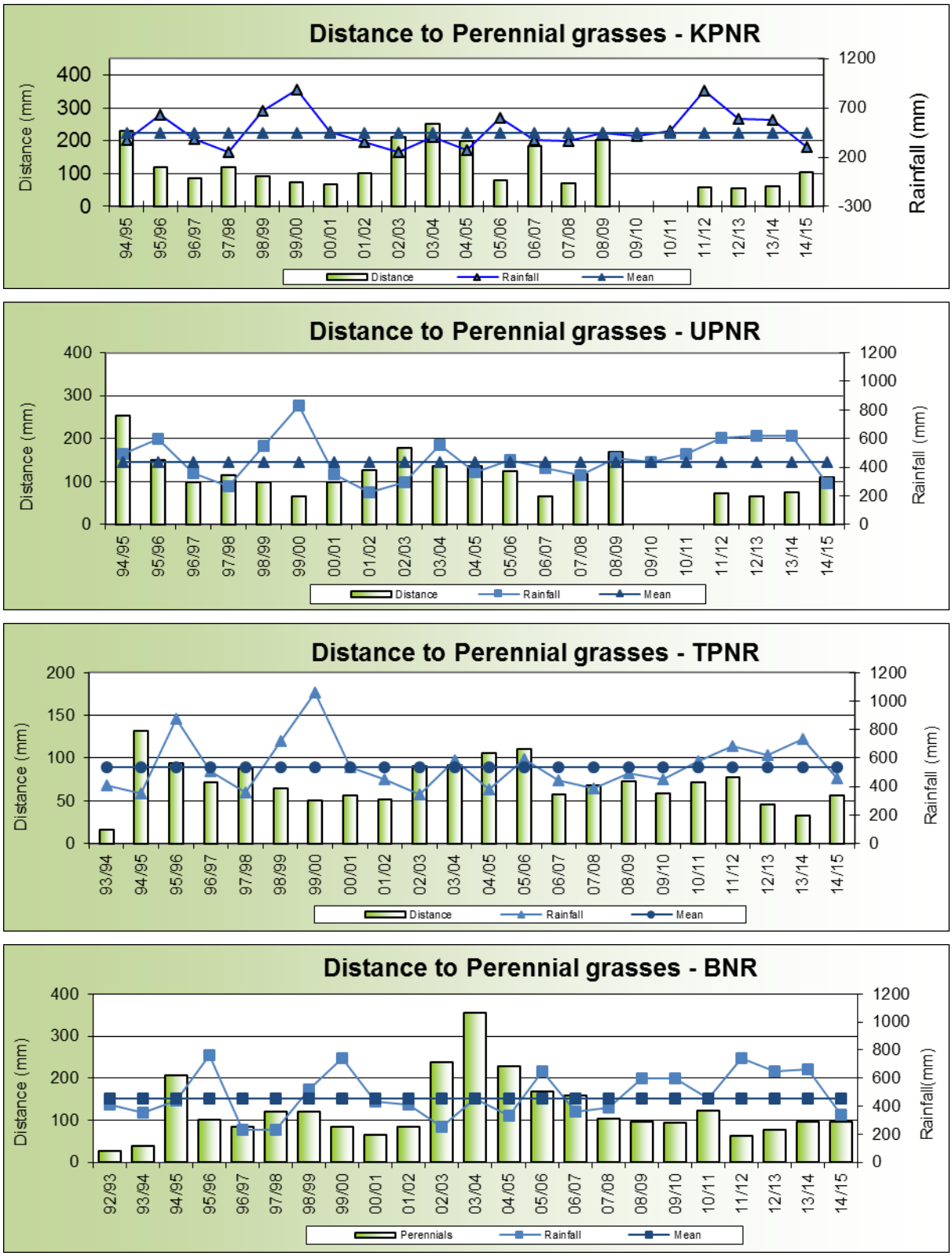

Figure 3 Mean distance to perennial grasses on APNR and rainfall.

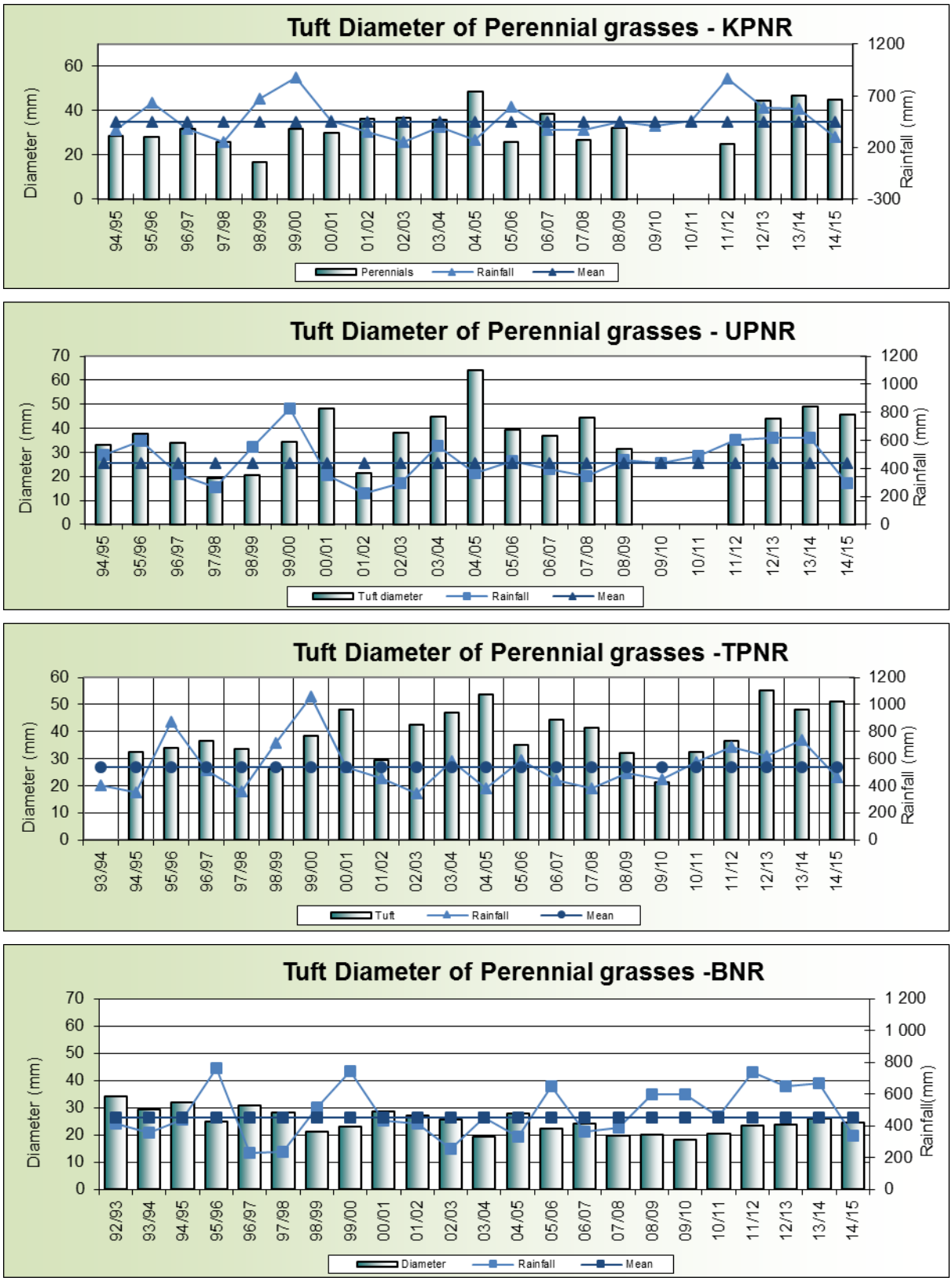

Figure 4 Mean tuft diameter of perennial grasses on APNR and rainfall.

Table 3 Perennial grass cover trends in the APNR (refer Figure 3 and Figure 4).

APNR overall	General Comment **2014/15**; and **Long term;** Distance measure (top), tuft measure (bottom)
	Decline (slight) - Moderate; **Moderate-low** **Improvement – Moderate-high; Moderate**
KPNR 22y	**Decline** – Low; Low **Stable –** High; Moderate-high
UPNR 22y	**Decline** - Low; Low **Stable –** High; Moderate-high
TPNR 24y	**Decline** – Moderate-high; Moderate-high **Improvement (slight) -** High; Moderate-high
BNR 24y	**Stable -** Moderate low; Moderate **Stable –** Moderate; Moderate

Grass standing crop is a function of herbaceous production and represents the portion of production that remains after utilisation (Figure 5 and Table 4). The grass standing crop at the end of the 2014/15 - summer season was **moderate-low** for the APNR overall. For the individual reserves the following KPNR (moderate-low), UPNR (moderate-low), TPNR (moderate) and BNR (low).

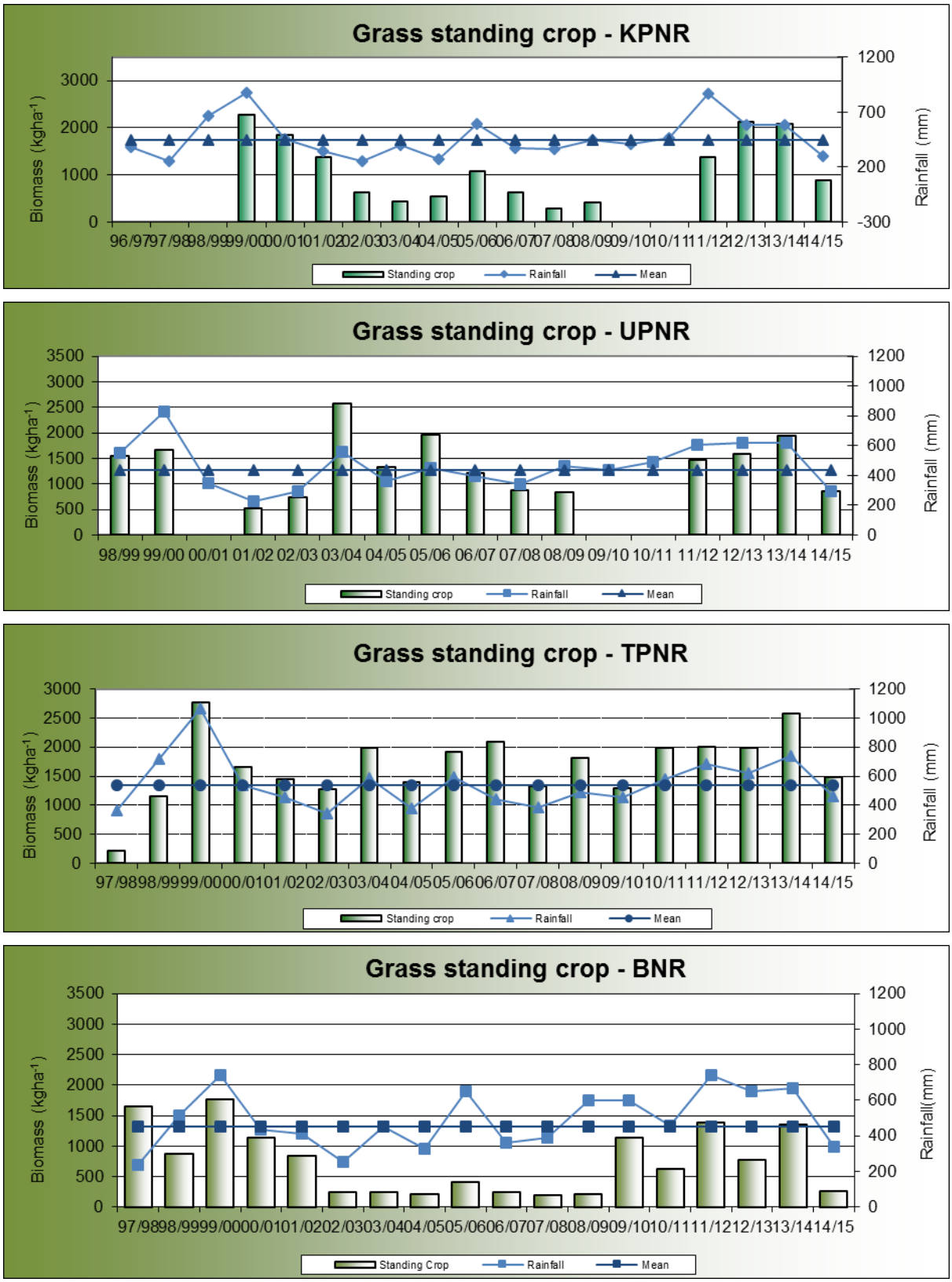

Figure 5 Grass standing crop on APNR and rainfall.

Table 4 Perennial grass standing crop trends in the APNR (refer Figure 5 and Figure 6).

Comment Long term	Trend VH=very high; H=high; MH=moderate high; M=moderate; ML=moderate low; L=low; VL=very low											
	04	05	06	07	08	09	10	11	12	13	14	15
APNR Overall												
KPNR	L	ML	M	ML	L	L			M	H	H	ML
UPNR	VH	M	MH	M	ML	ML			M	MH	H	ML
TPNR	MH	M	MH	H	M	MH	M	MH	H	MH	VH	M
BNR	VL	VL	L	VL	VL	VL	M	ML	M	ML	M	VL

Grass standing crop measurements have important implications for grazing and fire management. A forage flow estimate was thus made for the APNR based on the animal numbers obtained from the annual game count (Figure 6 and Table 5). As discussed with the various APNR management bodies, results indicate that for **the APNR as a whole, there would be sufficient grazing in the APNR until around October with shortages setting in thereafter. There would be a critical shortage of forage in the KPNR (from around September) and BNR (as early as June) and sufficient grazing in the UPNR and TPNR until the onset of spring/summer**. Note that this approximates these parameters and will be refined using energy requirements and flows (see discussion under the animal section). In conjunction with this, it is important to link up with the faecal analysis programme as it will give an indication of the physical condition of the herbivores (see final section of this report).

Table 5 Forage flows in the APNR.

Property	Comment
APNR	Grazing stress in various parts of the APNR

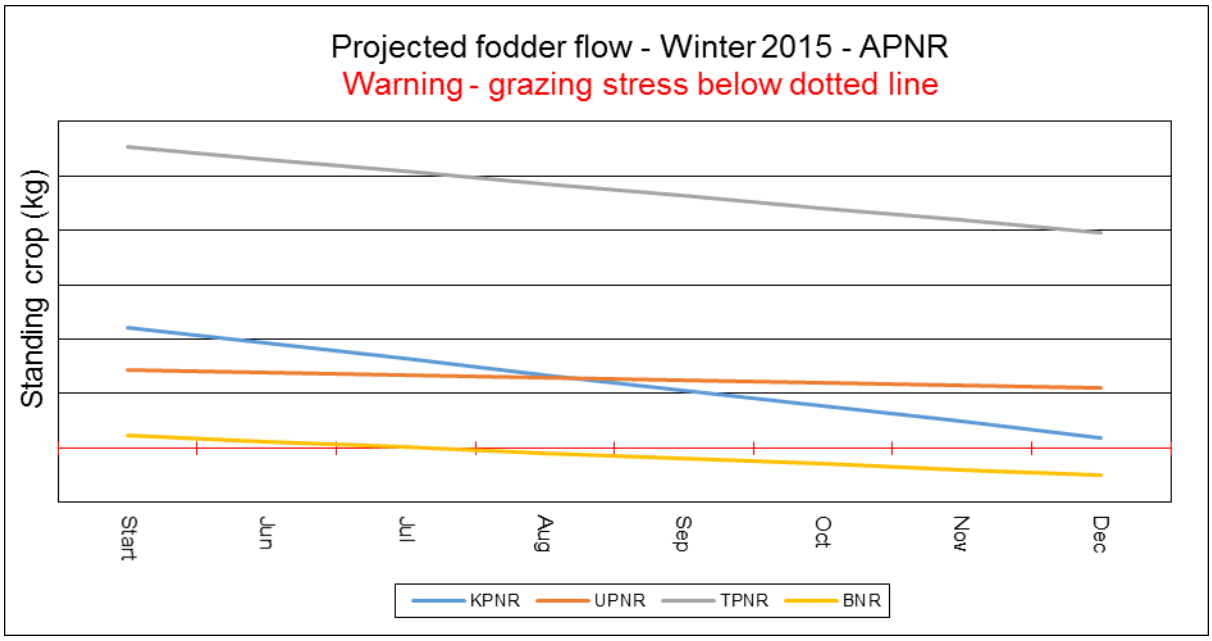

Figure 6 Projected forage flows on APNR for winter 2015.

Table 6 A comparison of the vegetation condition of a number of important grass parameters on KPNR-UPNR-TPNR-BNR and four reserves (with their property number in the ARC-API data set).

Grass Parameter	KPNR UPNR TPNR BNR	Res. 13	Res. 5	Res. 8	Res. 1*	Rank no.: KPNR; UPNR; TPNR; BNR - /8 2009/10-10/11 /6 TPNR and BNR 11/12 onwards /8											
						03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Perennials (%)	83 84 88 65	79	76	83	80	52 2	51 28	65 27	75 18	54 38	86 17	- - 16	- - 26	83 17	64 18	42 18	32 18
Cover (distance-mm)	103 110 56 98	74	68	55	45	64 3	74 58	76 48	84 17	48 37	87 46	- - 16	- - 36	18 75	67 28	67 28	78 36
Cover (tuft size-mm)	45 46 51 24	26	22	25	30	41 1	32 18	43 17	34 18	61 28	41 18	- - 36	- - 26	71 48	22 17	22 17	32 17
Standing crop (kg/ha)	879 863 1 482 257	545	494	526	1 977	61 2	62 38	75 48	75 38	73 28	54 18	- - 34	- - 26	85 27	25 38	54 27	34 28

- New insertion south.

The above illustrates that KPNR now ranks moderate, UPNR moderate, TPNR high, and the BNR relatively low when compared to four nearby reserves (APNR overall moderate). Note that with the changes in weather/climate patterns the prediction is that rainfall in these semi-arid savannas will become less predictable and more variable. As previously stated it could be that we are going to experience greater extremes in rainfall with ‘wetter wet seasons’ and ‘drier dry seasons’ with recent studies predicting more wet than dry highlighting the need for good grass cover. The KPNR, BNR, northern TPNR and UPNR experience drier conditions than the central and southern areas of the TPNR. As previously discussed, it must also be remembered that the BNR has ‘evolved’ from an area of small fenced properties, often with high stocking rates, to an area where

animals can move freely (water notwithstanding) in response to resource availability. The provision of artificial water however results in water dependent animals remaining in areas that they would normally have vacated during certain times of the year. This is a situation that is widespread throughout the APNR. The effect of high impact herbivore species such as elephant must be considered as declines in the grass layer indicate that while rainfall drives the system, grazing pressure can ultimately compromise the composition and vigour (distance and tuft) of the individual grass plants. Grass standing crop measurements have important implications for grazing and fire management. Therefore, in addition to animal number manipulation, the judicious use of fire, bush thinning and the rotation of water points should be used to manage herbivore distribution and impact. **Please read the 'drought' report$_{v8}$ compiled in this regard (Appendix C)**

Trees

Woody density varies across the different areas, with fluctuations broadly corresponding to 'wet' (decreased density –with an increase in competition with the perennial grass component) and 'dry' (increase in density) (Figure 7). The long term tree densities indicate a general decline in tree density for KPNR (slight decline from 12/13), TPNR and UPNR (slight increase from 11/12), and BNR (relatively stable since 11/12). The above illustrates the fluctuations one would expect within the tree layer. As expected the canopy cover in the generally tracks fluctuations in tree density in these reserves (Figure 8). The BNR has had a consistently higher canopy cover than areas to the east (gradual decline since 11/12). It may be that the BNR is consistently dominated by the shorter height classes resulting in higher canopy cover. Given the climatic and concerns of the perceived/real impact of elephant, we have started an in-depth analysis of tree density and cover for the entire study area and results will be reported on as they are analysed and interpreted.

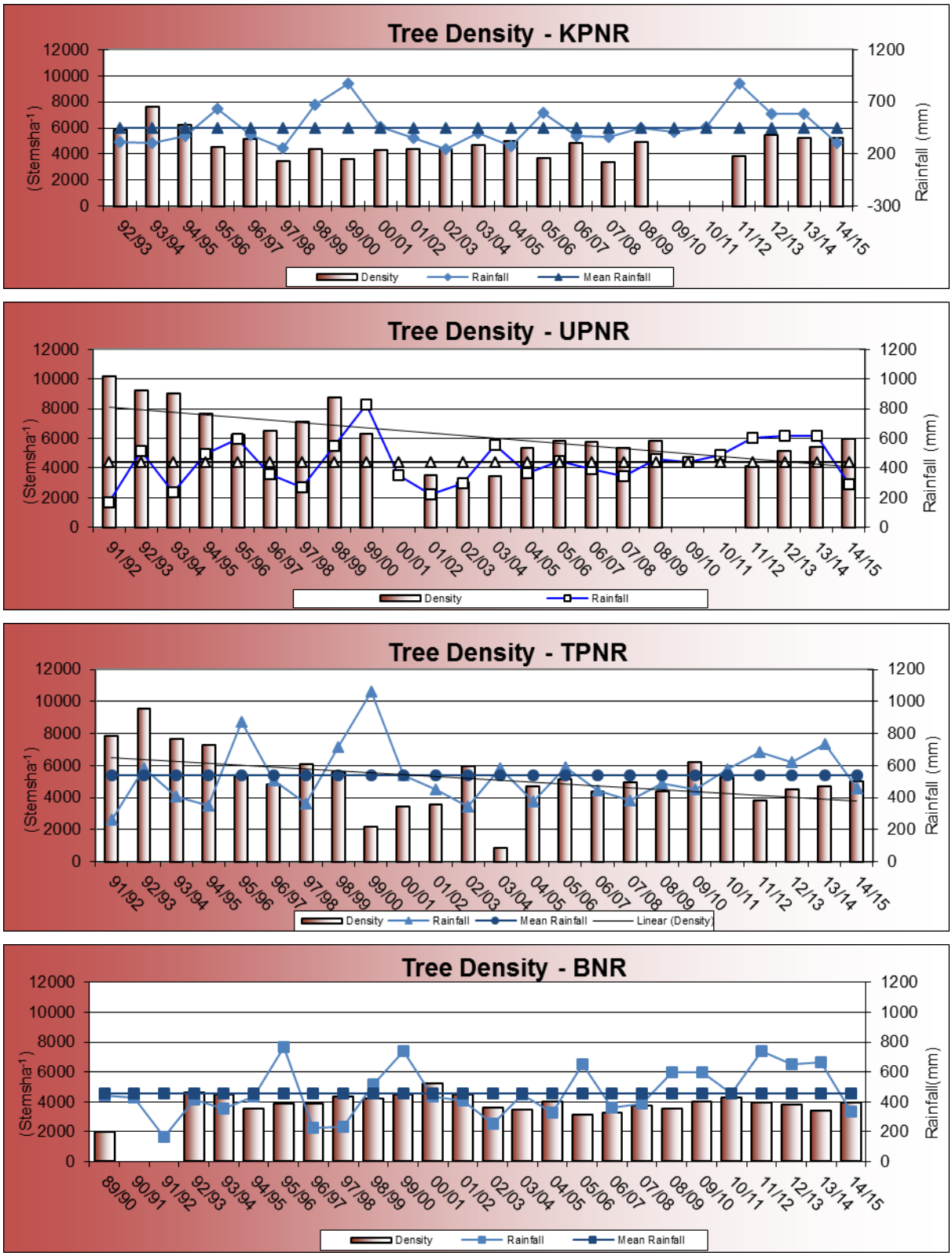

Figure 7 Mean woody densities on APNR and rainfall.

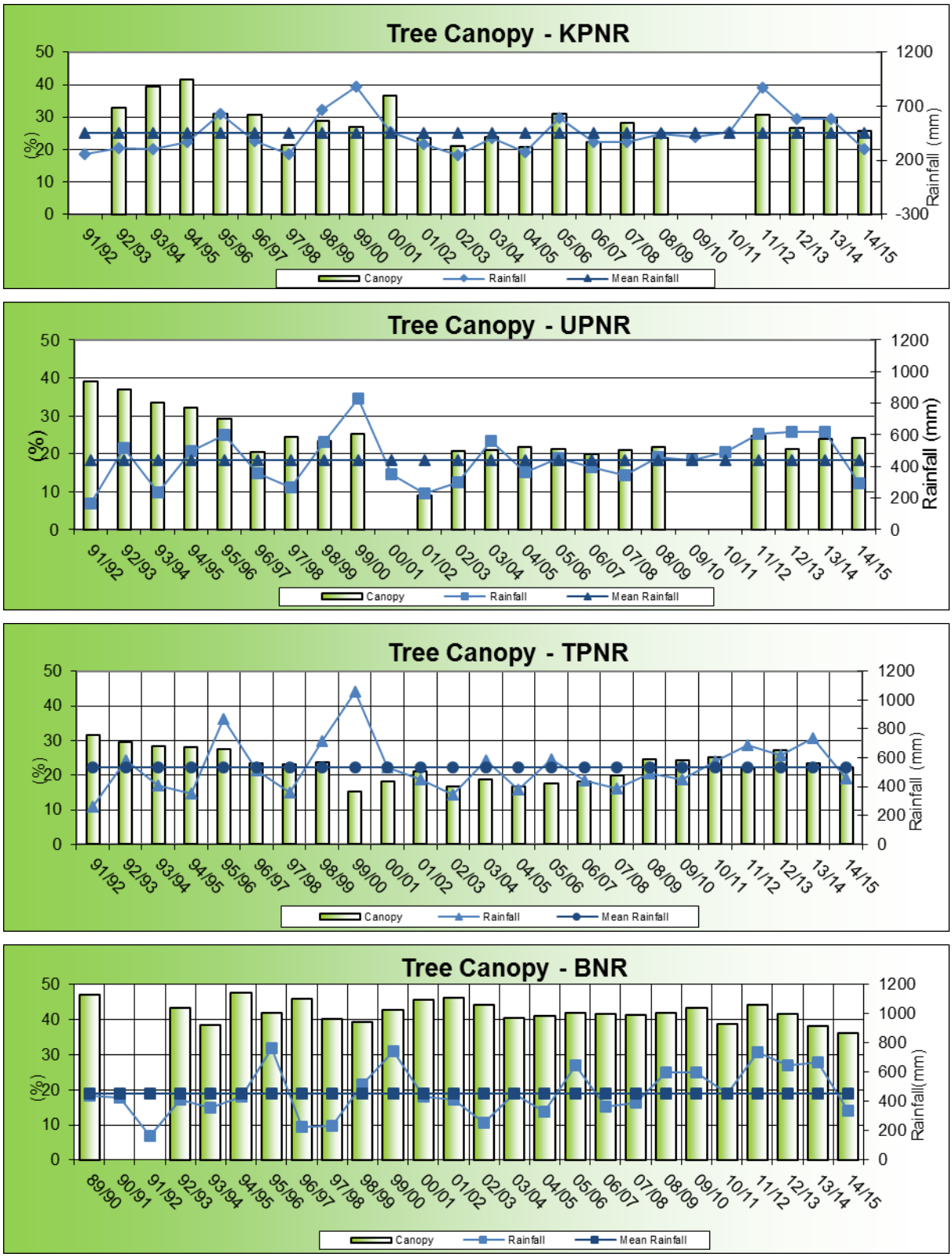

Figure 8 Mean tree canopy cover on APNR and rainfall.

Elephant impact

When we examine the 2007 to 2014 results we note two things: the overall density of elephant has varied from 0.69 to 0.85 to 0.80 to 0.73 to 0.96 to 0.96 to 0.93 to 1.19 to 2.0 elephants km^{-2} in the APNR indicating a gradual increase overall but with a sharp increase in 2014 and 2015; the elephant population is mobile within the APNR (and surrounding areas): KPNR (0.68 to 1.31 to 1.03 to 1.14 to 1.33 to 1.5 to 1.0 to 1.2 to 2.27 elephants km^{-2} – steep increase), UPNR (0.27 to 0.47 to 0.68 to 0.48 to 0.8 to 0.3 to 0.27 to 0.87 to 0.82 to elephants km^{-2} – stabilised), TPNR (0.62 to 0.84 to 0.72 to 0.49 to 0.72 to 0.91 to 0.87 to 1.01 to 1.24 elephants km^{-2} – increase) and BNR (1.03 to 0.39 to 0.67 to 0.61 to 0.84 to 0.7 to 1.33 to 1.63 to 1.56 elephants km^{-2} – stable but steep increase in recent years).

Elephant impact data are available for BNR only at this time. As data for the other three reserves become available the report will be updated. The severity of elephant impact, ranked on a seven-point scale indicates that **new** impact on trees was: 2014 for KPNR, TPNR and UPNR - 'no impact' KPNR 80% (stable - 80% 2013); UPNR 76% (more trees impacted - 82% 2013); TPNR 75% (stable but more trees impacted - 74% 2013); 2015 BNR 84% (stable - 2014 87%). The mortality measurements were as follows: 2014 for KPNR, TPNR and UPNR – KPNR 0.7% (decline – 1.7% 2013**);** UPNR 1.1% (stable – 1.2% 2013)**;** TPNR 1.3% (increase – 0.9% 2013); and 2015 BNR 2.9% (continued increase from 2% 2014 and 0.9% 2013). Worth noting in **2014** is the spike in damage in the 18% and 38% midpoint in the KPNR (not marked), the UPNR (not marked), 18% midpoint in the TPNR (marked) and 38% midpoint (not marked).

In terms of percentage damage per height class Figure 10 indicates a continued selection within the 2-5m and >5m classes: 2014 - KPNR 40% and 36% respectively which is relatively high and with a small spike in the 1.1-2m class (18%); 2014 - UPNR 45% and 39% respectively which is relatively high and with a spike in the 1.1-2m class (26%); 2-14 - TPNR 55% and 42% respectively which is relatively high and with a peak in the 1.1-2m class (29%); 2015 - BNR 27% and 26% respectively which is relatively moderate but increasing (21% and 22% in 2014 respectively). This parameter is monitored as homogenisation of structure is not desirable (e.g. all small trees or all large trees present and nothing in between).

Figure 11 shows the percentage of trees sampled per species which were impacted upon and Figure 12 the **relative** percentage of all tree species sampled that have been impacted upon. Table 7 provides a brief discussion of these results.

Table 7 Discussion of impact per species sampled.

Species	Reserve	% impacted and comment	Relative % impacted on and comment – rank in brackets per reserve
Combretum apiculatum	KPNR*	24% = stable	19 % (3)
	UPNR*	29% = increase in impact	13% (3)
	TPNR*	28% = decline in impact	30% (1)
	BNR	18% = stable	26% (1)
Colophospermum mopane	KPNR*	24% = decline in impact	24% (2)
	UPNR*	27% = sharp increase in impact	43% (1)
	TPNR*	25% = decline in impact	17% (2)
	BNR	25% = relatively stable	5% (7)
Acacia nigrescens	KPNR*	17% = decline in impact	18% (4)
	UPNR*	20% = stable	12% (4)
	TPNR*	24% = decline in impact	10% (5)
	BNR	19% = slight increase in impact	20% (2)
Sclerocarya birrea	TPNR*	59% = very sharp increase in impact	7% (4)
	BNR	30% = increase in impact	8% (4)
Grewia spp.	KPNR*	20% = decline in impact	33 % (1)
	UPNR*	22% = increase in impact	28% (2)
	TPNR*	19% = decline in impact	16% (3)
	BNR	11% = increase in impact	18% (3)
Mixed *Acacia*	KPNR*	17% = decline in impact	5% (3)
	TPNR*	23% = increase in impact	11% (4)
	BNR*	17% = decline in impact	7% (5)
	BNR	18% = stable	8% (4)
Commiphora molle	BNR	19% = stable	7% (6)

*2014 data;

The link between elephant density and impact on favoured trees is currently being investigated. *Combretum apiculatum* and *Colophospermum mopane* play similar roles in that relatively similar proportions of these species are selected for where they

dominate. *Colophospermum mopane* and *Grewia* spp. will in all likelihood continue to comprise a large proportion of the impact particularly in the drier north and east while in the central, south and west the impact shifts to *Combretum apiculatum*.

As with the tree density and canopy data, a clearer understanding of elephant impact is emerging as the monitoring programme continues. This is not an in-depth study of elephant impact but more an attempt to broadly quantify impact on a reserve scale. Species and areas of concern should be identified for closer investigation within an elephant management plan.

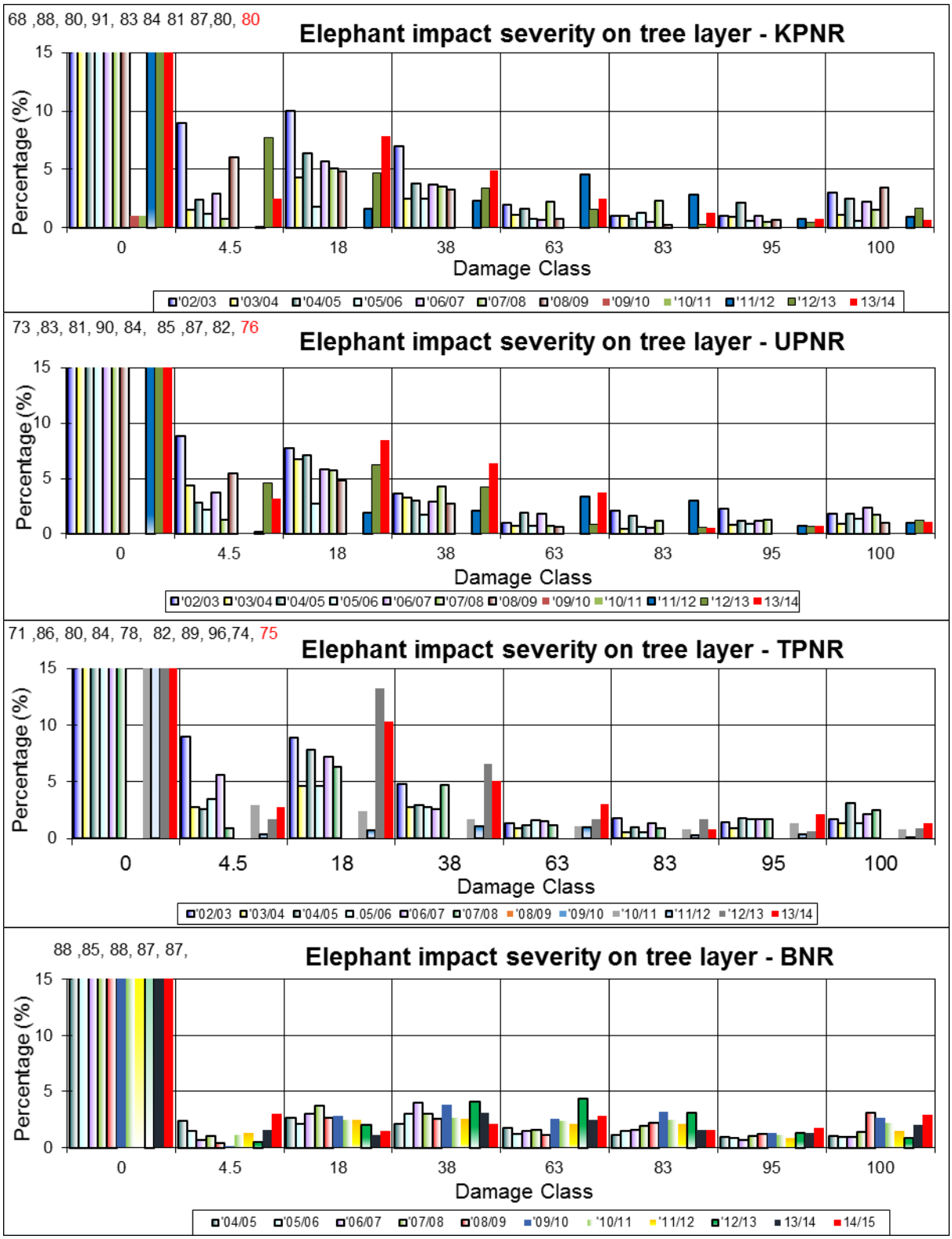

Figure 9 Severity of elephant impact on APNR reserves (KPNR, TPNR and BNR 2014).

Figure 10 Elephant impact by height class on APNR reserves (KPNR, TPNR and BNR 2014).

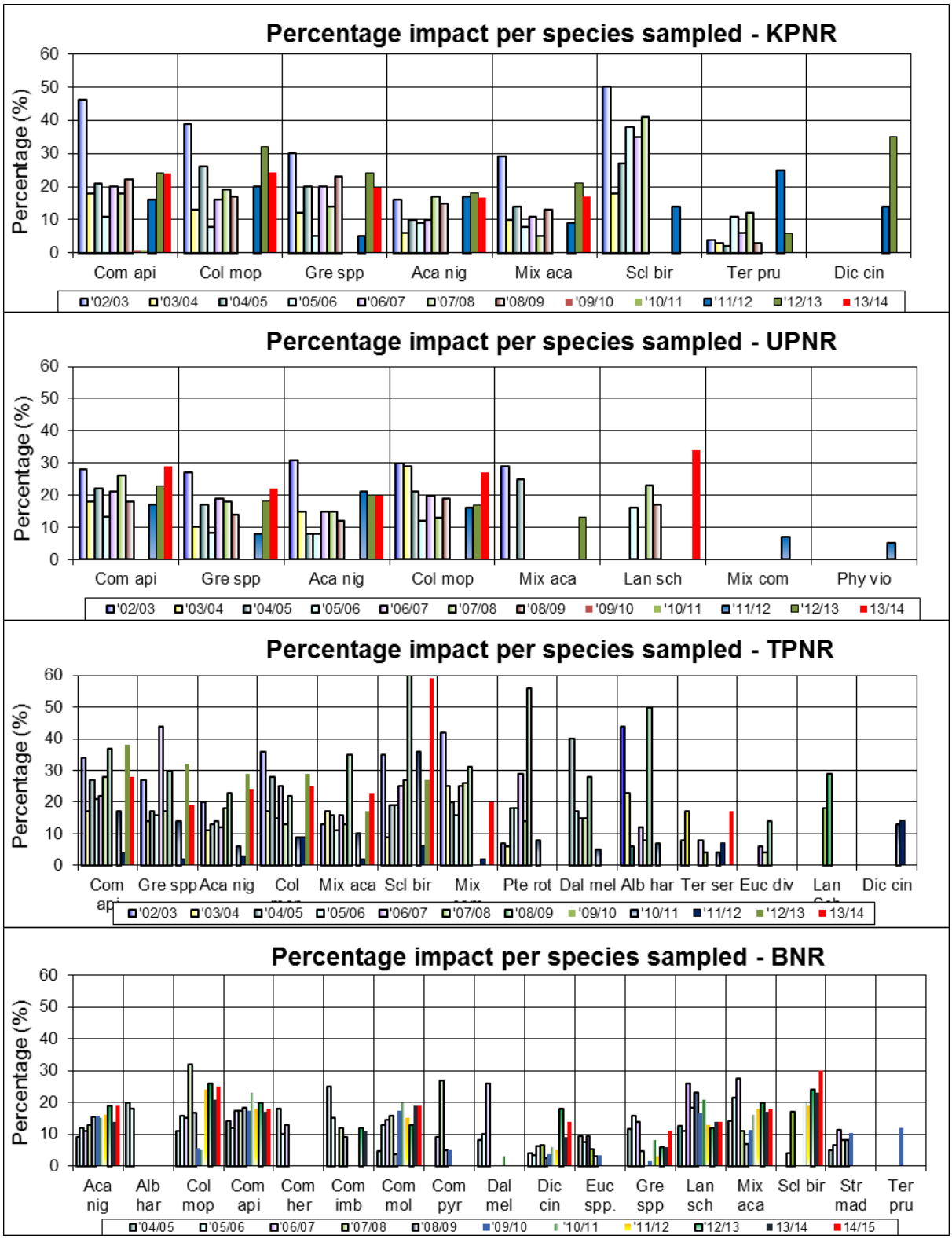

Figure 11 Percentage elephant impact per species sampled on APNR reserves (KPNR, TPNR and BNR 2014).

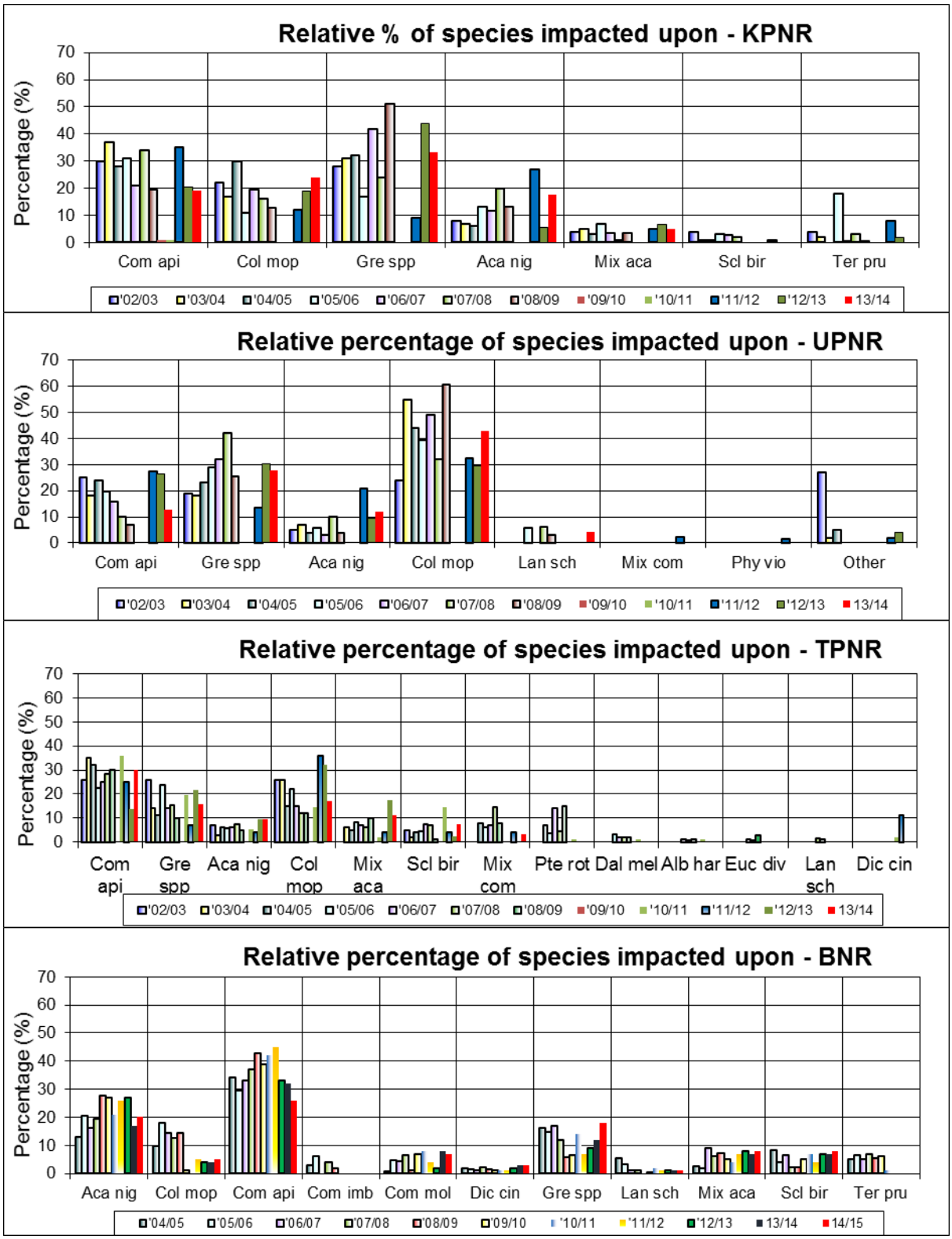

Figure 12 Relative percentage of species impacted upon on APNR reserves (KPNR, TPNR and BNR 2014).

THE ANIMAL COMPONENT

For the effective management of a game reserve, it is vital that the animals are counted on a regular basis. These estimates are critical for calculations relating to herbivore carrying/grazing capacity and stocking rate and the effect of their utilisation on the habitat. No form of wildlife management is possible without reliable information regarding herbivore numbers. Because different animals have different effects on the vegetation, it is important to determine the feeding class proportions on APNR. Appendix A presents the animal numbers from the 2015 count. Appendix C and D are included as they provide important discussion relating to the current drought that we are experiencing. Much of the discussion in this section is aimed at augmenting the information contained in **Appendix C** (drought report v8) in particular.

Due to the critical drought, Appendix C took precedence over this report hence the delay in this submission. Using the data collected during the annual ecological monitoring, the drought report was compiled and forwarded to the current Warden responsible for the APNR and the Chairman of the APNR. **After much discussion (we are at version 8) the report was forwarded to the authorities (MTPA and LEDET), SANParks (as neighbours) after which it will be sent to DEA who will decide on further circulation for ratification.**

The 2015 game count numbers were used to calculate stocking rates (Figure 13), feeding class ratios (Figure 14) and to examine herbivore trends (Figure 15) and projections. Numbers (2016) were projected as follows:

1. ‘16proj’ in Figure 13 = the 2015 count numbers plus the estimated natural increase; minus the proposed management/hunting removals (Appendix B); minus the adjusted offtakes due to the current drought (Table 4 Appendix C) but not including possible additional ‘emergency’ offtakes (Table 4 Appendix C) in the event of the situation deemed to be deteriorating sufficiently to warrant further management action (to be re-assessed at the end of May); re-introductions (0); and the calculated effect of predators (Table 7). The second series in Figure 13 presents these same calculations taking only the prey biomass into account (i.e. taking non-prey animals out of the calculation rhino, hippo and elephant -

showing what will be available to predators).

Table 7 Predator **estimates** for APNR were based on the following: (Colin Rowles, Craig Spencer, Mark Shaw and Almero Bosch *pers. comm.*):

Reserve / Species	KPNR	UPNR	TPNR	BNR
Lion	≈ 62 – previous call up 8♂, 29♀, ≈ 25 young	≈ 20 – estimate 8 ♂, 12 ♀	69 – 17 ad♂, 4 sa♂, 14ad♀, 15sa♀, 19 cubs	58 (previous reports 15♂, 22♀, 21 young)
Leopard	≈ 40	≈ 15 – estimate 4 ♂, 8 ♀, 3 cubs	50 - 13 ad♂, 5 sa♂, 24ad♀, 4sa♀, 4 cubs	≈ 8 – probably more ≈ 20
Cheetah	≈ 5	≈ 2 not all year	≈ 20 ?	≈ 12
Hyaena	≈ 50 previous call up 47	≈ 20 – shared with TPNR	≈ 40	≈ 26
Wild dog	≈ 12 – not present all year*	Uncertain	≈ 30 not present all year*	3 – Remainder of introduced pack?

NNB – These are estimates and are extremely difficult to determine without an in-depth study.

Peel, Kruger and Zacharias (2005) show that appropriate stocking rates, depending on veld condition and reserve location ranges between the Coe *et al.* (1976) upper guidelines of 3 100 kg km^{-2} and 4 000 kg km^{-2} and the agricultural guideline of 4 500 kg km^{-2} and 5 000 kg km^{-2}.

The stocking rate has increased steadily from the mid-late 1990's in the APNR and increased again in 2015. The stocking rate in the APNR remains well above the guideline (since around 2008) (Figure 13). In 2015 the stocking rate was: above the guideline for KPNR (above for 12/13 years – well above since 2008; above the guideline in the TPNR (above for 14/15 years – last 7/8 years well above the guideline; on the upper guideline in the UPNR (but largely below the guideline since 1996); well above the guideline in the BNR (10/12 years – largely due to high numbers of elephant, hippo and buffalo) (Figure 13). When we remove the rhino, hippo and elephant from the stocking rate calculations (essentially the non-prey species) we see that the **prey biomass**:

increased in the APNR in 2015 after increasing marginally year on year in since 2010 – the 2014 decline due to the fact that only the megaherbivores were counted in the BNR; increased in the KPNR (overall rising since 2010); increased in the TPNR; declined slightly in the UPNR (illustrating animal movement in and out of this relatively small reserve – see Appendix C relating to the drought); increased in the BNR to rates in line with 2013 (large decline in 2014 due to no count of species outside of buffalo as prey species). As previously stated, the fluctuation in stocking rate in the various reserves within the APNR is due to movement of, in particular large animals (elephant and buffalo). This is highlighted in the current drought where there has been an influx of animals from the KNP (little natural water and few artificial water points) to the many artificial water points in the APNR. **The latter highlights the need to look at the APNR holistically and in conjunction with the neighbouring KNP.**

Stocking densities throughout the APNR have generally been well above the guideline in recent years. As we come off a run of 'good' rainfall years, we have sensitized landowners to the possible effects of a dry/drought period. The question previously asked was "what if we have a poor season where the current relatively favourable situation switches quickly to one where we suffer food shortages and concomitant animal die-offs (particularly under heavy stocking densities)?" The strength of the APNR is that it is 'unfenced' and relatively large and animals are free to move to areas with better forage resources. Water dependent species (e.g. impala and wildebeest) are however generally sedentary and often don't move in response to diminishing resources (unlike species such as buffalo). So even though the APNR system is relatively large and 'open' (although this is not entirely true as there are still fences and people that restrict unlimited movement) drought will have an impact on the herbivore component. This is particularly relevant as discussed in the previous paragraph where the water situation between the APNR and KNP is completely unbalanced (see Appendix C and also Appendix D from the 2014 report).

Table 8. Comments on stocking rates 2015 in the APNR (see also Figure 13).

<table>
<tr><th>Comments</th><th>Comments (minus elephant)</th></tr>
<tr><td>APNR – Well above guideline
KPNR – Well above guideline
UPNR – At guideline
TPNR – Well above guideline
BNR – Well above guideline</td><td>The removal of these mega herbivores results in much altered stocking rates:
<table>
<tr><th>Reserve</th><th>Stocking rate with elephant (kgkm^{-2}) 2015</th><th>Stocking rate minus elephant (kgkm^{-2})</th></tr>
<tr><td>APNR*</td><td>10 274</td><td>4 377</td></tr>
<tr><td>KPNR</td><td>13 537</td><td>5 037</td></tr>
<tr><td>UPNR</td><td>4 493</td><td>1 401</td></tr>
<tr><td>TPNR</td><td>9 876</td><td>5 241</td></tr>
<tr><td>BNR*</td><td>10 151</td><td>4 311</td></tr>
</table>
The large decline after elephant removal in the proportion of feeding class 3 indicates the significant proportion of the biomass that elephant comprise. The ability of elephant (and impala) to both graze and browse makes them such successful competitors. Impala still perform an important ‘buffer’ role in the presence of predation. The low number of wildebeest highlights the latter statement and with the ‘boom and bust’ nature of warthog fluctuations, the situation in feeding class 2 is critical.</td></tr>
</table>

Table 9 Indicating skewed feeding class proportions in the APNR (also see Figure 14).

Comments – current situation					Comments (minus elephant)
Reserve	Feeding class 1	Feeding class 2	Feeding class 3	Feeding class 4	The removal of these mega herbivores results in much altered feeding class ratios:
KPNR	Below guideline	Critically low	Well above guideline	Well below guideline	
UPNR	Well below guideline	Critically low	Well above guideline	Well below guideline	
TPNR	Close to guideline	Critically low	Well above guideline	Well below guideline	
BNR*	Below guideline	Critically low	Well above guideline	Well below guideline	

Reserve	Feeding class ratios with elephant (%) 2014				Feeding class ratios minus elephant (%)			
Feeding class	1	2	3	4	1	2	3	4
APNR*	30	1	64	5	69	2	16	12
KPNR	25	1	69	5	67	2	18	14
UPNR	21	1	75	3	68	1	20	11
TPNR	41	1	53	5	76	3	12	9
BNR	27	1	66	6	63	2	20	15

The situation is not much changed since 2011 indicating high proportions of feeding class 3 due to high elephant numbers. The large decline in the proportion of feeding class 3 after removing elephant from the calculations removal indicates the significant proportion of the biomass that elephant comprise. See above table for additional comment. Feeding class 2 remains critically low throughout.

The actual number trends of the major animal species within the above feeding classes are presented in Figures 15 (a –d) with a combined figure for the APNR (discussed in Table 10).

Table 10 Brief discussion of animal trends in the APNR.

Species	Comment
Feeding Class 1 - Refer to Figure 15 (a)	
Buffalo **	There was an increase in the number of buffalo and similar to the 2013 high. Overall a steady general increase in the buffalo population since 1997 (the period under discussion) (Figure 15a-d). There was an increase in buffalo in the KPNR, a decline in the UPNR (movement in and out of a relatively small area), a sharp increase in the TPNR and a sharp increase in the BNR.
Zebra* **	The APNR population is similar to that of 2013 (note the injection of numbers with the inclusion of the BNR in 2005). In 2015 the numbers declined in the KPNR, increased in the UPNR, declined in the TPNR and similar to 2013 in BNR.
Waterbuck* **	Numbers increased markedly with the inclusion of the BNR (2005). The numbers in the APNR increased again in 2015 (due to large population in BNR which were not counted in 2014) but lower than the high of 2013. The numbers in the KPNR were stable, declined slightly in the TPNR, increased markedly in the UPNR and declined markedly from the 2013 levels in the BNR.
White rhino **	The white rhino population declined slightly but remained at high levels relative to the period under discussion (since 1997). There was a slight decline in the number counted in the KPNR, a marked decline in the UPNR, stable in the TPNR and similar numbers to those counted in 2013 in the BNR. The threat of poaching remains a grave concern.
Feeding Class 2 - Refer to Figure 15 (b)	
Wildebeest* **	The wildebeest population in the APNR exhibited a general decline prior to the inclusion of BNR. The inclusion of the BNR bolstered the population. There was an initial decline in the population in the year after BNR's inclusion but the trend in 2007 and 2008 was positive. The population stabilised in 2009 but this was followed by a continued decline in 2010 and 2011. There was a marked increase in the APNR population in 2015 to the highest levels since 2003. There was once again and a continued steady increase in numbers in the KPNR (4th year), markedly increase in the TPNR, stable but low numbers in the UPNR and a decline in the BNR population. **All efforts must be made to ensure that the wildebeest population remains viable**. In addition to predation, the contribution of habitat change to declines in species such as wildebeest should also be investigated.

Species	Comment
Warthog **	The warthog population declined when compared to 2013. This population will continue to exhibit fluctuations in response to wet (current - boom) and dry (bust) conditions". Count conditions also influence the warthog count. There was a decline in numbers in the KPNR, a marked decline in the TPNR, stable in the UPNR and a marked decline in the BNR when compared to 2013.
Feeding Class 3 - Refer to Figure 15 (c)	
Elephant **	The elephant population increased steeply to the highest number counted since 1998. There was an almost doubling of numbers in the KPNR, a stable UPNR population, a marked increase in the TPNR and a slight decline in the BNR.
Impala **	The impala population remained relatively stable when compared to high of 2013. The population declined slightly in the KPNR and UPNR, relatively stable in the TPNR a decline in the BNR when compared to 2013.
Feeding Class 4 - Refer to Figure 15 (d)	
Giraffe* **	The population increased markedly when compared to 2013. There was an increase in the number counted in the KPNR, stable in the UPNR, an increase in the TPNR and a steep decline in the BNR when compared to 2013. In addition to the lion – giraffe dynamic, the results highlight the fact that giraffe is a species that also moves over quite extensive areas.
Kudu* **	The APNR is in a healthy state with positive growth from 2010 to a new high in 2013. There was a slight decline in 2015 compared to 2013 but the numbers remain high. There was a decline in the KPNR population, stable in the UPNR, decline in the TPNR and a marked decline in the BNR compared to 2013. The overall healthy kudu numbers may be related to a thickening up of trees due to elevated CO_2 in the atmosphere. In addition to this there is some evidence that elephant may facilitate browsers by reducing the height of taller trees.
Black rhino **	19 black rhino were counted in the APNR.

*These populations tend to decline under increased predation to a point where they plunge to numbers that cannot be sustained (i.e. cannot produce enough to stop the population declines i.e. a predator pit). With the removal of fences, there has obviously been movement between the reserves and the KNP. This is very evident when one looks at the recent relatively stable game populations but with often wide fluctuation within the

APNR; ** See Appendix C for discussion around general increases in the APNR in 2015 (hinting at movement from the KNP).

The positive contribution of BNR in terms of animal numbers is evident from previous year's counts as this area experienced more intensive (predator) management in the past due to it being fenced. The challenge remains to manage the APNR in such a way that the animals can move in response to the mosaic of varying veld resources – this seems to be happening but not necessarily due to management. The management plan that has been accepted by DEAT (de Lange *pers. comm.* January 2010 and signed by the MEC of Mpumalanga in May of 2011 and recommended for approval by C. van Zyl of LEDET in July 2009*)* should contribute to this happening through an active management programme. Preliminary 'Thresholds of Potential Concern' are available and emphasise the importance of setting the limits of acceptable change. This is emphasised by the tenuous position of certain prey species on the one hand (see above) and high densities of mixed feeders (elephant and impala) on the other hand in the APNR. It is recommended that preliminary TPCs for herbivores on APNR are set on the basis of measurable criteria such as proportion of the total biomass a species constitutes, estimated rates of increase and survival, impact on other species, as well as an element of predator impact, calving percentage and survival and calving interval. Should a population move outside the limits of the TPC, the situation must be investigated and remedial action taken where practicable.

The following is included from the 2013 report as the dry 2014/15 is likely to have an effect on the herbivore populations in the APNR (**read Appendix C**). "The following is a discussion some thoughts I have relating to animal management and drought. Over the past few years we can see that the grass layer has not been limiting for grazers in general on APNR. Further I think that given the fact that buffalo move in large herds over extensive areas and are not sedentary around a single water point that they have a generally beneficial effect on the vegetation for, among others, the following reasons. High densities of large hooved animals:

- Break soil crusts by their hoof action allowing for a good soil surface to seed contact;

- Reduce the height of moribund grass, thus allowing sunlight to penetrate the shorter vigorous grass tufts while reducing the temperature of the soil and making it more suitable for rainfall infiltration; and
- Deposit concentrated amounts of dung and urine.

All of the above promotes seedling establishment, particularly in bare areas and promotes a healthy productive perennial sward of grasses. Closer plant spacing (increased density) with a better litter layer (organic matter) and stable soils results in less evaporation and more effective rainfall (infiltration) with lower soil temperatures, less rainfall runoff, silting up of streams etc. The presence of predators, in particular lions, causes the herd to bunch when chased thus intensifying the positive impacts outlined in points 1-3 above.

The fact that these large herds are mobile also means that they seldom 'camp' on a patch for a long period of time but are continually moving through different areas. Data relating to the movement of the buffalo (and other species) herds on APNR would be useful in supporting or refuting this statement – we have spatial data from the game counts but restricted temporally. This means that unlike selective water dependent grazers, buffalo will utilise an area and then move on thus reducing the chance of overgrazing. Overgrazing is something that occurs because of excessive artificially supplied surface water and the resulting high densities of water dependent species (e.g. impala). The one thing I must emphasise is that animal control may need to be considered where water point provision has resulted in increased animal numbers due to their increased distribution throughout a reserve and resulting insufficient forage for animals during dry periods (obviously critical in fenced situations and under the current drought conditions). The alternative is that the population is allowed to fluctuate with the prevailing conditions, i.e. a die-off in drought (weaker animals). The tricky issue if the latter option is pursued is the effect on the resources resulting from such a 'laisse-faire' approach. Ultimately some debate would need to be entered into in this regard to gauge the feeling of the land owner in consultation with the managers/ecologist working on the reserve.

The fact that, due to fencing, there is no longer movement to the higher rainfall areas

and more reliable forage resources in the west near the mountains means that there will be losses in drought years. These population declines would vary from minimal to steep but may be viewed part of a longer term cycle (unlike warthog that follow a boom and bust cycle over short time periods due to their selective feeding behaviour). Droughts are also times when lions feast on weakened buffalo herds. Ultimately an important decision to be taken is whether or not we are prepared to allow drought related mortality to occur and whether the cost to the veld would be acceptable if numbers are allowed to increase unchecked?

I would welcome discussion using the energy flow model (see below) that yields the number of animals required to minimise grazing stress. In addition to the fact that the system is open to the KNP, the influence of favourable rainfall years on vegetation cover has obvious implications for, among others: fire, herbivore dynamics and interactions, predator-prey relations, counting conditions and ultimately game numbers. In addition to the data collected by management, much information exists within the current landowner and lodge structure. I would be willing to assist in the collation and presentation of any such data collected within the APNR. To this end we at ARC-API continue to enjoy the collaboration on ecological issues between the various wardens, researchers and landowners in the area." See Appendix C for a detailed discussion in this regard.

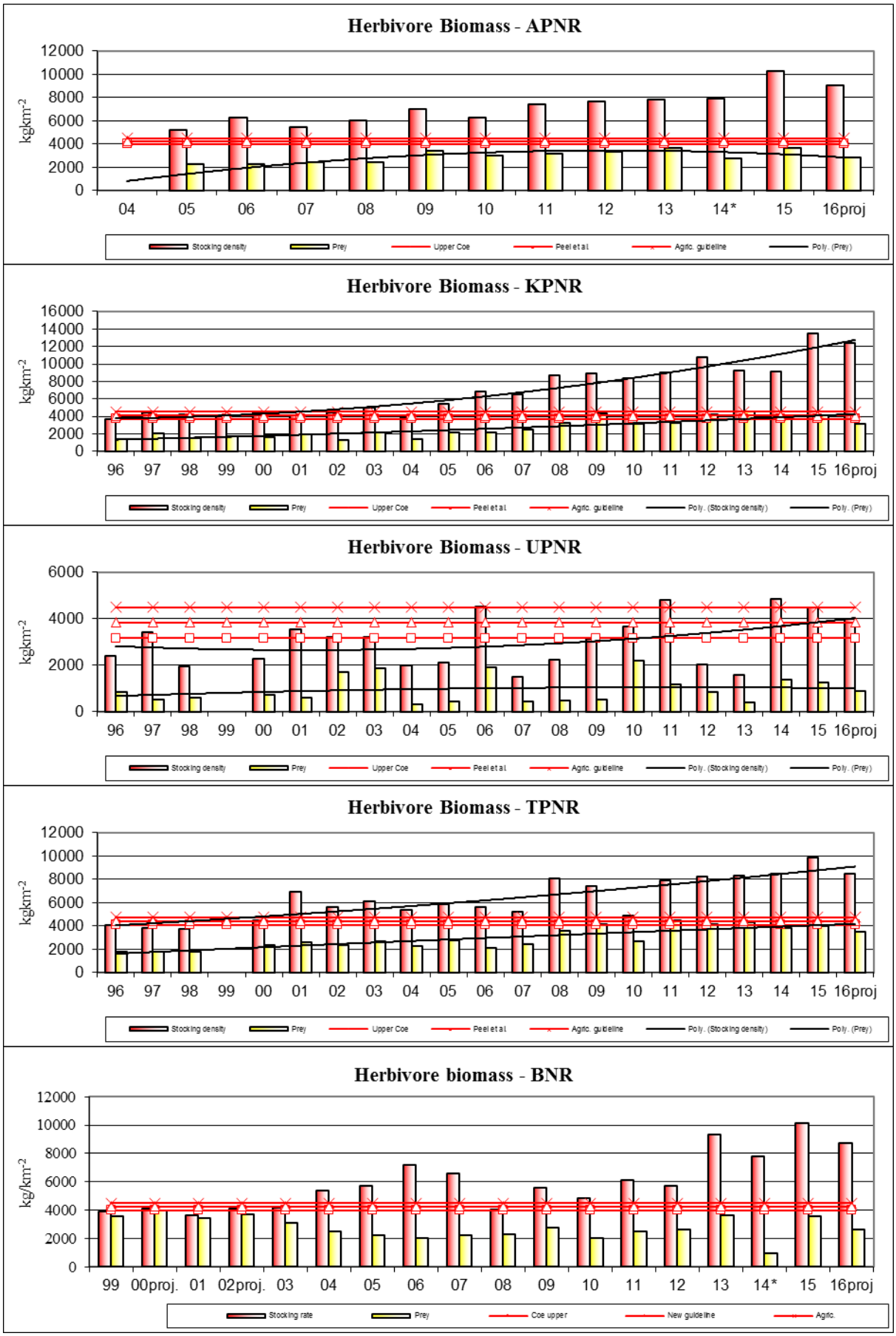

Figure 13 Animal biomass (kg km^{-2}) in the APNR (*2014 only megaherbivores counted in BNR).

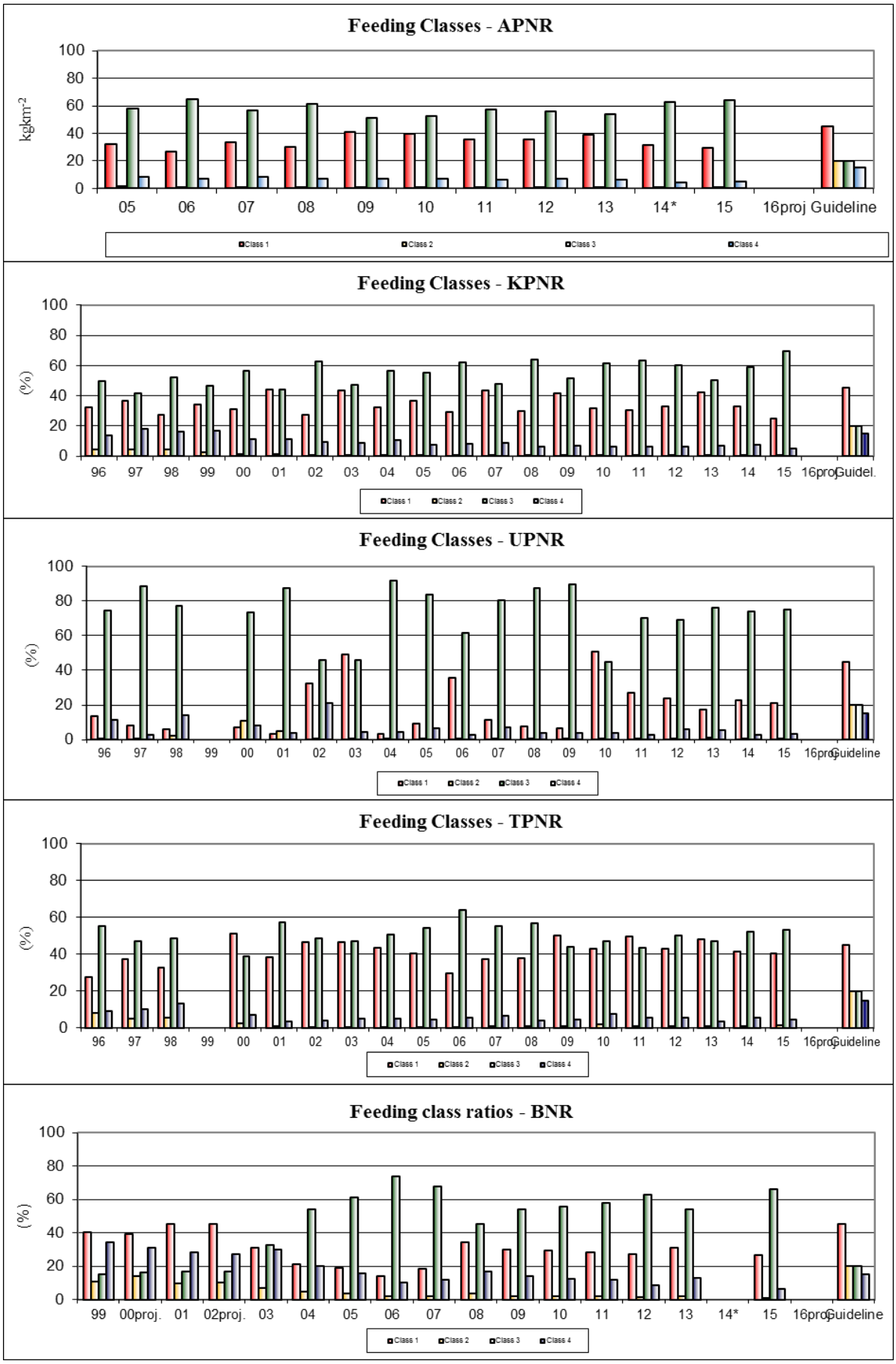

Figure 14 Feeding class ratios in the APNR (*2014 only megaherbivores counted in BNR).

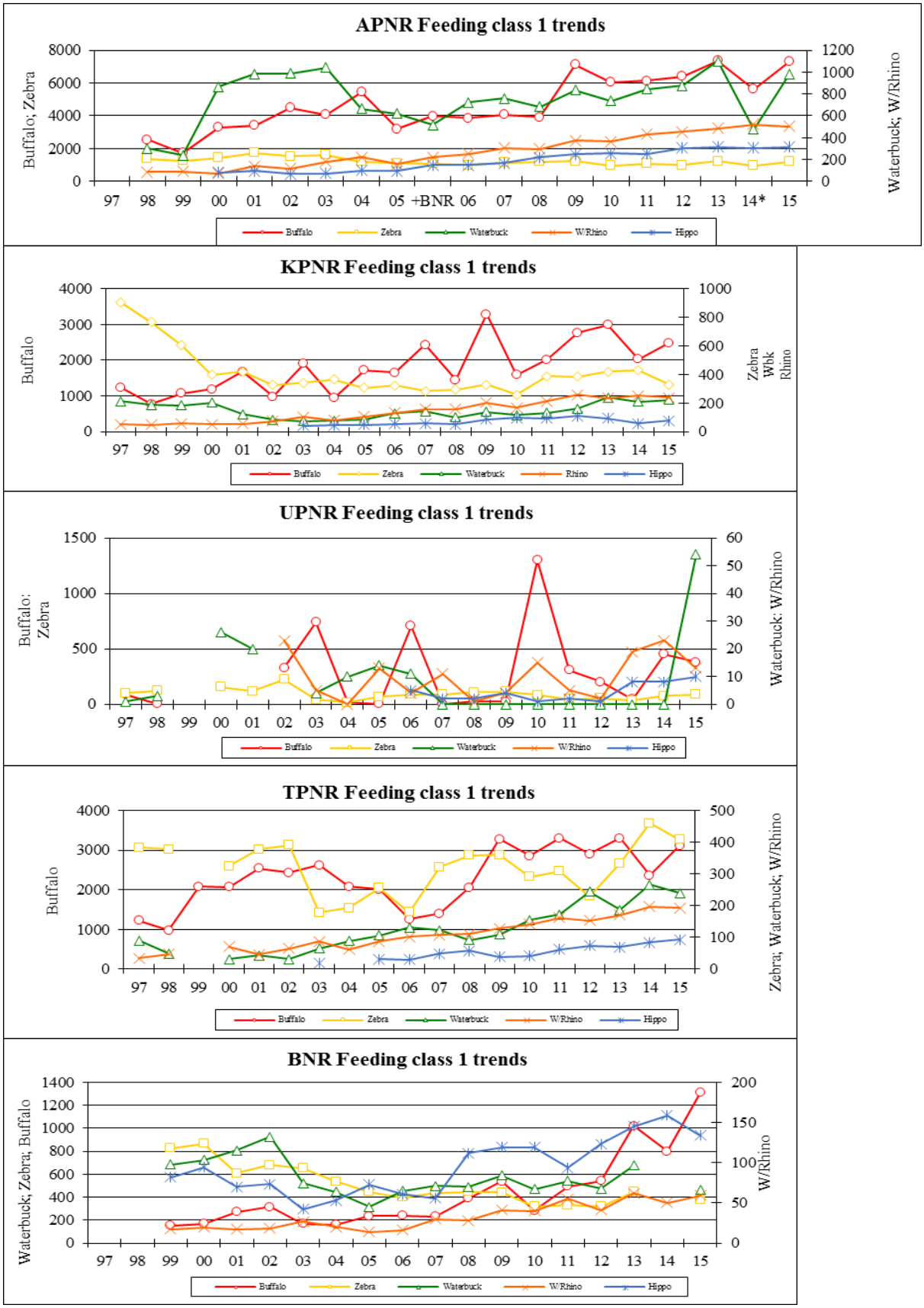

Figure 15a Large herbivore trends in the APNR (feeding class 1) *For 2014 only species that were also counted in the BNR count.

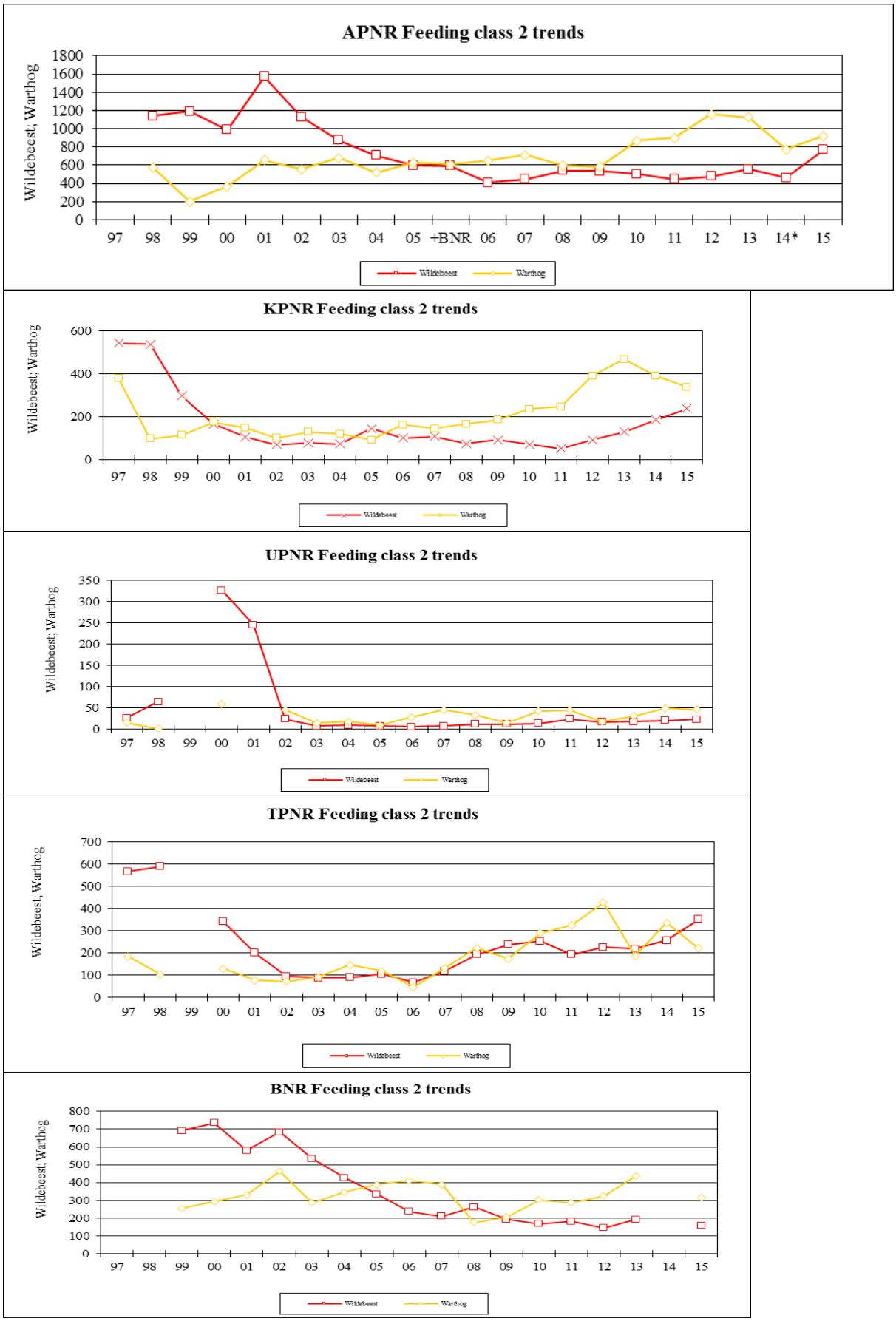

Figure 15b Large herbivore trends in the APNR (feeding classes 2) *For 2014 only species that were also counted in the BNR count.

Figure 15c Large herbivore trends in the APNR (feeding class 3) *For 2014 only species that were also counted in the BNR count.

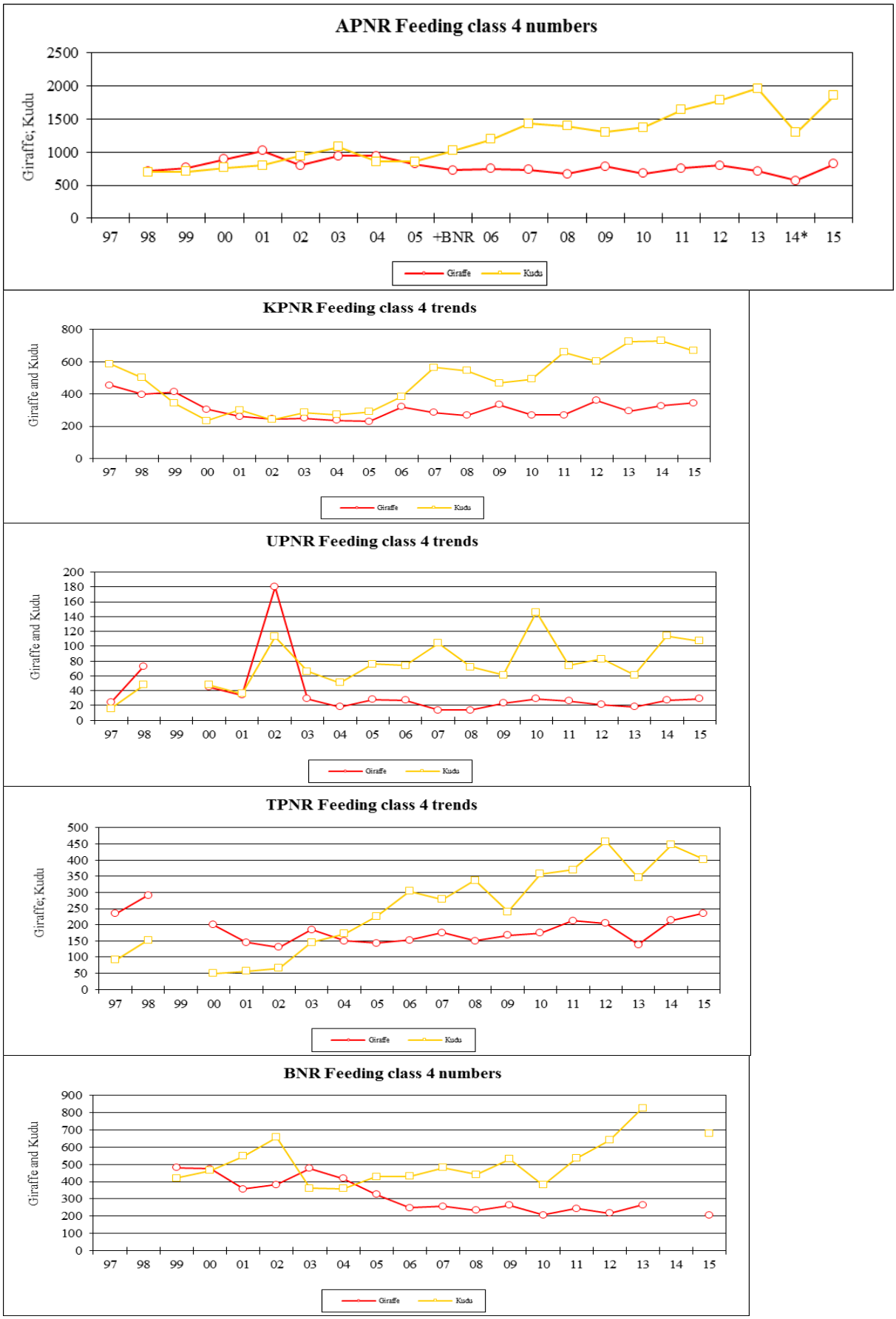

Figure 15d Large herbivore trends in the APNR (feeding classes 4) *For 2014 only species that were also counted in the BNR count

Energy flows and sustainability in the APNR

We examined the effect of resource use by grazers by inserting the resource requirements for wildebeest, warthog, impala, waterbuck, zebra, buffalo, hippo, rhino and elephant. I investigated whether the individual populations were able to stabilise their own 'population metabolism' using flows of endosomatic energy (food and work) (Peel 2005). The average energy demand of the different species was obtained from which an estimate of the activity patterns as they affect the feeding requirements of the various species. The approach is looked at in terms of useful energy flows into a system minus a certain fraction that is reduced by internal overheads (e.g. consumption used to maintain the population) and external overheads (e.g. predation that reduces the population). Where an indicator of environmental loading (EL), the biophysical cost of the diet, is introduced. The EL relates to the metabolisable energy of the forage (ME = 10.5 $MJkg^{-1}$ dry matter - Lombaard 1966) and the total amount of forage (from field data collection in this study). The latter takes into account the proportion of the forage that is available to the animals. Estimates vary from 22% to 49% in the broad-leaved savannas to between 15% and 80% in fine-leaved savannas (in highly nutritious systems). As discussed with management during 2015, using this method, Figure 16 shows that the resource was not limiting for the grazing species in the KPNR, UPNR and TPNR. There was insufficient forage in the BNR. Note that once the grass layer is depleted (resulting in an energy deficiency for grazers), mixed feeders (elephant and impala) will switch to the woody (browse) component thus increasing the impact on this layer. Early season measurements for 2016 indicate that, given the projected numbers (as discussed above under 'proj 16') there will be insufficient energy in the KPNR and BNR and sufficient (albeit marginal) for UPNR and TPNR in that order. See Appendix C for updated data in this regard and the need for urgent management action.

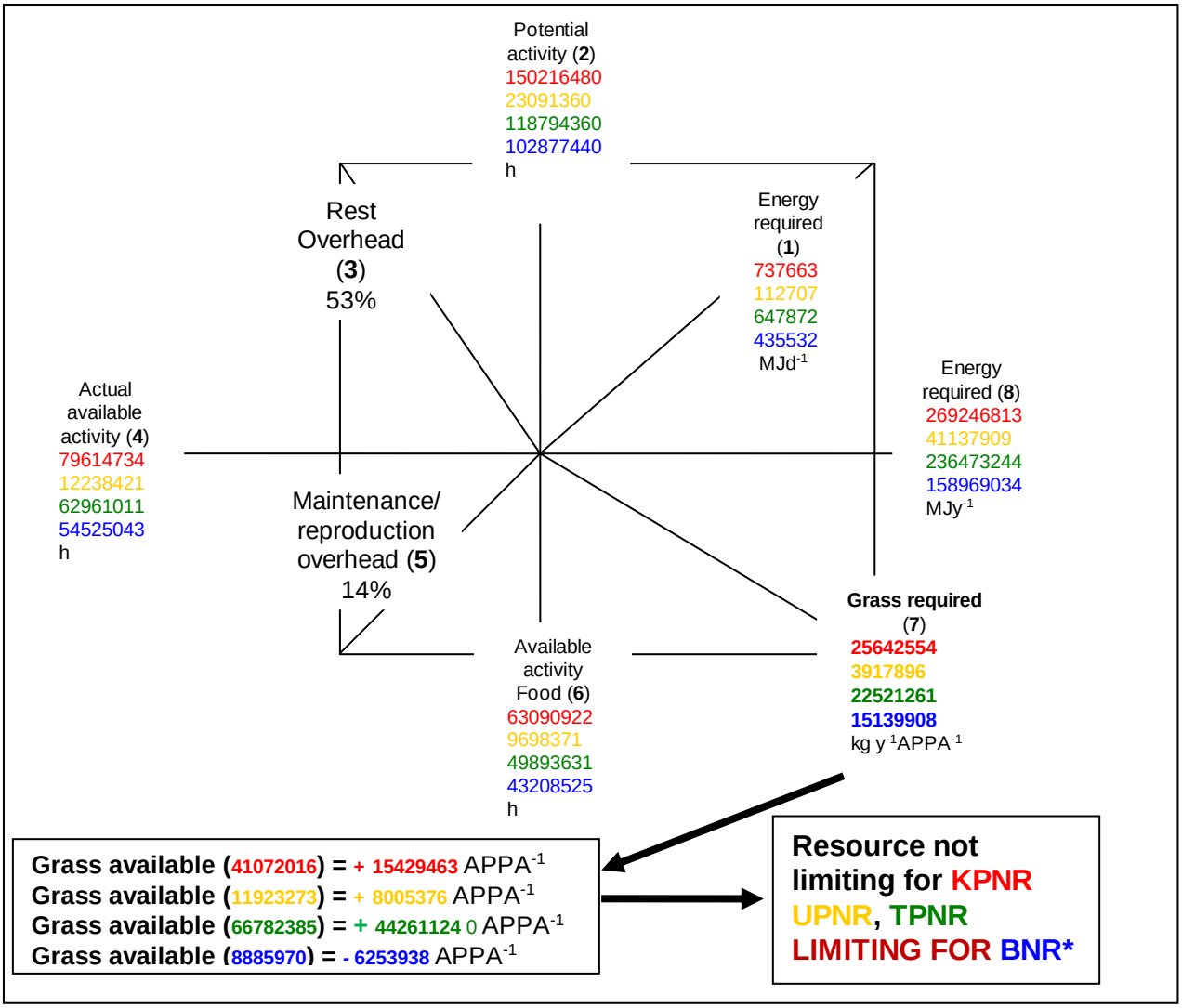

Figure 16 Resource availability in a multi-species grazing system – APNR 2015 (KPNR- red; UPNR- gold; TPNR- green and BNR- blue).

An amount of 1 % of the total value (not hunting) of the animals present on a reserve is considered reasonable when deciding on doing a game count (ABSA 2003). Game values were obtained from various sources including wardens from the area. I assume 1% for the vegetation and faecal analysis-monitoring programme (not including the cost of land, infrastructure etc.). Table 11 summarises the situation for the APNR reserves based on the 2015 game count and only including megaherbivores for BNR:

Table 11: APNR estimate of costs as a proportion of the value of animals present.

Species	Total Value (R)	(1) Total cost of vegetation monitoring and faecal analysis per annum (Exc. Vat) (R)	(2) Total cost of helicopter count @ say R6 500 per hour (Exc. Vat) – say 75h (R)
Black rhino	9975000	≈140 150	487 500
Buffalo	27341250		
Bushbuck	1056000		
Duiker - Grey	1359000		
Elephant	20790000		
Giraffe	10404000		
Hippo	12010500		
Impala	56950892		
Kudu	12457253		
Nyala	1247326		
Warthog	255712		
Waterbuck	4245554		
White rhino	139333892		
Blue wildebeest	2999100		
Zebra	4178940		
Crocodile	1666500		
Steenbok	2163429		
Ostrich	17268		
	308451615		
Cost of ecological monitoring (1) and (2) as percentage of value of game (%)		(1) 0.05	(2) 0.16
Cost of ecological monitoring as percentage of value of game (%)		0.21	
Recommended percentage (%)		2.0	

* - Estimate of what the reserve would currently receive per animal – from managers in the area; **- Mean of estimated male and female costs.

The above indicates that the cost of the various ecological monitoring exercises is well within the guideline for the APNR reserves.

FAECAL ANALYSIS

A total of 17 reserves have extended their ecological monitoring programme to include looking at animal condition as an adjunct to the ARC-API veld-monitoring programme. Dr Rina Grant, Research Co-ordinator for the Northern Plains Project in the Kruger National Park, is collaborating with us on this project.

Protein is the most common nutrient that limits animal performance and survival. Faecal protein, measured as faecal Nitrogen (N), gives an idea of what the animal is able to select. The measurement is correlated with forage digestibility, dietary protein, phosphorous concentration and weight change. Phosphorous (P) is commonly limiting during dry periods in particular. P is important in energy storage and as a part building block of bones and teeth (it is also thus important in lactation). P deficiencies generally lead to reduced reproduction rates. The higher the protein and phosphorous concentrations and digestibility the greater the palatability of the plants. Environmental conditions affect N and P concentrations and rainfall in particular is correlated to their availability.

The paper by Grant, Peel, Zambatis & van Ryssen 2000 (reference given under **REFERENCES**) is available on request.

RESULTS AND DISCUSSION

Faecal samples have been received from the BNR for a number of years and we received samples from Olifants West (BNR) and UPNR in the winter of 2015. The results of analyses are presented in Figure 17.

Results show that the N levels for grazers are generally lower than those for mixed feeders and browsers thus supporting the premise that in these savanna systems the grass layer is the limiting layer. This is illustrated by the results obtained in the current drought conditions. The results for N levels for Olifants West for 2015 indicate the following relative to the guideline for: buffalo – at guideline; zebra - below; impala – above; elephant – well below; giraffe - well above. The results for UPNR for 2015 indicate the following relative to the guideline for: buffalo – below; wildebeest – well

below; impala – above; giraffe – well above; kudu – well below.

The results for P levels for Olifants West for 2015 indicate the following relative to the guideline for: buffalo – below; zebra – well below; impala – guideline; elephant – well below; giraffe - guideline. The results for UPNR for 2015 indicate the following relative to the guideline for: buffalo – below; wildebeest – below; impala – guideline; giraffe – above; kudu – below. P levels were generally low in the APNR in 2015 (see implications given above)

I would encourage pooled samples as this gives us an idea of the situation within the population and not just a single animal. Data are also largely discontinuous and therefore of limited value and I encourage the various reserves within the APNR to make use of this valuable animal based system indicator.

Consistent data collection and the pooling of greater numbers of animals per sample (and including a spectrum of sex and age classes) will allow us to monitor N and P levels in relation to threshold's that may indicate a dietary deficiency (N) or P deficiencies that may lead to low reproductive rates. As previously requested sex and age data, lambing/calving rates and survival/mortality (related to sex and age) could prove to be an important adjunct to the faecal analysis and by extension the ecological monitoring programme as a whole (Appendix E).

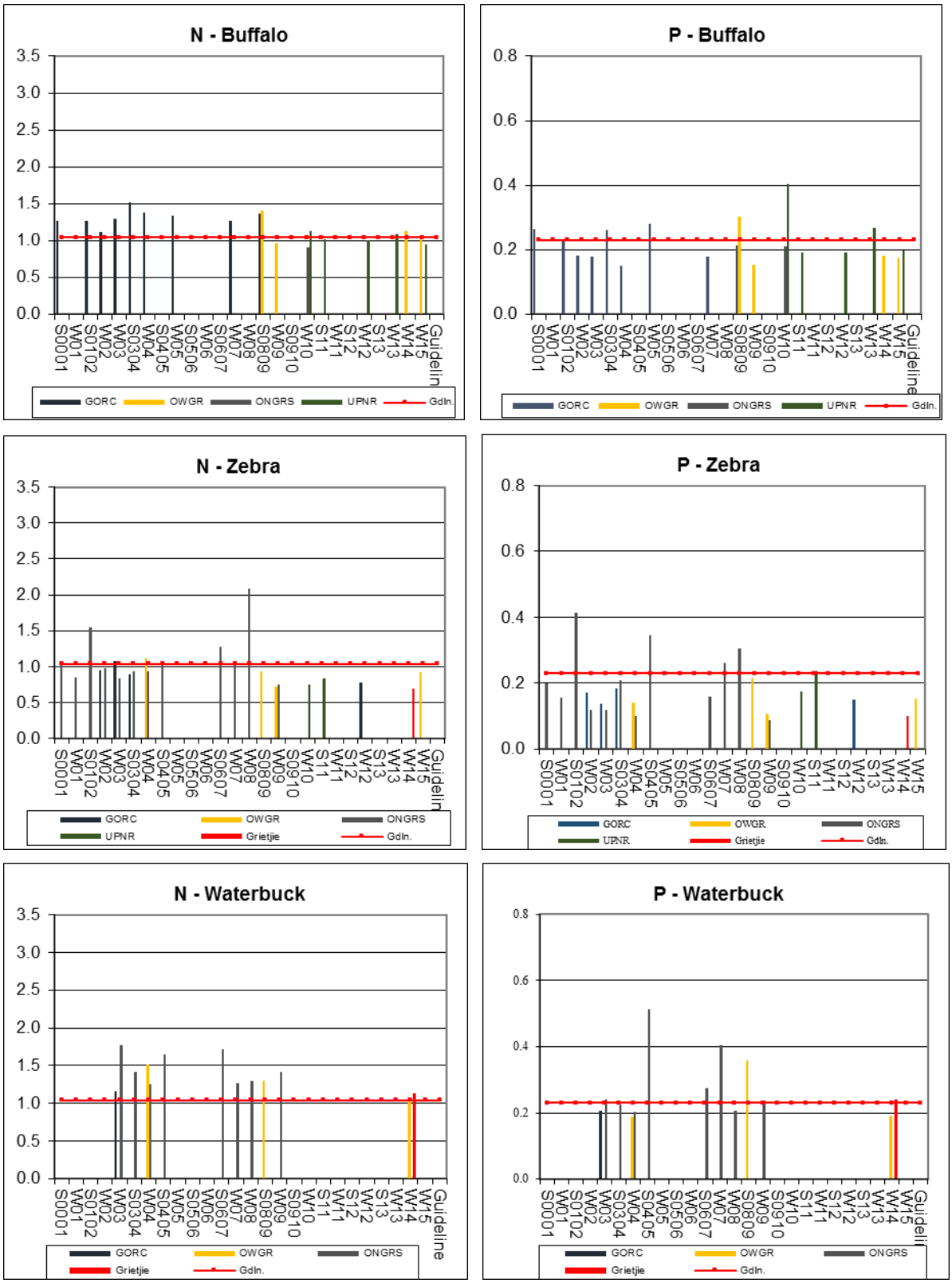

Figure 17 N and P trends in some herbivores on APNR where: S = Summer collection and W = Winter collection

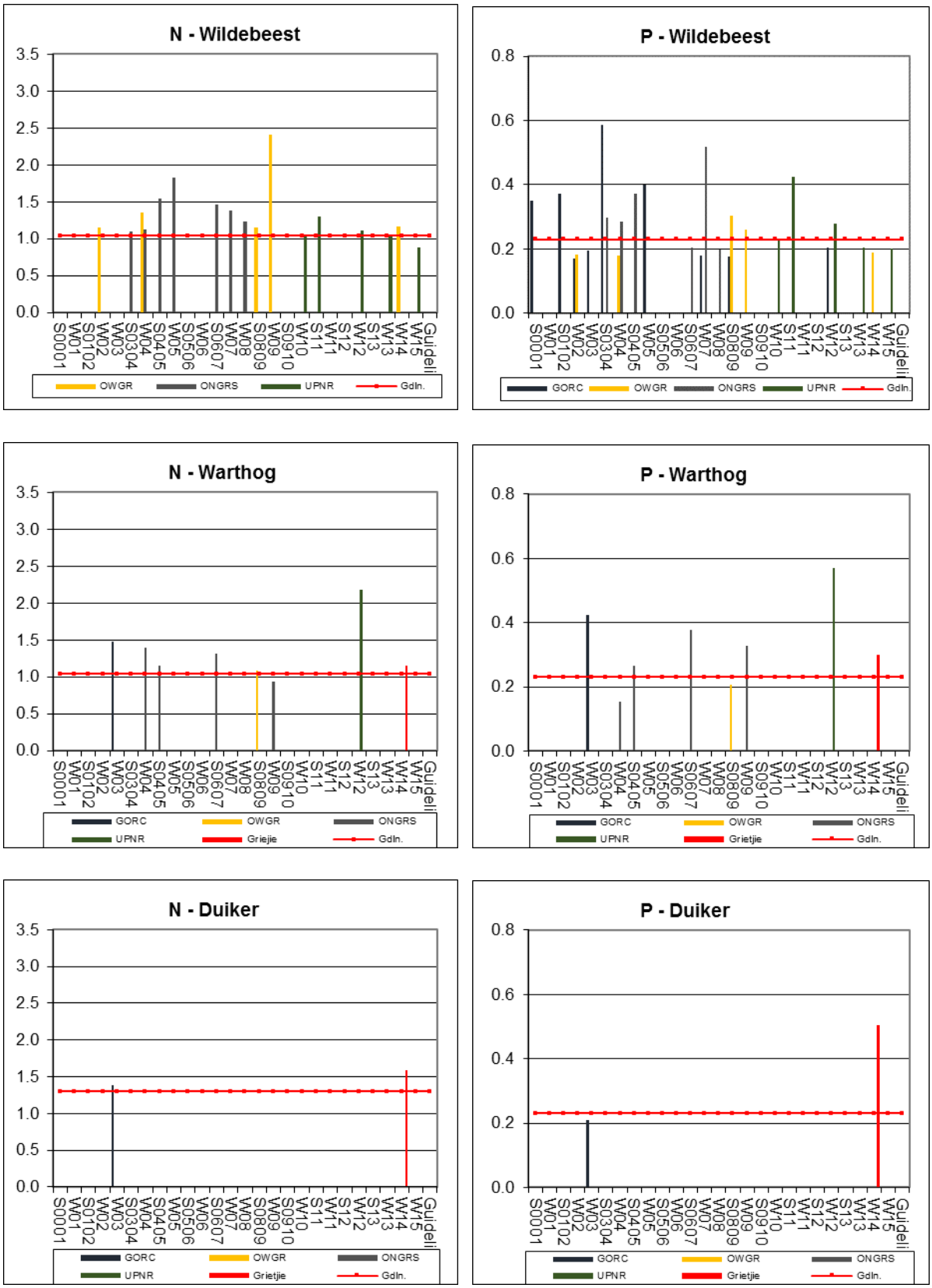

Figure 17 (cont'd) N and P trends in some herbivores on APNR where: S = Summer collection and W = Winter collection.

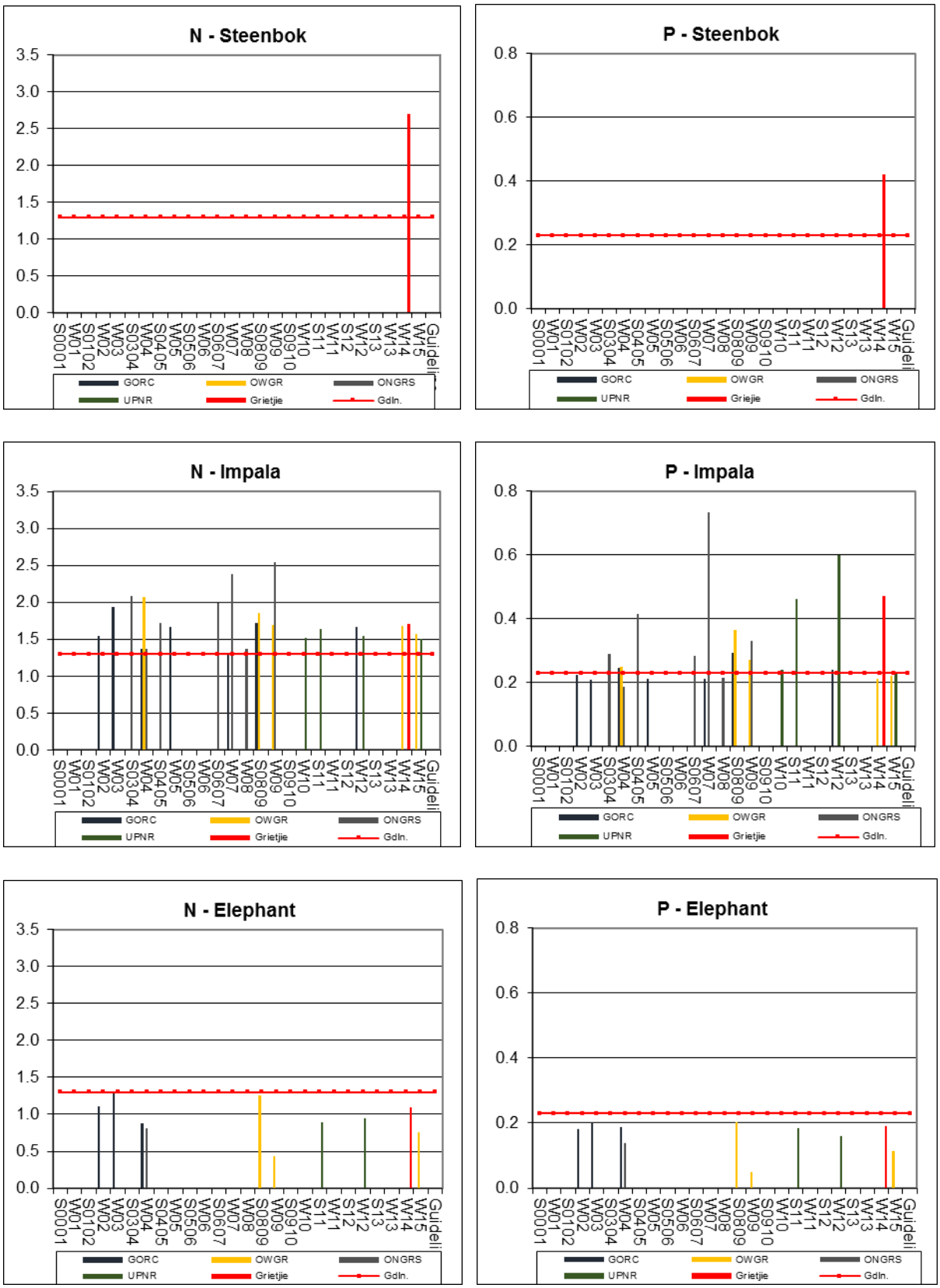

Figure 17 (cont'd) N and P trends in some herbivores on APNR where: S = Summer collection and W = Winter collection.

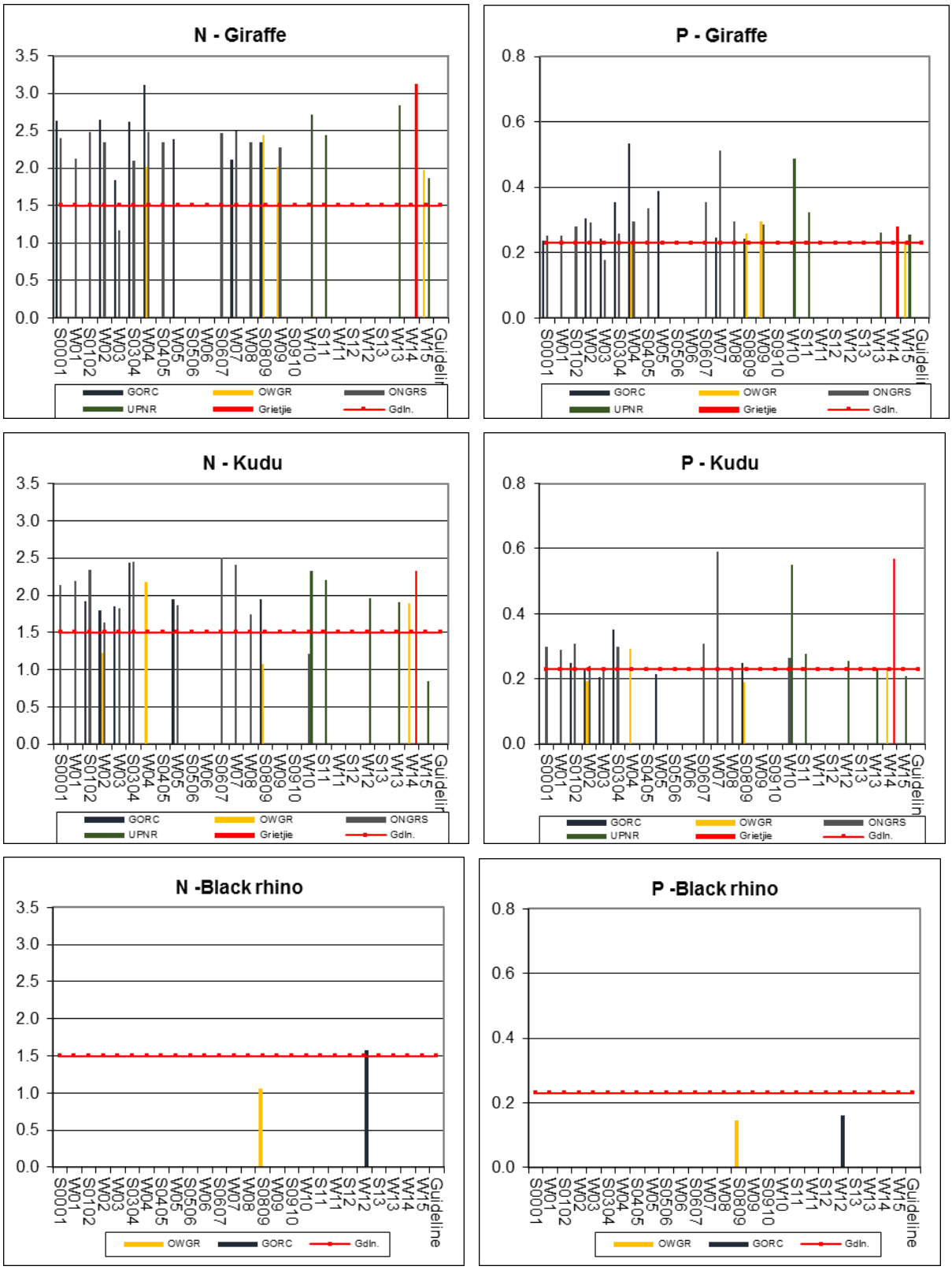

Figure 17 (cont'd) N and P trends in some herbivores on APNR where: S = Summer collection and W = Winter collection.

The APNR is in an excellent position in terms of information available for the management of herbivores and, where reliable trends are sought, the value of regular consistent counting methods and teams cannot be overemphasised. The importance of the ecological monitoring programme is apparent, as any change in management actions will interact with climatic conditions to influence the vegetation component.

Overall, the monitoring programme has received excellent support from all members within the APNR. We have a database from which sound management decisions can be made, where hazards can be avoided and opportunities grasped to the benefit of the properties. I thank all concerned for the keen interest shown in this project and would like to restate that I am available to discuss the ecological monitoring programme with you at any time.

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Appendix A

Numbers of larger animals obtained from the 2015 helicopter count – APNR (excluding Kempiana – red text indicates that Balule did not count these species). In 2014 BNR counted with a different helicopter and team and only rhino, elephant, hippo and buffalo were counted in that reserve. The 2013 figures for BNR for the species not counted are included in brackets below the APNR totals for 2014 to provide some context of trend. *2010 top Brits figure, bottom count number; 2011 buffalo and elephant counts APNR used.

Species	Total								
	2007	2008	2009	2010*	2011	2012	2013	2014	2015
Black rhino				- 3	8	11	17	4	19
Blue wildebeest	443	539	532	504 504	447	477	556	460 (193)	769
Buffalo	4 067	3 912	7 121	6 036 4 661	6 123	6 411	7 358	5 633	7 291
Bushbuck	120	53	63	- 52	74	76	85	33 (52)	136
Elephant	1 178	1 566	1 388	1 254 1 226	1 651	1 666	1 634	2 100	2 772
Giraffe	732	666	786	679 681	752	800	713	568 (254)	816
Hippo	165	222	247	256 259	251	306	314	308	314
Impala	20 697	22 745	24 851	24 667 24 692	26 904	29 441	30 626	22 491 (8 718)	30 289
Kudu	1 428	1 396	1 300	1 375 1 365	1 640	1 783	1 960	1 291 (828)	1 855
Nyala	73	42	63	23 62	52	112	98	56 (39)	107
Warthog	709	596	579	868 863	901	1 159	1 122	774 (437)	919
Waterbuck	760	681	837	736 739	846	877	1 099	476 (675)	977
White rhino	306	295	375	363 359	433	452	486	521	503
Zebra	1 131	1 207	1 242	953 953	1 076	985	1 233	961 (448)	1 205

Appendix B

Correspondence relating to the hunting quota for the APNR for 2016.

ARC-ANIMAL PRODUCTION INSTITUTE

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Tel: (013) 753 7147 *Fax:* (013) 753 7039 *(Int:* +2712)

E-Mail: mikep@arc.agric.za *Web site: www.arc.agric.za*

Enquiries / Navrae

Ref..no / Verw. nr

Removals 2016

11/11/15

Dear Colin

GAME REMOVALS 2016: APNR

Our meeting of 14 October 2015 and your correspondence of 2 November 2015 (included as table and figures in Appendix A below) refers. The 2015 game count numbers are used to calculate stocking rates, feeding class ratios and to examine herbivore trends with a view to determining sustainable offtakes for the various reserves within the APNR while also taking into account the current state of the rangelands. Note the following:

2. I am making my comments on the proposed management/hunting removals based on the 2015 count;
3. My annual report will contain projections forward and take the possible effect of predators into account where possible (I await estimates from the various reserves);

4. As stated in my correspondence in regard to demographic studies within the APNR the following. The reserves comprising the APNR are taking steps to collect demographic data to ensure that offtakes within the elephant and buffalo populations in particular are sustainable (APNR Wardens *pers. comm*.). In this regard I commend the actions that all concerned put into the protocols;
5. The taking of minutes at the meeting is critical as it allows anyone who has queries to go through the discussion and processes that were followed regarding the final offtake decisions.

In addition to the fact that the system is 'open', the influence of favourable/drought rainfall years on the vegetation has implications for, among others: fire, herbivore dynamics and interactions, predator-prey relations, counting conditions and ultimately game numbers. In addition to the data collected by management, much information exists within the current landowner and lodge structure (e.g. predation data, sex and age elephants).

The APNR summary (attached below) is again a well-considered document. I have looked at the offtake proposals and largely support them with some discussion included. As stated last year I agree that large scale (possible) removal of impala be done for ecological and economic reasons. In addition to this and in the light of the current drought I propose that consideration be given to removing some buffalo as there is likely to be a die off in this population. This will not only save some grazing but is an opportunity to utilise this species. On the other hand it may be that this is a time when the lion population benefits from a weakened buffalo population. The question as to why not other species as well is that most to the other 'prey' herbivores are relatively finely balanced with the predator, in particular the lion, population. See further comments in the table below.

I continue to enjoy the collaboration on ecological issues between the various wardens, researchers and staff of the management authorities in the area. Please do not hesitate to contact me in this regard.

Yours Sincerely

(DR. MIKE PEEL: Pr.Sci.Nat; M.G.S.S.A.)

SPECIALIST SCIENTIST RANGELAND ECOLOGY

Count totals for the APNR Reserves for 2015.

Species:	KPNR	TPNR	UPNR	BPNR	APNR
Buffalo	2 488	3 113	380	1 310	7 291
Elephant	1 255	660	219	638	2 772
Hippo	77	93	10	134	314
White Rhino	238	193	13	59	503
Giraffe	345	236	29	206	816
Impala	11 912	8 283	1 805	8 289	30 289
Kudu	668	402	107	678	1 855
Waterbuck	221	240	54	462	977
Blue Wildebeest	239	351	22	157	769
Zebra	330	408	87	380	1 205
Warthog	338	220	46	315	919

Proposed Total APNR off-takes for 2016/17.

Species	Count APNR	Offtake Proposal Total and as a % of reserve total (in columns) (✓- acceptable; ✓ - but requires further study/extenuating circumstances; x - high)				% of APNR population (✓; ✓; x)	Comments
Buffalo	**7 291**	KPNR	TPNR	UPNR	BNR		Acceptable overall (<2% commercial ♂ and <3% ♀). Requires data from the demographic studies. TPNR and BNR have begun this process in an effort to determine the sustainability of current offtake rates. Consideration should be given to removal related to the drought notwithstanding the fact that lions in particular target weak buffalo during dry periods and may take pressure of vulnerable prey species such as wildebeest, giraffe and zebra etc.
Trophy bulls >40"		4 – 0.16✓	6 – 0.19✓	0	4 – 0.31✓	0.19✓	
Classic bulls 38"		12 - 0.48✓	21 - 0.67✓	3 - 0.79✓	13 – 0.99✓	0.67✓	
Dagga Bull 37"		21 - 0.84✓	5 - 0.16✓	0	0	0.36✓	
Management Bulls 35" commercial		10 - 0.2✓	5 - 0.16✓	**15 – 3.95✓**	20 – 1.53✓	0.62✓	
Management Bulls 35"		5 - 0.2✓	0	5 – 1.32✓	0	0.14✓	
Cows Commercial		10 - 0.4✓	5 - 0.16✓	0	17 – 1.3✓	0.44✓	
Cows		30 – 1.21✓	12 - 0.39✓	0	0	0.58 ✓	
Total offtake	**223**	92 – 3.5✓	54 – 1.73✓	23 – 6.1✓	54 – 4.1✓	2.99✓	
Elephant	**2 772**	KPNR	TPNR	UPNR	BNR		A guideline to maximum percent of the total for sport hunted elephant is 0.75 - 1% which is exceeded if we look at the first two rows (left). However this is a guideline that requires verification in our area and may require data collection as per the buffalo demographics study. Of the reserves that bulls make up more than the guideline the following: Bulls make up 13% of TPNR, 31% of UPNR and 62% of BNR population. In addition to this the slightly high offtake can be justified due to the current drought.
30 lbs		5 - 0.4✓	7 - **1.06✓**	2 – **0.91✓**	10 - 1.57✓	0.8✓	
40 lbs		1 – 0.08✓	4 – 0.61✓	4 – **1.83✓**	0	0.3✓	
Total offtake	**33**	6 - 0.48✓	11 - **1.67✓**	6 – **2.74✓**	10 – **1.57✓**	**1.2✓**	
White Rhino	**503**	KPNR	TPNR	UPNR	BNR		The largely conservation directed effort in this regard to white rhino removals is supported. The hunting request is ecologically acceptable.
Commercial hunt bulls			1 - 0.52✓			0.20✓	
Live sales			**18 – 9.33✓**	**1 – 1.69✓**		3.78✓	
Total offtake	**20**		19✓	1✓		3.98✓	
Hippo	**314**	KPNR	TPNR	UPNR	BNR		
Hippo bulls commercial hunt		0	2 - 2.15✓	0	1 – 0.75✓	0.96✓	Acceptable
Total offtake	**3**						

Species	Count APNR	Offtake Proposal Total and as a % of reserve total (in columns) (✓- acceptable; ✓ - but requires further study/extenuating circumstances; x - high)				% of APNR population (✓; ✓; x)	Comments
Impala	**30 289**	KPNR	TPNR	UPNR	BNR		
Landowner consumptive and culling		1500 - 12.6✓	1700 - 20.5✓	450 – 24.9✓	998 – 12.04✓	15.35✓	Acceptable. The percentage removal compared to last year is down. We are in a drought and I believe that if necessary more removals can be considered. Impala are water dependent non-mobile species and can exact heavy losses to rangelands. This does not ignore their function as a buffer to vulnerable species such as giraffe, wildebeest and zebra etc. on the other hand it is probable that lion will turn to the weakened buffalo population.
Total offtake	**4 648**	✓	✓	✓	✓	✓	
Waterbuck	**977**	KPNR	TPNR	UPNR	BNR		
Trophy bull commercial hunt		0	1 - 0.42✓	0	8 – 1.73✓	0.92✓	Acceptable. Balule is a traditional stronghold for waterbuck. A demographic study of waterbuck would be useful to assess the sustainability of the requested trophy animals in the future.
Total offtake	**9**						
Kudu	**1 855**	KPNR	TPNR	UPNR	BNR		
Kudu commercial		1 - 0.25✓			6 - 0.88✓	0.38✓	Acceptable.
Landowner		4 - 0.6✓			15 – 2.21✓	1.02✓	Acceptable.
Total offtake	**26**						
Warthog	**919**	KPNR	TPNR	UPNR	BNR		
Landowner		10 – 2.96✓			13 – 4.13✓	2.5✓	Acceptable. Can increase as these animals will die during the drought. Also an important prey species however.
Total offtake	**23**			1	25		
Giraffe	**816**	KPNR	TPNR	UPNR	BNR		
Commercial			1 - 0.42✓			0.12✓	Acceptable
Total offtake	**1**		1				
Zebra	**1 205**	KPNR	TPNR	UPNR	BNR		
Commercial							
Total offtake	**1**		1				
Lion		KPNR	TPNR	UPNR	BNR		

Species	Count APNR	Offtake Proposal Total and as a % of reserve total (in columns) (✓- acceptable; ✓ - but requires further study/extenuating circumstances; x - high)				% of APNR population (✓; ✓; x)	Comments
Male			1				Acceptable. A demographic study of predators would be useful to assess the sustainability of the requested trophy animals in the long term.
Total offtake	**1**	KPNR	TPNR	UPNR	BNR		
Leopard							
Male			1	1			Acceptable. A demographic study of predators would be useful to assess the sustainability of the requested trophy animals in the long term.
Total offtake	**2**						

Appendix A to Appendix B correspondence above.

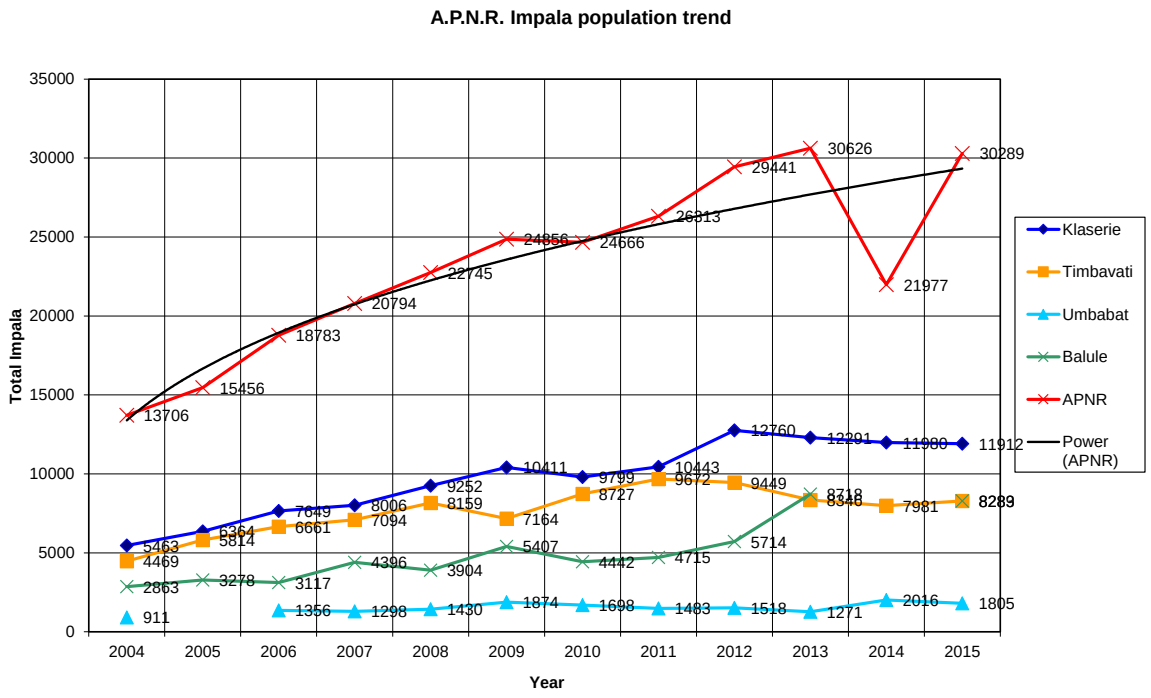
Correspondence for the proposed offtakes for the APNR for 2016/17 received from Colin Rowles.

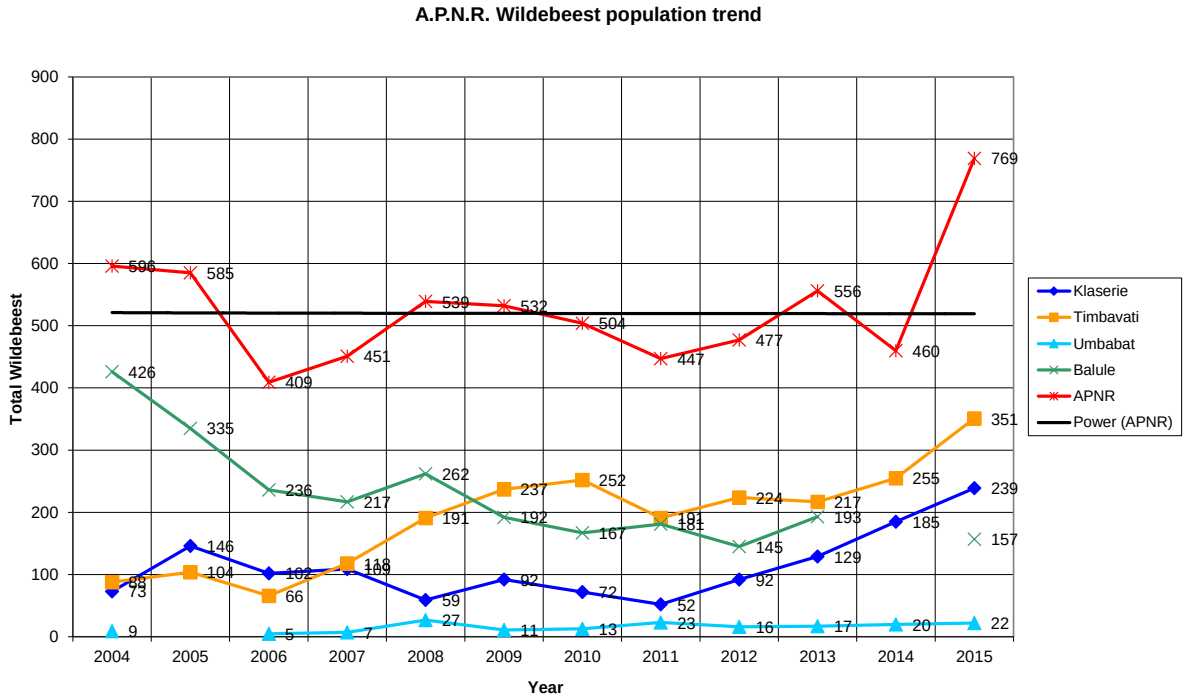
Proposed Off-takes for 2016/17. The table below provides a summary of the off take requests per reserve, as discussed and approved at the APNR meeting held on the 26th of October 2015.

2016/17 APNR Wildlife resource utilization summary.					
Professional Hunting	KPNR	TPNR	UPNR	BPNR	Totals
40lb Elephant	1	4	4	0	9
30lb Elephant	5	7	2	10	24
Trophy Buffalo	4	6	0	4	14
Classic Buffalo 38"	12	21	3	13	49
Dagga Bull Buffalo 37"	21	5	0	0	26
Management Bull Buffalo 35"	5	5	15	20	45
Buffalo Cows	10	5	0	17	32
Rhino Bull	0	1	0	0	1
Male Lion	0	1	0	0	1
Leopard	0	1	1	0	2
Hippo	0	2	0	1	3
Zebra	0	1	0	0	1
Waterbuck	0	1	0	7	8
Kudu	0	1	0	6	7
Giraffe	0	1	0	0	1
Land Owner Hunting					
Dagga Bull Buffalo 37"	0	0	0	0	0
Management Bull Buffalo 35"	5	0	5	0	10
Adult Buffalo Cow	30	12	0	0	42
Warthog	10	0	0	13	23
Kudu	4	0	0	15	19
Waterbuck	0	0	0	1	1
Live Capture					
Rhino	0	18	0	1	19
Culling					
Impala	1500	1700	450	998	4648

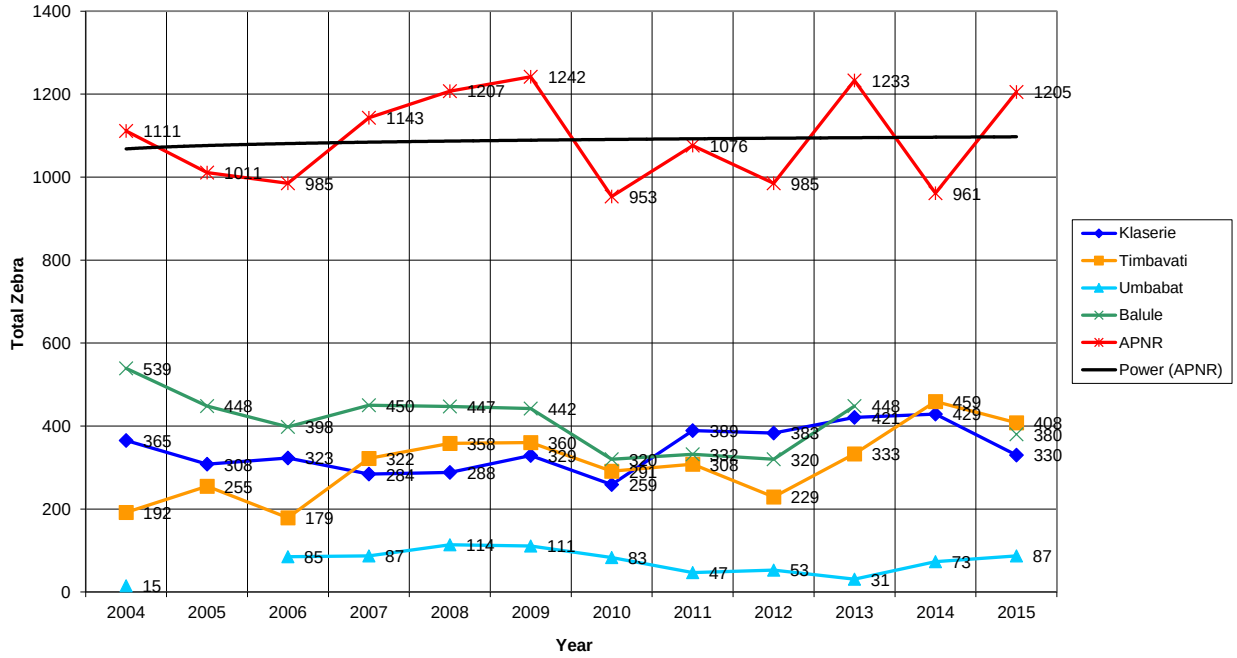
Annual Aerial Census 2015.

A.P.N.R Reserve herbivore population trends.

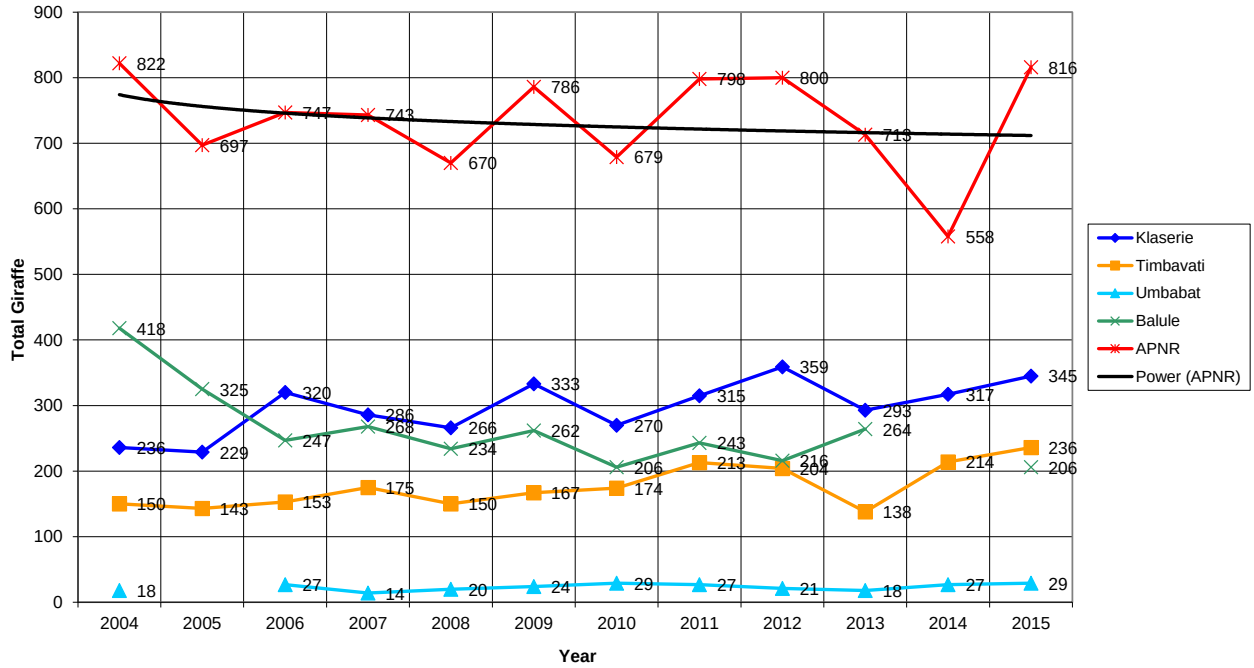




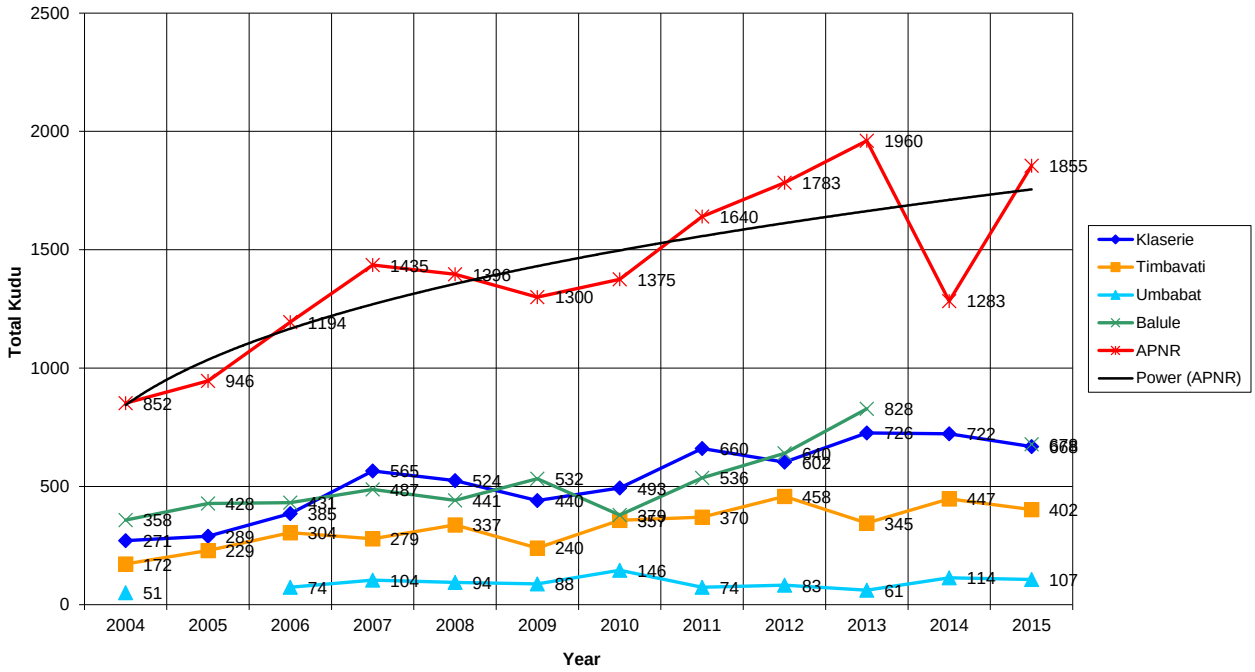
A.P.N.R Zebra population trend



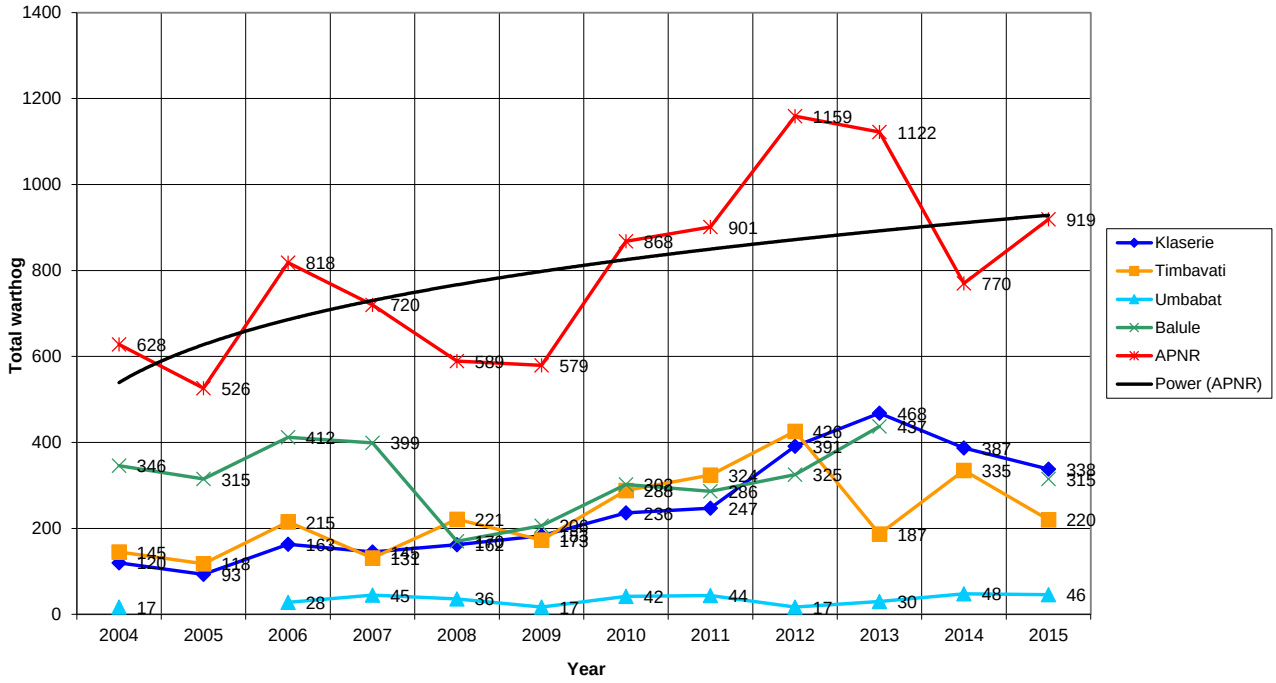
A.P.N.R. Giraffe population trend



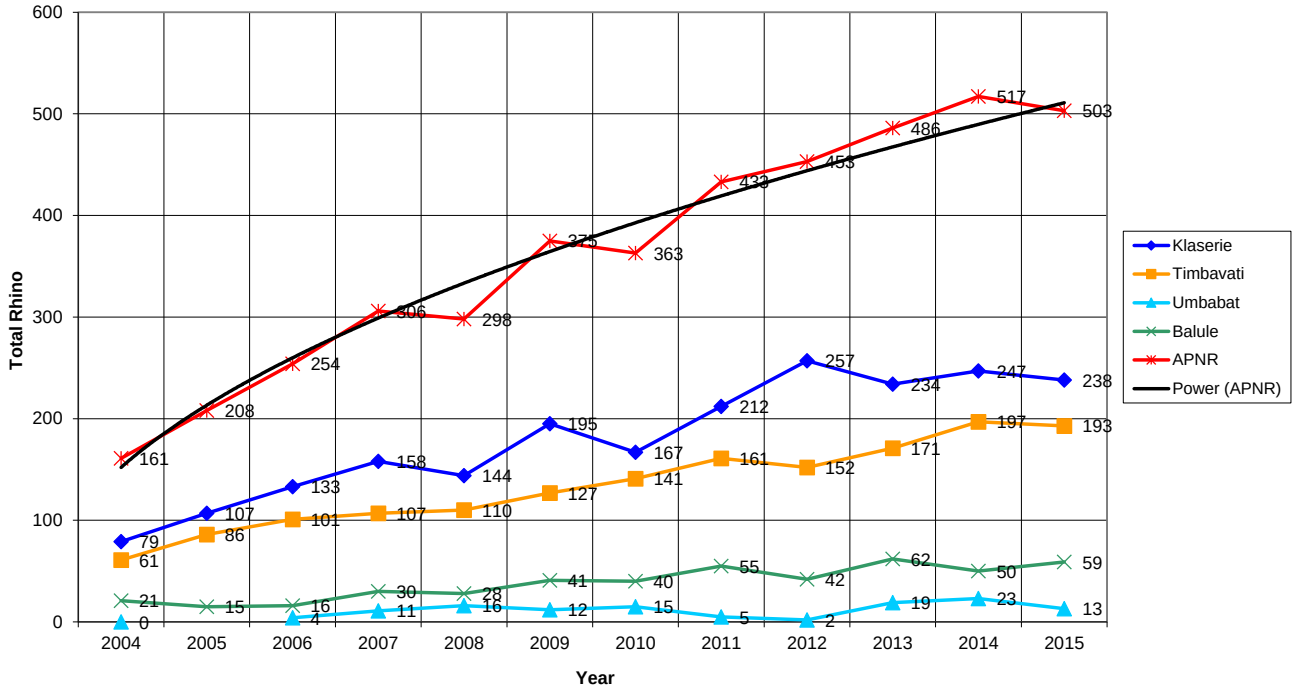
A.P.N.R Kudu population trend



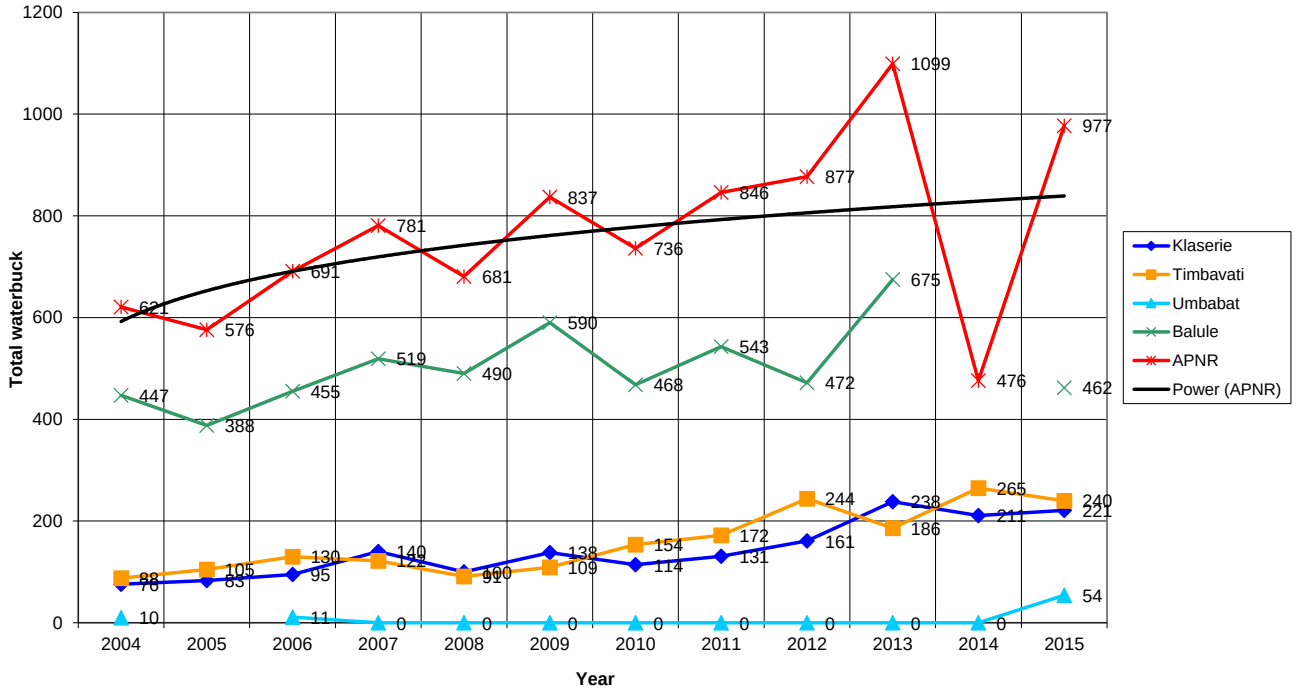
A.P.N.R Warthog population trend



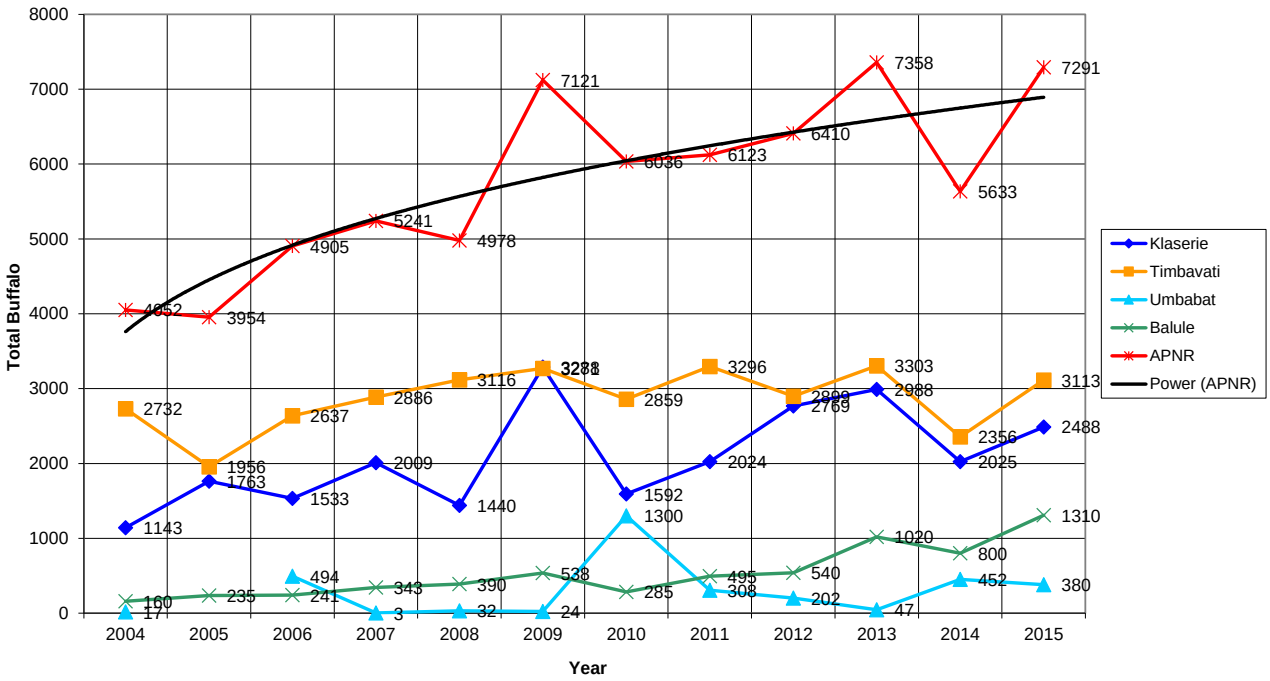
A.P.N.R. White rhino population trend



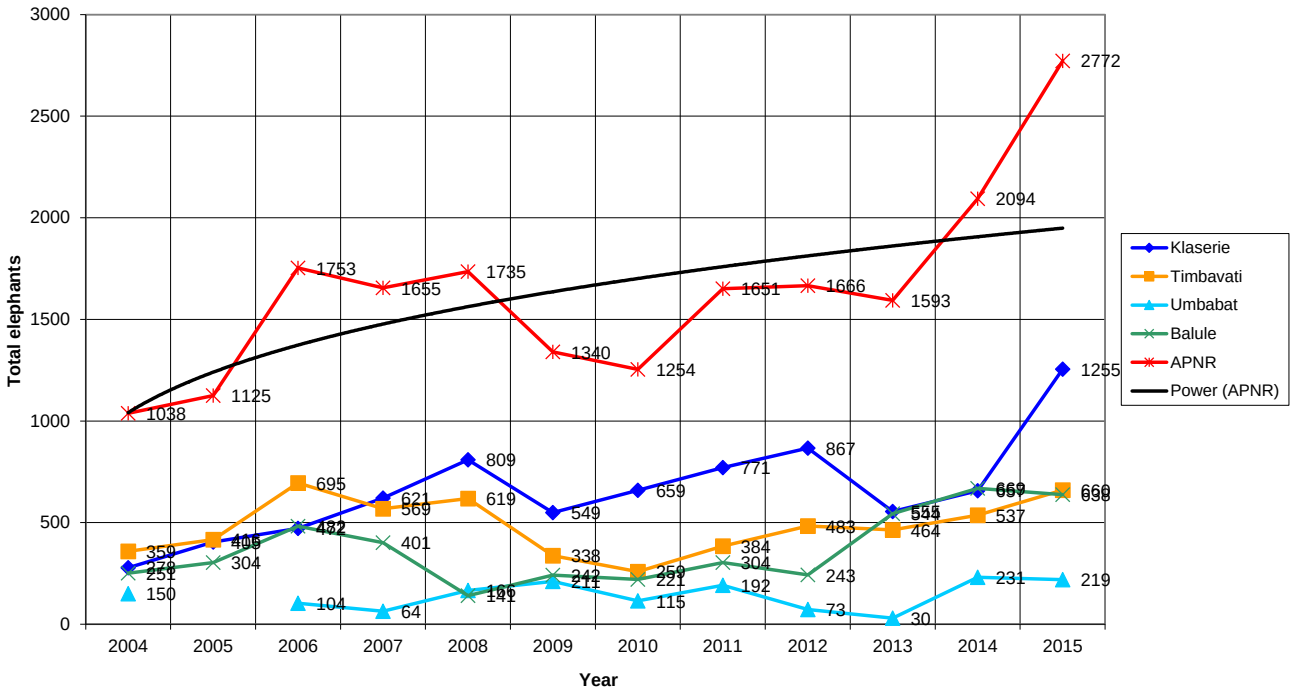
A.P.N.R. Waterbuck population trend



A.P.N.R. Buffalo population trend based on data from each reserve and not K.N.P.



A.P.N.R. Elephant population trend based on data from each reserve and not K.N.P.



Appendix C

Correspondence relating to management response to current drought - APNR.

FOR CONSIDERATION: CHAIRMEN AND WARDENS APNR (v8)

12/04/16

Klaserie, Balule, Umbabat and Timbavati Representatives
Attention Colin Rowles (Reserve Warden Representative)

Dear Colin

GRAZING SITUATION AND OFFTAKES 2016: APNR

This report is a follow up on the letter dated 06/12/15 and correspondence dated 26/01/16 that I (MP) wrote to the wardens of the APNR (the latter document to chairpersons as well) and expressing my concern around the critical grazing situation within the APNR. With the reduction in water points in the Kruger National Park (KNP) the current vegetation situation is unlike in the recent favourable rainfall years where species such as elephant, buffalo and impala increased in number resulting in high stocking densities and feeding ratios skewed in favour of mixed feeders (elephant and impala) (Appendices after references). We are into the second season of drought and the fact that there is reduced surface water in the neighbouring KNP will ultimately 'force' game to enter the adjacent protected areas such as the APNR. While these animals may return to the KNP their presence in the APNR is adding pressure on the already stressed grazing situation. The soaking rains over the past few days will obviously alleviate the situation but grass growth will still be limited given the lateness of the rain – so the challenge remains.

The letter is also prompted by our request made at the DEA/SANParks/Provinces meeting held on the 16th Feb 2016 at Skukuza. The request was that, in view of the time lag involved in getting a quota approved, whether it would be possible to submit and increased quota now – with the proviso that if by May is was not considered necessary then the extra removals would not be implemented. All state agencies agreed to this proposal.

This summary repeats some of that discussion but is expanded to provide context of where we stand in the APNR in relation to the KNP with respect to objectives and management in particular and the potential implications of these differences in terms of plant-animal interactions. This document is therefore presented as follows:

1. An executive summary highlighting recommendations;
2. A summary of the letter sent to wardens in December 2015;
3. Objectives relating to protected areas;
4. Protected areas functioning at different scales due to management (fencing and water in particular) and climate change (not covered here but to be noted);
5. Management in the light of the current drought situation.

I look forward to taking the process forward.

Sincerely

(Mike Peel and Jeremy Anderson)
(COPY DR JULIUS TJELELE (ARC-API)
MR. COLIN ROWLES TO CIRCULATE

1. Executive Summary

a. Large private nature reserves (e.g. the APNR) adjacent to the KNP have embraced the basic philosophies of the KNP management approach since the removal of the fence between them, have similar general objectives but function on different spatial scales. In the latter areas movement is possible but, due to size (spatial scale) and management issues such as water provision these areas present a unique set of management challenges (from point 3);
b. The summary letter sent to wardens in December 2015 predicted grazing shortfalls in 2016 and the need to increase management offtakes to just cover grazing requirements (point 2). However only sustainable yield quotas – or even less were requested (Table 1). The drought has worsened and these numbers are now considered far too low and require appropriate adjustment;
c. An over-supply of water in protected areas adjacent to the KNP led to an eruption of relatively water dependent herbivore species. The higher concentrations of animals resulting in increased grazing, trampling, dunging and urination which in turn affects water infiltration, run-off, grass cover, species composition, the tree:grass ratio, and ultimately biodiversity and sustainability (from point 4). The KNP has closed more water points which exacerbates the situation and the probability of large numbers of animals entering the well-watered APNR (estimate 1 water point 731 ha^{-1} in the APNR vs 1 water point 51 440 ha^{-1} in the KNP. As previously stated the recent soaking rains will obviously alleviate the situation but grass growth will still be limited given the lateness of the rain – so the challenge remains;
d. Water provision is clearly the major factor here - is there a possibility of somehow equalising the density of water between the APNR and the KNP?; We do not necessarily suggest reopening water points in the KNP but closing more in the APNR. The areas to be selected should be proposed by the individual reserves themselves as a matter of urgency (e.g. to protect a stand of charismatic tree species;

e. The following are considered the minimum offtakes (live where possible and additional to the hunting quota) to alleviate the current drought situation (there will still be losses if these offtakes are effected) – buffalo ≈ 1 450 (add another 500 if considered necessary); impala ≈ 9 700; elephant ≈ 330 (but up to 1 000 if considered necessary); white rhino ≈ 100 (but up to 150 if considered necessary); hippo ≈ 45 (but up to 100 if considered necessary); and
f. Method of offtake is aimed at immediate action. Live removals of white rhino and hippo is essential; Large scale contraception of elephant is considered feasible in the middle term and should be considered as a matter of urgency under the guidance of Audrey Delsink – but this will only become effective in time which in the current situation we do not have; Live removal of all species is preferred and we need to list the properties that have been approached to illustrate the lengths to which we have gone to try and move the animals live. Where all of these avenues have been exhausted then culling must be considered in the short term until the contraception programme becomes effective. In this regard an incredible opportunity exists to initiate the 'wildlife economy' in communal rangelands e.g. Andover and others. For this opportunity to be exploited (and it could be an excellent public relations exercise for private protected areas to contribute animals to communal protected areas) authorities need to get these areas fenced immediately and expedite logistic issues such as permit issuing, staffing etc. – the expertise exists to determine range condition and the number and type of animals that these areas could accommodate.

2. Summary of letter sent to APNR Wardens December 2015

We examine the effect of resource use by grazers by inserting the resource requirements for wildebeest, warthog, impala, waterbuck, zebra, buffalo, hippo, rhino and elephant to determine whether the individual populations (using 2015 counts and projecting forward to 2016) can be sustained on the grass available in 2015 and an estimated grass biomass following a dry/drought 2015/16 season.

Results and Discussion

Following a poor 2014/15 rainfall year the mean grass standing crop within the various APNR areas was:

KPNR 879 $kgha^{-1}$; UPNR 863 $kgha^{-1}$ (corrected from estimated 532 $kgha^{-1}$); TPNR 1 482 $kgha^{-1}$; BNR 257 $kgha^{-1}$.

Energy flows and sustainability in the APNR

We examined the effect of resource use by grazers by inserting the resource requirements for wildebeest, warthog, impala, waterbuck, zebra, buffalo, hippo, rhino and elephant. I investigated whether the individual populations were able to stabilise their own ‘population metabolism’ using flows of endosomatic energy (food and work) (Peel 2005). The average energy demand of the different species was obtained from which an estimate of the activity patterns as they affect the feeding requirements of the various species. The approach is looked at in terms of useful energy flows into a system minus a certain fraction that is reduced by internal overheads (e.g. consumption used to maintain the population) and external overheads (e.g. predation that reduces the population). Where an indicator of environmental loading (EL), the biophysical cost of the diet, is introduced. The EL relates to the metabolisable energy of the forage (ME = 10.5 $MJkg^{-1}$ dry matter - Lombaard 1966) and the total amount of forage (from field data collection in this study). The latter takes into account the proportion of the forage that is available to the animals. Estimates vary from 22% to 49% in the broad-leaved savannas to between 15% and 80% in fine-leaved savannas (in highly nutritious systems).

As discussed with management during previous years and again in 2015, using this method, the resource was not limiting for the grazing species in the KPNR, UPNR and TPNR. However there was a grazing shortage for BNR.

I then projected forward to 2016 taking only the 2015 numbers into account (with reduced increments due to drought/no predation/no natural mortality) and then removing the grazer offtake requests as per the APNR offtake committee correspondence of 2015 as follows:

Table 1 Indicating the initial grazer and mixed feeder offtake requests approved by LEDET, MTPA and SANParks.

Species	KPNR	UPNR	TPNR	BNR	APNR
Buffalo	**92**	**23**	**54**	**54**	**223**
Elephant	**6**	**6**	**11**	**10**	**33**
White rhino		**1**	**19**		**20**
Hippo			**2**	**1**	**3**
Impala	**1 500**	**450**	**1 700**	**1 000**	**4 650**
Warthog	**10**			**13**	**23**
Waterbuck			**1**	**8**	**9**
Zebra			**1**		**1**

The results were as follows for 2015:

1. KPNR at 560 kgha^{-1} (less than this received in 4/13 years measured) for 2016 would suffer grazing stress. Theoretically, there are a number of scenarios we could look at but the number to be removed to have sufficient grazing at that grass standing crop would be 200 impala and 60 buffalo;
2. UPNR would be okay from around 300 kgha^{-1} if the offtakes are effected. There is also quite a bit of movement in and out of this reserve;
3. TPNR at 510 kgha^{-1} (less than this received only in 1/16 years measured) for 2016 would suffer grazing stress. Theoretically, there are a number of scenarios we could look at but the number to be removed to have sufficient grazing at that grass standing crop would be 80 buffalo (given the high buffalo numbers);

4. BNR at 450 kgha^{-1} (less than this received in 7/17 years measured) for 2016 would suffer grazing stress. This indicates that during dry/drought times it is quite feasible that we will have a low standing crop. Theoretically, there are a number of scenarios we could look at but the number to be removed to have sufficient grazing at that grass standing crop would be 200 impala and 80 buffalo.

The above just serves as an illustration of the necessity for proactive management in dry/drought times and the need for the reserves to look at adapting their offtake proposals. This is not to say die-offs will not occur among weaker animals and we also know that in the browser component species like kudu (especially adult male kudu) go into the winter in relatively poor condition after the rut. So at the end of winter they are much weakened and a poor winter and rain and cold snaps can result in large scale die-offs.

I am wary to reduce prey species such as wildebeest, zebra and waterbuck because the lion population has the ability to relatively quickly push them into a predator pit. This is also a time when lions target the weakened buffalo population so their removal needs to be carefully considered. All the while the grazing resource will be stressed so time is of the essence.

The above assumes a drought situation and the potential need to accelerate removals in the event of a poor season. We have reached a situation where relatively large numbers will need to be removed. The worst case scenario is that we suffer a drought and lose animals and where but some pressure will have been taken off the veld through removals; we will recoup something from offtakes. The best case scenario would be that we do not suffer a drought and the veld holds out and where: some normal attrition would take place; pressure is taken off the veld; we recoup something from offtakes.

Insert 2016: leading on from the above we can now say that the bulk of the summer rains have failed and a second year of drought is upon us (again despite the recent rains). **So while the proposed offtakes as given above were a minimum to maintain the grazing component it is now imperative that we adapt our**

management again particularly in the light of the changed surface water situation. For this we need to provide some context.

3. Objectives relating to protected areas

The following Table does not represent the actual objectives of the APNR or the KNP but outlines the philosophy relating to setting objectives for protected areas and the importance of spatial scale in setting realistic objectives.

Table 2: Issues relating to objectives, spatial scale (size) – OR why we don't manage all areas in the same way.

Philosophy/High Level Objective	Relevance: Large National Park e.g. KNP	Relevance: Protected Areas (smaller) e.g. APNR
Maintain essential ecological processes and life support systems	High	Moderate
Preserve genetic diversity	High	Moderate
Sustainable utilisation of species and ecosystems	Moderate-low	High

So while the APNR and KNP have a broadly similar philosophy, spatial and temporal heterogeneity at different scales are prime determinants of system qualities. Heterogeneity is an important consideration in any operation based on the use of natural resources, for example, the Kruger National Park (KNP - *c.* 2 000 000 ha) has adopted the Noss (1990), definition of biodiversity as an underlying basis for their revised management plan (Braack 1997a; Braack 1997b) which is expressed operationally in terms of so-called 'thresholds of potential concern', endpoints of which even include the desirability of having a certain limited percentage of land in a 'degraded' condition for a period of time due to biodiversity considerations (we need to ask the KNP (Marisa?) if this philosophy has changed but either way the spatial scale issues are relevant). **Large adjacent private nature reserves (e.g. the APNR) which embrace the basic philosophies of the KNP management approach since the removal of the fence between them, have similar general objectives but function on**

different spatial scales. In the latter areas movement is possible but, due to size (spatial scale) and management issues such as water provision these areas present a unique set of management challenges. In the latter case 'island populations' are more likely to undergo more extreme eruptions in numbers and related vegetation over-utilisation than in larger 'open' systems which are waterless for parts of the year (e.g. Owen Smith 1983).

4. **Protected areas functioning at different scales due to management (fencing and water in particular) and climate change;**

The living requirements of wild animals include food, water and cover. Large herbivores are limited by the amount of nutrients and forage available to them. In addition to this, herbivore species differ in their dependence on surface water. The spatial and temporal distribution of water therefore plays a major role in determining the distribution of herbivores and by extension the condition of the soils and vegetation.

The sub-division of land and the fencing off of conservation areas in the savannas of the north-eastern Lowveld of South Africa began in the late 1960's. This broke the natural east-west herbivore migration and, because many of the fenced off areas did not have perennial water, artificial water points had to be constructed. The result was a network of artificial water points in the Lowveld supplying 'excess' surface water in these areas.

Such an over-supply of water led to an eruption of relatively water dependent herbivore species such as impala, wildebeest and zebra around such water points, the higher concentrations of animals resulting in increased grazing, trampling, dunging and urination which in turn affects water infiltration, run-off, grass cover, species composition, the tree:grass ratio, and ultimately biodiversity and 'carrying capacity'. Many artificial water points therefore may have a negative impact in terms of resource degradation which is directly related to increased animal activities. The figures included in the Appendix illustrates; The increase in herbivore biomass with an increase in rainfall (in particular impala and to a lesser extent elephant extent – buffalo have also increased steeply in the past few years); The increase in animal biomass in the APNR and the skewed feeding class ratios dominated by mixed feeders (largely impala and elephant) which are highly successful and competitive species due to their ability to switch from grazing to browsing. So this year we can expect an increase in tree impact by elephant (to potentially undesirable levels) due to a depleted grass layer. In addition to this the high buffalo numbers will result in increased competition with white rhino and possible related mortalities (this cannot be entertained and live removals of both is essential). Hippo are also likely to come under pressure and removals are essential (live).

To illustrate the current water situation we compare the density of open water points in the APNR (Rowles *pers. comm.*) and the KNP (within a 10km strip in the KNP Coetzee *pers. comm.*). The data are being continually updated (see Figures below and summarised in the Table that follows).

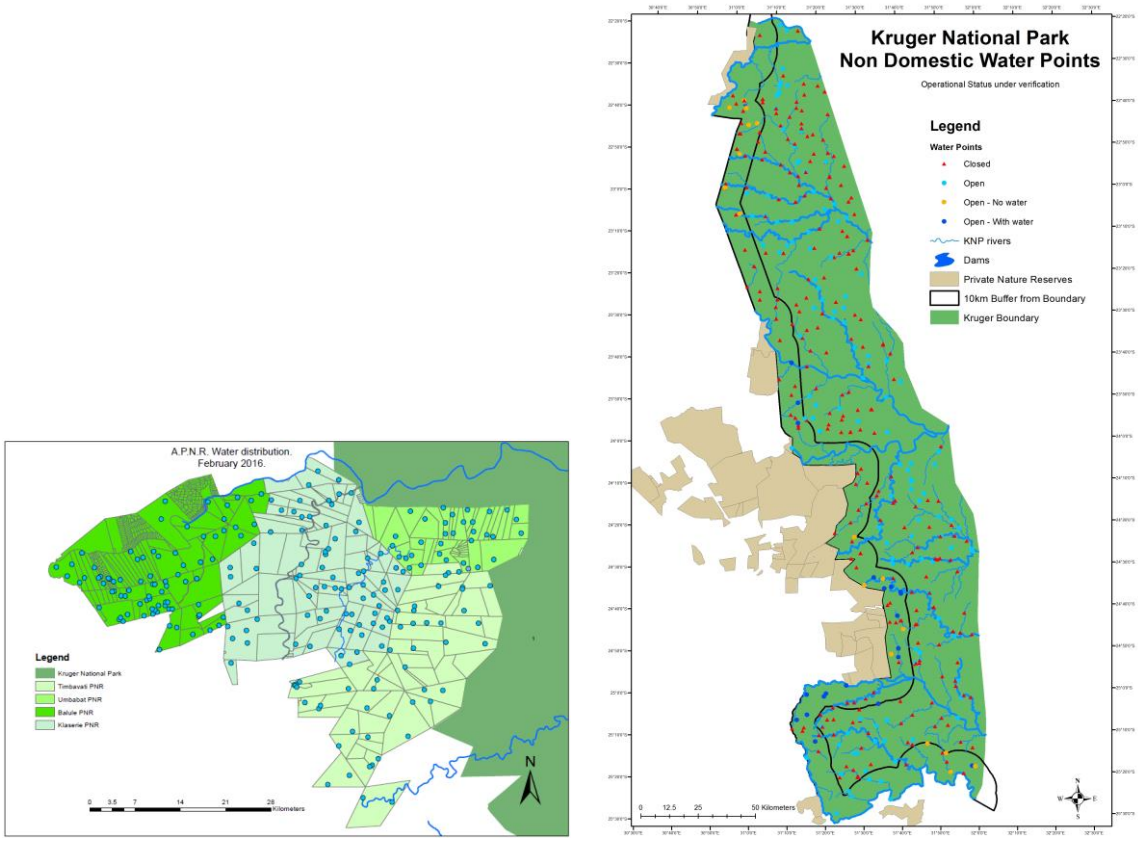


Figure 1 indicating open artifical water points in the APNR and in the KNP (focusing on the area adjacent to the SSW, Manyeleti and APNR).

Table 3 presenting the current density of water points in the APNR (Rowles *pers. comm.*) and KNP (Coetzee *pers. comm.*).

Protected Area	Density of open water points (ha open water point^{-1})	Density of Kruger water points (ha open water point^{-1}) in adjacent KNP*;**	To equal the density open water points in the adjacent APNR the KNP would need *n* water points (left figure in this column) vs actual open (right figure in this column)
Balule*	488	26 540	54 - 0
Klaserie**	719	26 540	37 - 0
Umbabat	805	13 330	17 - 0
Timbavati	1 136	38 110	34 - 0
APNR overall	731	51 440	70 - 0
APNR 10km buffer bordering KNP	Area water point^{-1} = to be inserted once received from KNP	51 440	To insert

*Although BNR does not border directly on the KNP we took the area in KNP that corresponds to the area between the southern- and northern-most boundaries of the PA; ** for the KPNR there is a small area that is adjacent to the KNP but the calculation was made as for BNR.

We are informed that the KNP has closed a large portion of their artificial water points (awaiting details) and in the vicinity of the APNR. The large disparity in the density of water between the APNR and the KNP has obvious implications for game distribution. There is generally more natural surface water during 'wetter' years but under the current worsening drought conditions we expect movement (probably large scale) from the 'less watered' KNP areas to the well/excessively watered APNR. The following, refers to the 1982/83 drought in the Klaserie. Stocking densities in the KPNR, similar to the single grazing capacity figure laid down by Agriculture, resulted in a large scale herbivore population crash subsequent to the 1982-83 drought (from Peel 2005). The cause of the population crash was precipitated by the provision of artificial water points which allowed water dependent animals in particular to increase to artificially high numbers and to alter the habitat to suit their needs. This in turn resulted in a decline in the spatial heterogeneity of the natural resources and extensive grass mortality which was exacerbated by the drought (Walker *et al.* 1987).

5. Management scenarios in the light of the current drought situation – to manage or not to manage

As stated above, with the water closures in KNP we can expect further movement into the APNR. The current grass standing crops will be well short of what they were last year and which formed the basis of my offtake proposal under point 1 above (in addition to the hunting offtakes) that was sent to APNR wardens in December 2015.

We have started our vegetation surveys in the wetter south of the Lowveld (historically high grass biomass) and we are measuring now and will re-measure at the end of the wet season to get an idea of the available grass biomass. Early results indicate grass standing crops of 300 $kgha^{-1}$ and generally less. The drier north (APNR) will therefore in all likelihood be sitting at around 200 $kgha^{-1}$ or less (even if we have late rains (as we are) the rangeland is unlikely to bulk up significantly). Balule will in all probability be in an even worse situation when we consider the 2014/15 season results.

The numbers of buffalo and impala to be removed in a 300 and 100 $kgha^{-1}$ situation, using 2015 numbers (with reduced increments, including hunting quotas and zero predation for a 2016 estimate) is as follows:

Table 4 – adjusted offtake (**starting immediately**) proposal for the APNR for 2016.

Reserve	Buffalo	Impala	Elephant**	White rhino*** (live)	Hippo	Comment
Balule	54 ; 400	1000 ; 1 500	10 ; 100	0 ; 10	1 ; 30	Still grazing stress
Klaserie	92 ; 500	1 500 ; 4 000	6 ; 100	0 ; 50		Still grazing stress
Umbabat	23 ; 40	450 ;150	6 ; 30	0 ; 1		Sufficient grazing
Timbavati	54 ; 500	1 700 ; 4 000	11 ; 100	1 (hunted) and 18 (live) ; 32 (live)	2 ; 15	Still grazing stress
Emergency additional – May 2016	≈500		≈700	≈ 50 live	≈55	

*Offtake quota first number, additional offtake second number and emergency offtake third number; **dispersive shooting (e.g. the Rhodesian (now Zimbabwe) experience of culling a female from the herd and the resulting dispersion out of the area for up to three months. In this instance it may be that less animals will need to be managed); *** live removal or removal while retaining a share of the animals – NNB buffalo are starting to compete with the rhino grazing and we cannot afford to lose rhino to drought and poaching. Other species removals per the hunting quota are not included here but are supported as per previous correspondence.

The main mitigating factor for intense management is the current water situation relating to the closure of water points in the KNP. To summarise from point 1 above: The 'assumed' drought has materialised and we need to accelerate removals or risk large scale animal losses and resource (in particular grazing) degradation which may take years to recover. As stated above: We have reached a situation where relatively large numbers will need to be removed. The worst case scenario is that we suffer a drought and lose animals but some pressure will have been taken off the veld; we will recoup something from offtakes. The best case scenario would be that we do not suffer a drought and the veld holds out and where: some normal attrition would take place; pressure is taken off the veld; we will recoup something from offtakes.

There is evidence of the KNP elephant population 'stabilising' – we need confirmation of this. Given the gravity of the situation, the requirements for immediate game reduction is clear and in the following table we outline some of the options with their usefulness in the short term with comments (from Henley August 2014 – from the Norms and Standards for Managing Elephants in S.A.) and moving from least to most disturbance.

Table 5 indicating actions and comments relating to potential for immediate action regarding elephant.

Action	**Comment**	**Time**
Do nothing	Acceptable in a man-induced situation?	N/A
Manipulate the environment to control elephant distribution and their effects	Close water – unlikely in APNR to the required density to match KNP; Dispersive shooting (e.g. the Rhodesian (now Zimbabwe) experience of culling a female from the herd and the resulting dispersion out of the area for up to three months – in this instance it may be that less animals will need to be managed); Bees/chillis	Immediate Immediate but difficult large scale in the short-term. Difficult feeding bees in drought conditions
Translocation	Depending on destination – but seems to be few 'takers' in this regard	Immediate – funding required
Contraception	Audrey Delsink has outlined a protocol that may be useful and for relatively large numbers in the future	Immediate – but time lag to take effect so not an option in the short-term – Funding required (Approach Audrey Delsink as a matter of urgency).
Culling	Unpalatable but necessary?	Immediate

The first option is that the various game populations are allowed to fluctuate with the prevailing conditions, i.e. a die-off in drought (weaker animals). The tricky issue if the latter option is pursued is the effect on the resources (particularly grazing) resulting from such a 'laisse-faire' approach. Ultimately some debate would need to be entered into in this regard to gauge the feeling of the land owners and adjacent neighbours (KNP) in consultation with the managers/ecologists working on the reserve. Where a hands-off management approach is taken the **decision would be to**

not control numbers outside of the relatively small hunting quota. We do not believe that this is an option given that the problem is largely man-induced (water provision …).

However, management of species at risk such as white rhino is critical – we cannot afford to lose rhino through drought. Dispersive 'culling' of elephant may be an option as described above. Further, droughts are times when the lion population takes advantage of the weakened condition of species like buffalo. By removing large numbers of buffalo, lions may target some relatively vulnerable prey species such as wildebeest, zebra and waterbuck. The latter should not be managed as the lion population has the ability to relatively quickly push them into a predator pit. This is not to say there will not be die-offs within these populations. All the while the grazing resource will be stressed.

The second option is to take positive action and to reduce selected herbivore populations as rapidly as possible. These populations would be elephant and impala – both mixed feeders and buffalo, white rhino and hippo – all grazers.

We propose an adaptive management approach where opportunities are grasped (allow numbers to climb) and hazards are avoided (large scale die-offs related to veld degradation). Under the current circumstances we therefore propose a closely monitored adaptive management approach where in 2016 the APNR implements large scale management interventions in the interests of habitat conservation and in particular reducing the risk of rhino dying of starvation.

PROMPT ACTION IS CRITICAL TO SUCCESS.

The sooner game removals take place the better. However, there are three potentially negative factors that can be mitigated by prompt action on the part of the APNR staff and the relevant conservation authorities (SANParks, Limpopo and Mpumalanga). The sooner the large scale removals are effected, the lower risk of any of the following factors impacting on the programme and the lower the risk of avoidable mortalities. These factors are:

- As the dry season progresses, animals will inevitably lose condition as food

availability and quality declines. The greater the loss in physical condition, the greater the risk of mortalities during capture and especially transport. Therefore from an animal welfare point of view, it will be better to remove the animals immediately (with the possibility of removing more in the case of emergency after May;

- The APNR lies within an area known for recurrent outbreaks of anthrax. As waterholes dry up and the underlying mud is exposed, so are anthrax spores and the risk of an outbreak occurring increases. If an outbreak does occur, the risk is high that the movement of live animals from the APNR will be prevented by the Department of Veterinary Services. To reduce the risk of this happening, removals should be done before water points dry out and risk of an anthrax outbreak is still low.
- The longer the animal numbers destined for removal remain on the veld, the greater the impact of their grazing and browsing will be. The sooner they are removed, the quicker the reduction in herbivore pressure and the more food that will be available for the remaining populations. This will also take pressure off the veld and allow for a more rapid recovery when favourable seasons return.

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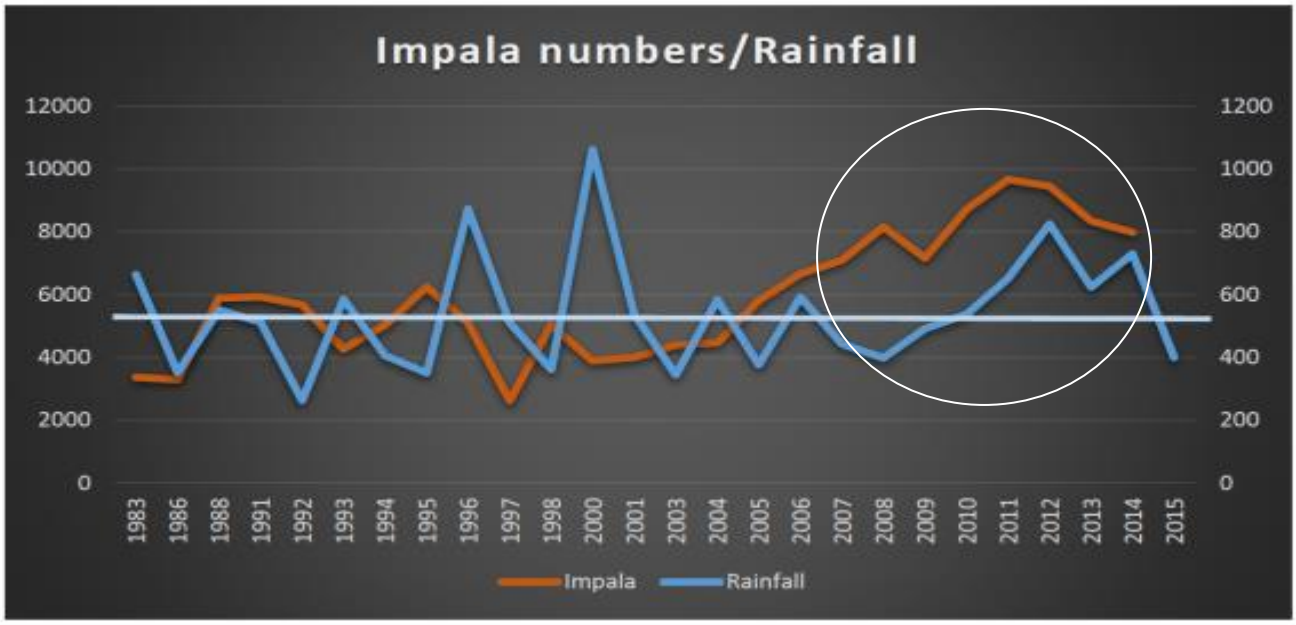
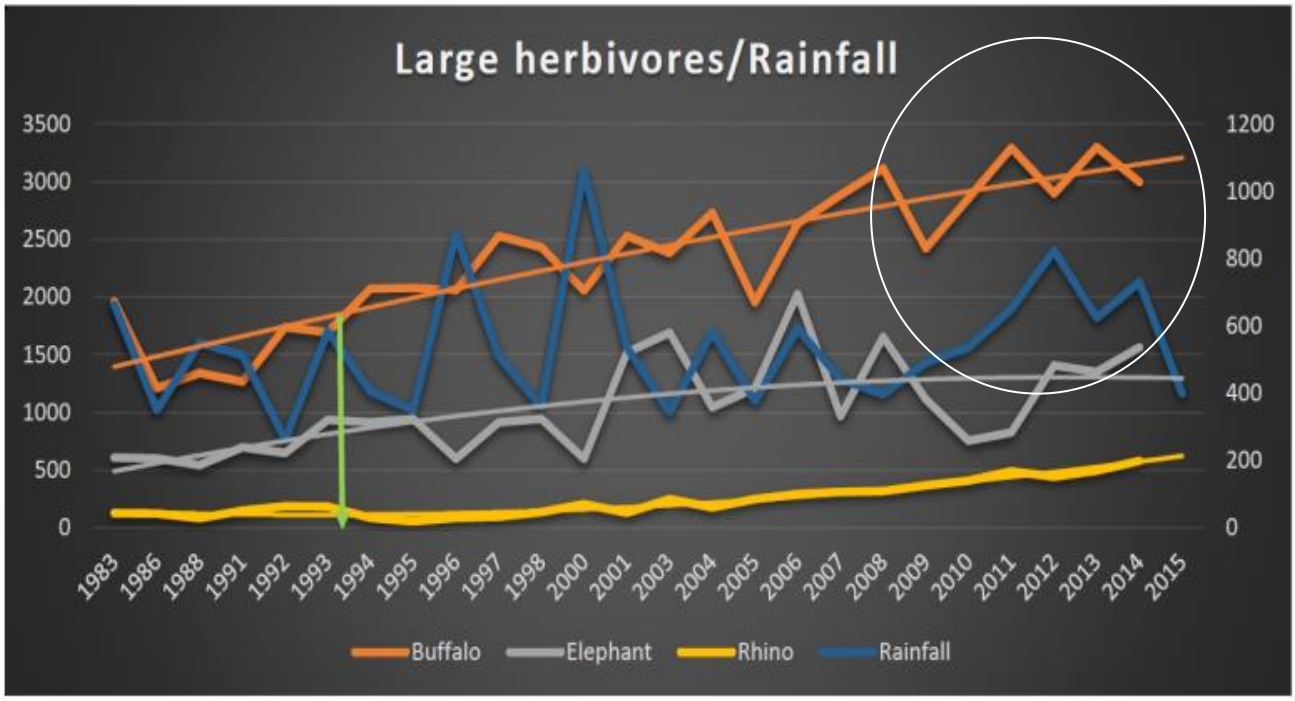
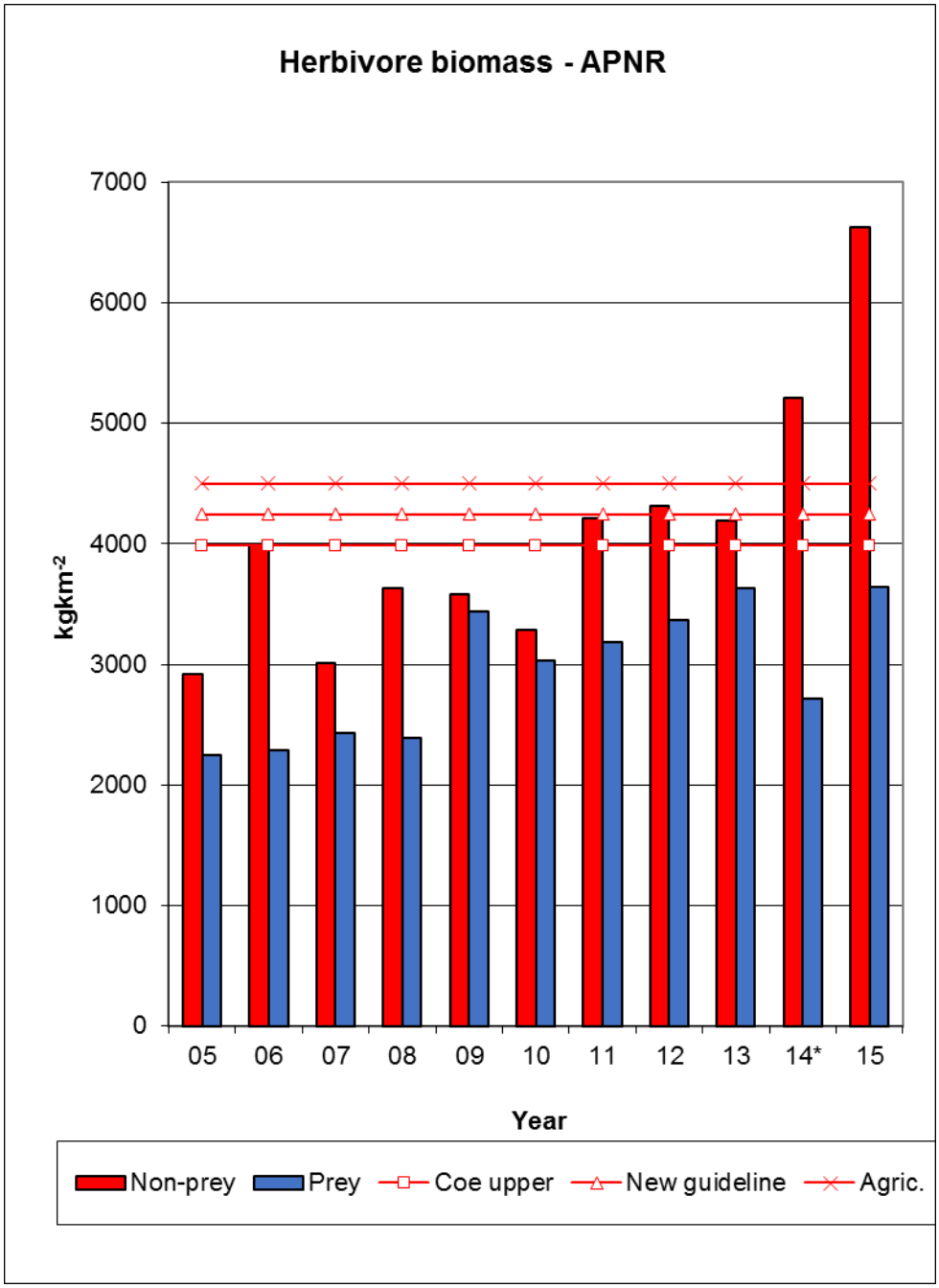
Appendix showing increase in impala and buffalo in particular with rainfall (circled area) and to a lesser extent elephant (Jeremy Anderson out of Jacques Brits report).

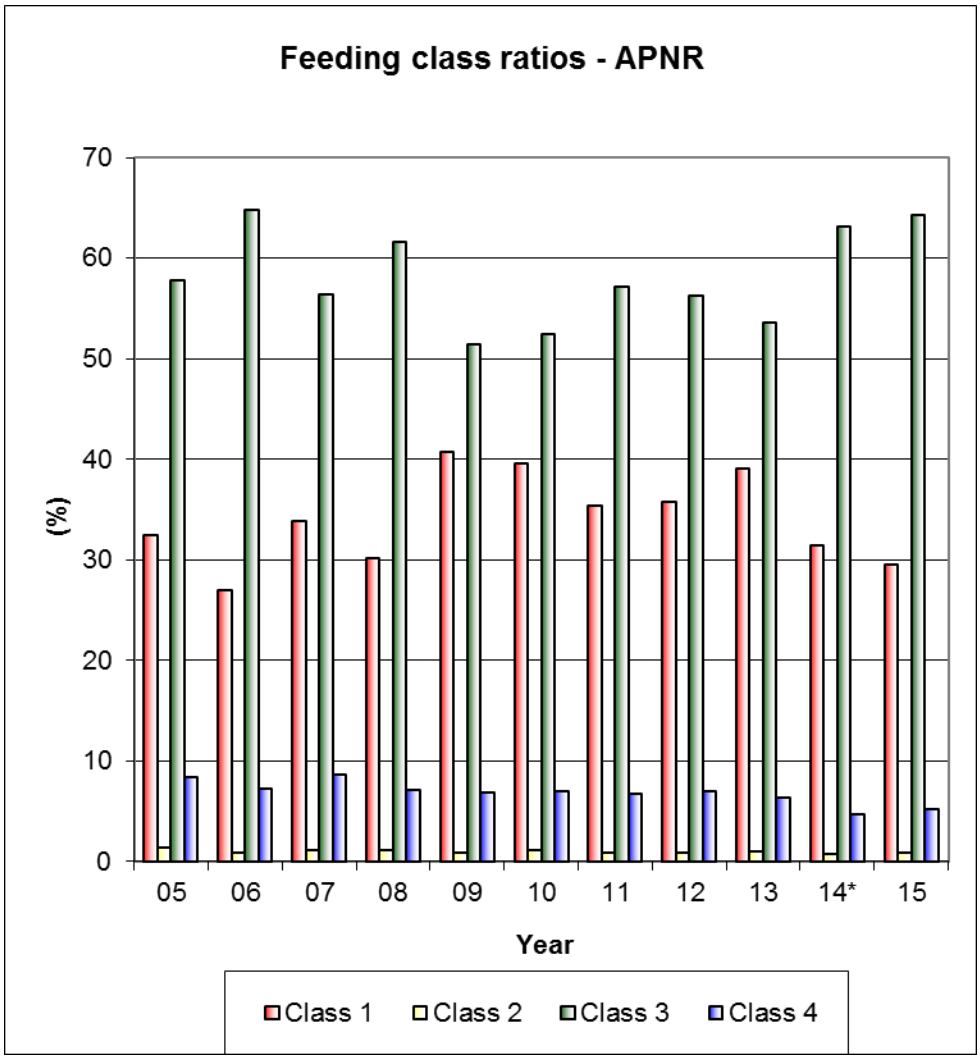




Appendix showing increase stocking densities in the APNR (Peel report 2015 *in prep.*).



Appendix showing skewed feeding class proportions in the APNR (Peel report 2015 *in prep.*). Note Class 3 mixed feeders (elephant and impala) dominate the biomass (64%); class 1 bulk grazers (buffalo, hippo, rhino – 30%), class2 selective feeders (wildebeest and warthog 0.9%) and class 4 feeders - browsers (5%).



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18th February 2016

Sanparks - Dr Freek Venter. Dr Marisa Coetzee.
LEDET – Mr Mametja, Mr J Kruger
MTPA – Mr Riaan De Lange

Dear Sirs/Madam.
Association of Private Nature Reserves (APNR
Supplementary and emergency drought relief offtake.

We refer you to our letter of 19th November 2015 (copy attached for ease of reference) and in particular to the penultimate paragraph in respect of potential supplementary offtakes deemed potentially necessary in view of the continuation and deterioration of the drought conditions in the region.
At Joint Committee meeting held at Klaserie Headquarters on 25th January 2016 between representative members of the APNR, their respective wardens, representatives of Sanparks/KNP and officials of MTPA and LEDET and after review of the document submitted by Dr M Peel and Jeremy Anderson (also attached), it was agreed that the Association would seek your urgent written approval so as to facilitate the issuing of the required permits by the relevant Provincial authorities during the upcoming season, beginning 1st April 2016.
We understand from Messer's Riaan De Lange, MTPA, and Mr Johan Kruger from LEDET, that the original annual offtakes as set out our letter of 19th November, have been approved by the two provinces. Furthermore, they both confirmed that this supplementary application has been well motivated by the supplementary report of Dr Peel and Mr Anderson and that no further supporting evidence would be required by them. However, Dr Marisa Coetzee Sanparks/KNP, has requested that a dry season distribution map of available water to wildlife within the APNR be prepared. This map has also been attached for your attention.
Furthermore, it was agreed that the drought conditions would be continually monitored and in the event that vegetation levels were to significantly improve, the APNR and its constituent members would consider a downward review of these offtake numbers.
Also note that the Peel/Anderson recommendations far exceed the proposals contained herein, which reflects to some degree the capacity of the reserves to handle in a professional manner the overall offtake situation.
As a result, it is still anticipated that there will still be a large number of in field mortalities, particularly in the impala population.

Also to be noted that the offtake of,

i) buffalo is based on hunting/culling of cows and heifers.

ii) rhino will be by live capture, and translocated.

iii) Hippo will be capture/Culled or hunted.

We set out below the allocation of animals per constituent member of the Association;

	Buffalo (cows)	white rhino (live)	hippo (live/hunting)
KPNR	80	15	-
TPNR	80	10	-
BNR	80	8	30
UPNR	20	4	-
TOTAL	260	37	30

We trust that you will deal with this application in an urgent manner, but in the event that you require any further information please do not hesitate to contact the writer.

Yours faithfully

CL Rowles

APNR Warden Representative

Appendix D

Lowveld Protected Areas: To Manage or Not to Manage

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As we are all aware, the Lowveld has experienced average to above average rainfall over the past six years. During these 'years of plenty', with the veld looking great we are often numbed into a false sense of security and as game numbers increase, we try to create a sense of 'anticipatory awareness' – the dry times will return and we cannot predict when, how long and what the severity of the dry period will be when it comes. In fact it appears that with increased variability in climatic conditions, prediction may become more and more difficult.

The Rangeland Ecology group of the Agricultural Research Council has over many years presented potential animal trend scenarios to a large number of land users based on current veld condition and animal numbers (both based on up to 25 years of historical data) under varying rainfall conditions and with the predicted response of the grass layer to these variables. The bottom line is that we do not want unpleasant surprises and we need to be proactive rather than reactive when taking management decisions relating to animal numbers. In the following discussion I share some thoughts relating to animal management under fluctuating environmental conditions.

The fact that, due to land fragmentation there is no longer movement to the higher rainfall areas and forage resources in the west near the Drakensberg range means that there will be animal losses in drought years. Population declines especially in larger grazer species such as buffalo, zebra and wildebeest would vary from minimal through steep as evidenced by the 1982-83 drought for example where some grazers were reduced to between 10 and 20% of their pre-drought numbers following large scale perennial grass mortality. Mortality amongst these grazing herbivores may be viewed as part of a longer term cycle and droughts are also times when predators, in particular lions, feast on weakened animals.

The question is whether or not we are prepared to allow drought related mortality to occur and whether the cost to the veld would be acceptable if numbers are allowed to increase unchecked? Management decisions are also linked to whether the protected area is fenced (no movement to favourable grazing areas possible) or not.

The relationship between grass production and standing crop is highlighted with recent favourable rainfall seasons in the eastern Lowveld (mean or above rainfall since 2008/09 in the example given below) resulting in an increase in grass standing crop (the portion of production that remains after utilisation) (Figure 1). The latter is due to a favourable perennial composition and cover and improved soil moisture conditions that promote grass growth (Figure 1). This has in turn resulted in a steady increase in herbivore numbers in Lowveld Protected Areas (Figure 2) which largely reflects these favourable grazing conditions.

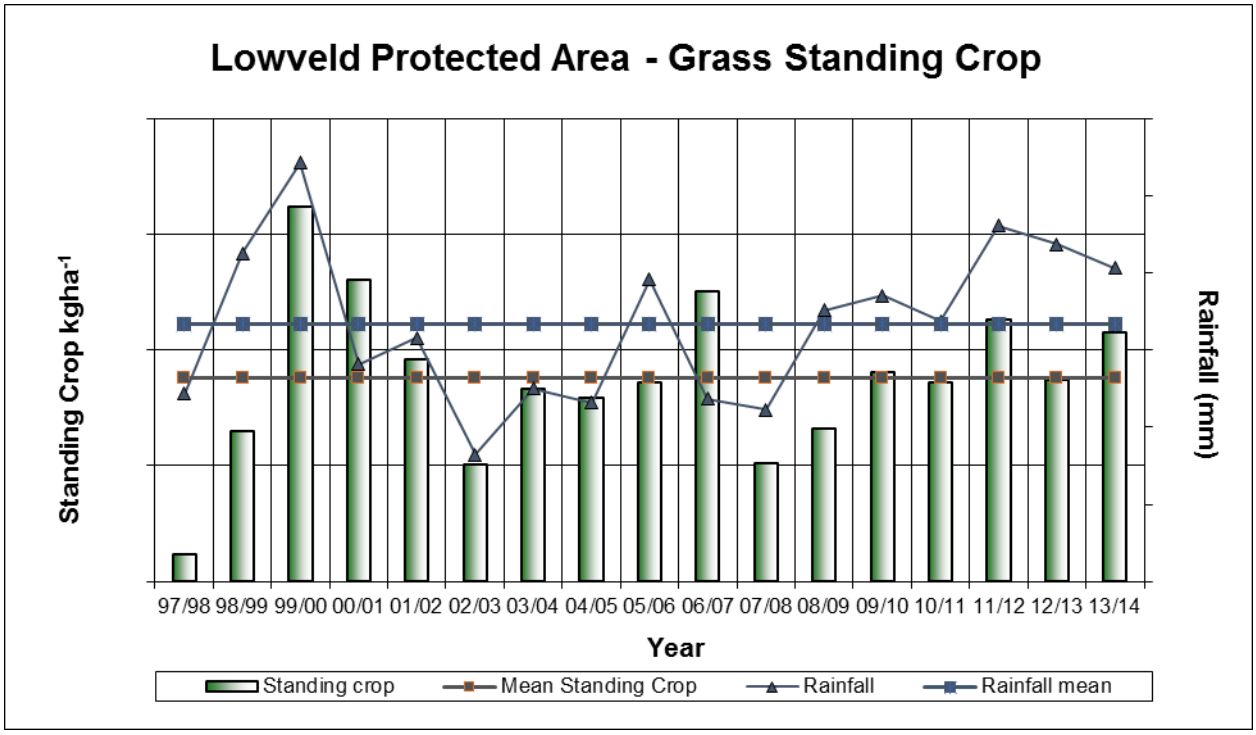


Figure 1 illustrating the favourable relationship between annual rainfall and grass standing crop (note mean or above mean rainfall since 2008/09 and above or above average grass standing crop since 2009/10 – note lag of one rainfall season before the grass response becomes clearly evident.

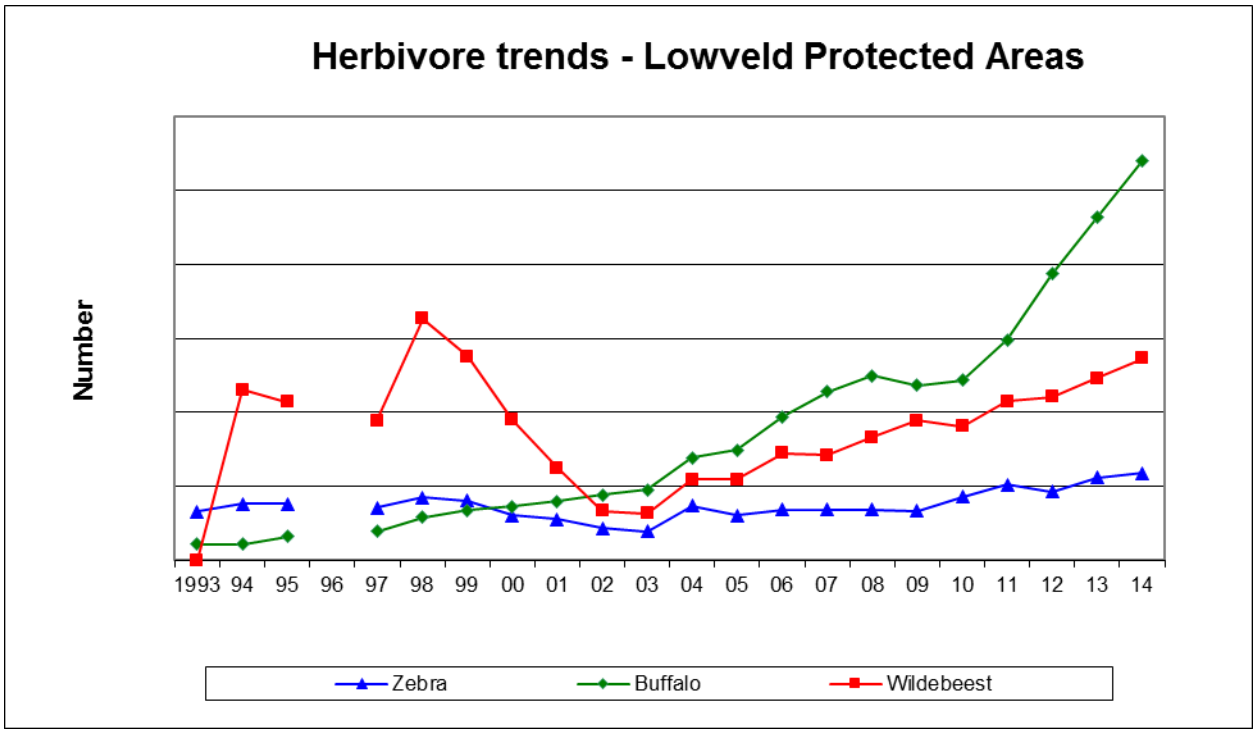


Figure 2 illustrating trends in three grazing species in the protected areas of the eastern Lowveld. Note the increases in these important grazers in response to the data shown in Figure 1 (increased rainfall and increased grass standing crop from around 2008/09 and linked increases in grazing animals)

Over the past few years we can see that the grass layer has not been limiting for grazers in general (Figure 1). Further I think that given the fact that grazers like buffalo move in large herds over extensive areas and are not sedentary around a single water point, that they have a generally beneficial effect on the vegetation for, among others, the following reasons. High densities of large hooved animals:

- Break soil crusts by their hoof action allowing for a good soil surface to seed contact;
- Reduce the height of moribund grass, thus allowing sunlight to penetrate the shorter vigorous grass tufts while reducing the temperature of the soil and making it more suitable for rainfall infiltration; and
- Deposit concentrated amounts of dung and urine.

All of the above promotes seedling establishment, particularly in bare areas and promotes a healthy productive perennial sward of grasses. Closer plant spacing (increased density) with a better litter layer (organic matter) and stable soils results in less evaporation and more effective rainfall (infiltration) with lower soil temperatures, less rainfall runoff, silting up of streams etc. The presence of predators, in particular lions,

causes buffalo herds to bunch when chased thus intensifying the positive impacts outlined above.

The fact that these large herds are mobile also means that they seldom ‘camp’ on a patch for a long period of time but are continually moving through different landscapes. This means that unlike selective water dependent grazers, buffalo will utilise an area and then move on thus reducing the chance of overgrazing (a function of time and not necessarily number – veld needs rest). For example excessive artificially supplied surface water results in high densities of sedentary water dependent species (e.g. impala). So where and when do we exercise animal control? Even on unfenced areas animal control may need to be considered where water point provision has resulted in increased animal numbers due to their increased distribution resulting in insufficient forage for animals during dry periods (obviously more critical in fenced situations). The alternative is that the population is allowed to fluctuate with the prevailing resource conditions, i.e. a die-off in drought (weaker animals). This may be acceptable in unfenced, ‘open’ situations but is it appropriate in fenced areas where animals are unable to migrate? The tricky issue if the ‘laisser-faire’ option is pursued, is the long term effect on the resources resulting from overgrazing

A hypothetical example from a fenced area – to manage or not to manage

We examine the effect of resource use by grazers by inserting the resource requirements for grazing species and determine whether the grazing population is able to maintain themselves under varying environmental and attendant resource conditions. For this exercise the model is based on a fenced protected area using real data (main grazers rounded off: buffalo 1 000; wildebeest 550; zebra 250; impala 3 100), year 1 grass standing crop (≈ 1 700kg ha^{-1} which provides some residual for the year 2 season’s standing crop) and as a worst case scenario a projected a grass standing crop for year 2 season which yields only 600kg ha^{-1} (approximately the lowest standing crop on the PA in question for some 18 years). The results indicate that there would have been insufficient forage for the grazing animals present on the PA. This information is critical for managers to take early animal management decisions and depending on the amount of risk they are willing to take. Any animal management would be aimed at preventing:

- Excessive animal die-off; and
- Veld degradation.

This situation obviously brings into question the species that we should consider managing. We need to be wary about reducing prey species such as wildebeest and zebra which, in this case are showing encouraging increases (Figure 2). The reason for this caution is that the lion population has the ability to relatively quickly push these and other more sensitive species (e.g. waterbuck) into a predator pit (as happened under high predator levels for wildebeest and zebra between 1997 and 2002 (Figure 2). The latter situation required predator, in particular lion, management – a discussion for another day!). Consideration could be given to the removal of species such as impala but caution is again advised as impala are an important buffer to other prey populations that may be under pressure. All the while the grazing resource would be stressed. To address this situation the removal of around 20 buffalo would have ensured that there was just sufficient food to satisfy the needs of the grazing population (this is obviously an oversimplification but is used here purely for illustrative purposes).

The reality is that we had a good year 2 season so the stressed grazing situation never materialised. If we feed the year 2 standing crop in (≈ 2 100kgha^{-1}) and project an increase in animal numbers minus predation (actual data obtained from the protected area concerned) and remembering that populations close to 'ecological carrying capacity' do not generally increase at rates attained when a population is increasing with surplus resources (on the fast part – logarithmic part of the growth curve) then anything less than 680kgha^{-1} would result in a shortage of grazing. Note: The point at which grazing stress becomes an issue increases from 600kgha^{-1} to 680kgha^{-1} (assuming reduced animal increment levels for the reasons given above resulting in more grass but still a stressed grazing resource to 'break-even). At 600kgha^{-1} it would be difficult to reduce the number of buffalo alone (in one exercise) to get to the 'break even' point as this number would be projected at around 1 150 to reduce to around 900 (a 10% increase in buffalo from 1 000 is 100! Plus the other species would also increase in number). Is this logistically practical? We need to look at other species as well. In addition, for example, 700 impala could be removed to stabilize the situation. As stated above however we need to be wary to reduce prey species such as wildebeest and zebra (which are both increasing), as well as waterbuck due to their susceptibility to heavy predation.

BUT the above assumes a drought situation and we are coming off a run of good seasons. The good news is there was sufficient grazing and offtakes should be aimed at maintaining this situation depending on rainfall. A staggered offtake is logistically preferable but what I aim to illustrate in this discussion is how quickly 'things can get away'. On fenced areas where the animals cannot move the situation is even more critical!!

An active adaptive management approach means that in the worst case scenario:

- We suffer a drought
- We lose animals;
- Pressure is taken off the veld;
- Feeding is considered in some instances;
- We recoup something from offtakes.

The best case scenario would be that;

- We do not suffer a drought
- We lose animals through natural attrition
- Pressure is taken off the veld;
- The veld remains in a favourable condition;
- We recoup something from offtakes.

In unfenced protected areas there is obviously another option in terms of management, that of a laisser faire or hands-off approach. However, populations cannot increase at consistent rates under stressed conditions so one would expect a drop off in natural increments. So we use adaptive management where opportunities are grasped (allow numbers to climb) and hazards are avoided (large scale die-offs related to veld degradation).

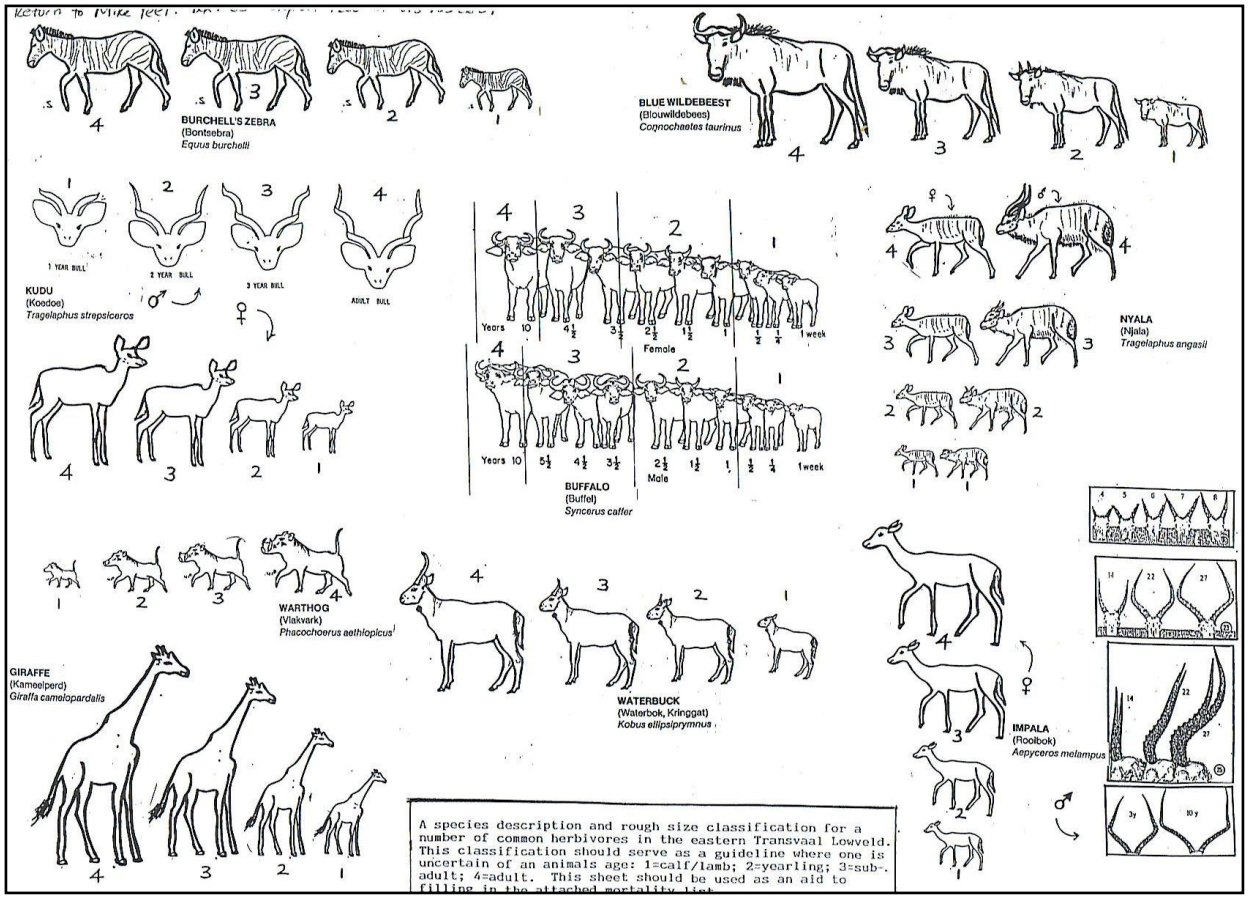
In many Lowveld protected areas the stocking rates are such that it would require a relatively large management effort to reduce the numbers to adapt to any decline in veld condition. As the grazing resource is generally limiting, grazer species in particular require constant monitoring (removal, feeding or no action). These 'managed' animals would be animals not removed by predation but considered necessary for removal for ecological reasons while at the same time being careful not to push prey species into a

‘predator pit’ and all the while striving to achieve the ecological and economic objectives of the protected area in question.

Appendix E

Sex and age structures of herbivores on APNR reserves (use attached sheet to assist with sex/age classification-PTO)

Date	Species	Number	Age class/sex								Location/GPS
			1		2		3		4		
			M	F	M	F	M	F	M	F	



Guide to assessing age in various game animals for use in age classification (previous page).