Ecological Monitoring: Palabora Mining Company – Pompey

Dr. Mike Peel

Twelfth Report: 2015

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ACKNOWLEDGEMENTS

Tony Swemmer as well as the management of Palabora Mining Company are thanked for their enthusiasm and support for the ecological program.

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EXPANDED SUMMARY

This report serves as the "ecological audit - update" for the Palabora Mining Company Pompey (PMCP). We began with ecological monitoring studies on PMCP in 2002/03. The general background to the study, methods used, and initial results and discussion can be obtained from reports dating back to this time (see reference list). The emphasis in this report is placed on the presentation of results and a discussion of the study to date. A formal aerial survey was conducted on Pompey in 2015.

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 and the woody/herbaceous ratio. This report is presented as an expanded summary.

As discussed in the previous report, consideration should be given to see how 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 can be integrated into the PMC BAP plan. 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 (necessary for effective management, development and regulation of sustainable utilisation) from the relevant Nature Conservation and Environmental authorities;
3. The Management Plan assists in the yearly planning of veld management tasks and the budgeting thereof.

We have completed such Management Plans for the we have completed such plans for the **Associated Private Nature Reserves (APNR), Blue Canyon Game Conservancy**

(BCGC), Sabi Sand Wildtuin (SSW), Hans Merensky, Thornybush Private Nature Reserve, Eden Nature Reserve (Nelspruit), Penryn College, Raptors View, Longmere Estate, Kapama Game Reserve, Thornybush Game Reserve and **MalaMala Game Reserve** and these are now lodged with the Department of Environmental Affairs and Tourism, Limpopo Economic Development, Environment and Tourism (LEDET) and the Mpumalanga Parks and Tourism Authority (MTPA). There is only a limited precedent available to guide the compilation of a Management Plan in terms of the new legislation. SANParks have submitted a number of Management Plans for their National Parks. We recently reviewed a number of management plans for **De Beers Ecology Division.**

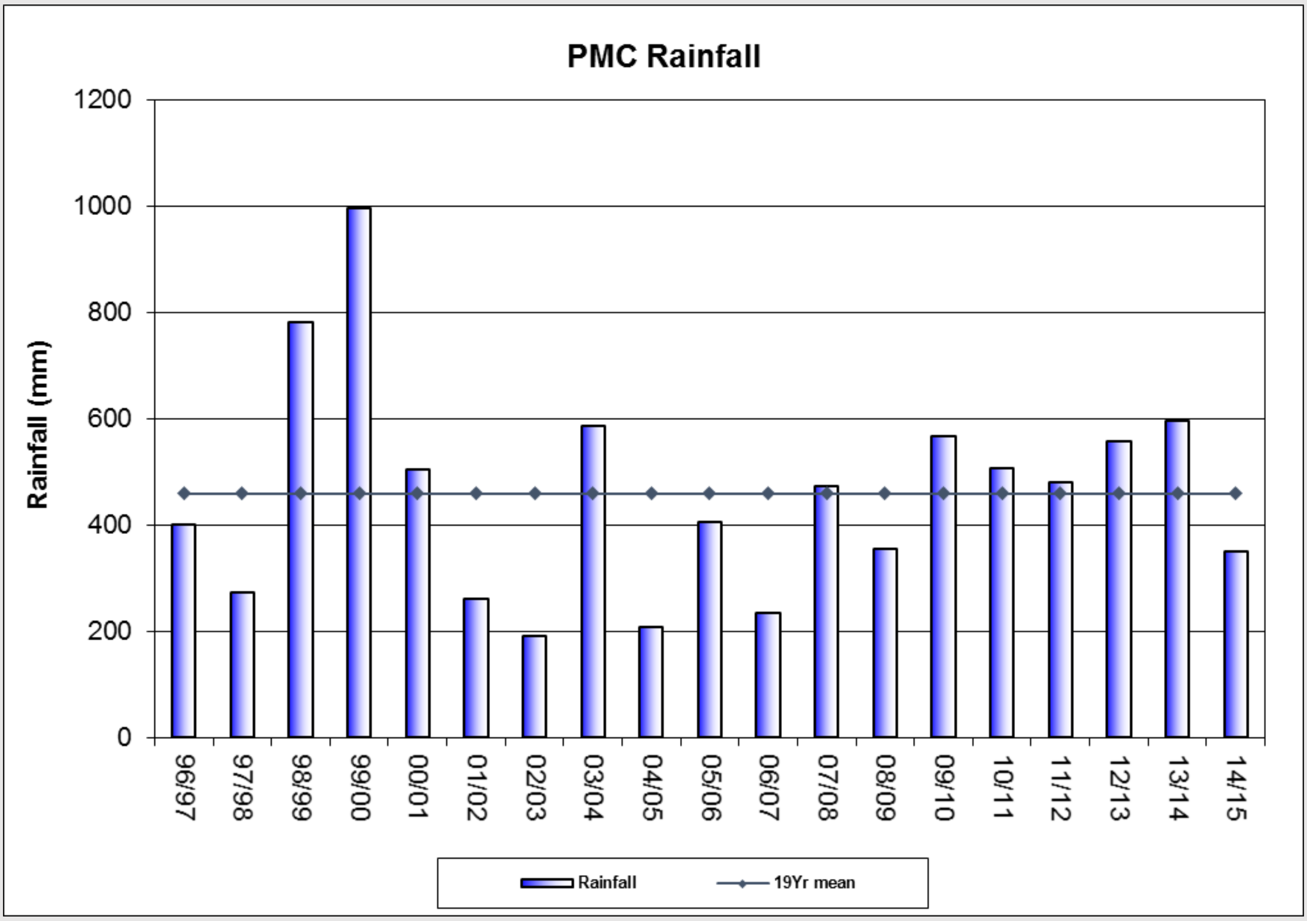
RAINFALL

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 means 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’. Current modeling efforts hint at an increase in annual rainfall in this area which puts a premium on good grass/herb cover to avoid increased runoff and erosion.

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/expected rainfall is received. PMCC can be said to have had a ‘dry’ season following five successive ‘wet/very wet’ seasons (Table 1 and Figure 1). A question to management - have the additional rain gauges been placed on Pompey?

Table 1 Comments on rainfall on PMCC. * The mean annual rainfall changes annually as new data are added each year. So each year is based on the mean of the years for which rainfall data are available.

Year	Rainfall (mm)* (460mm; y=19)	% of long term mean	Comment
1996/97	401	87	Dry
1997/98	272	59	Drought
1998/99	783	170	Very wet
1999/00	997	217	Very wet
2000/01	505	110	Wet
2001/02	262	57	Drought
2002/03	192	42	Severe drought
2003/04	587	128	Very wet
2004/05	209	45	Severe drought
2005/06	406	88	Dry
2006/07	234	51	Drought
2007/08	474	103	Close to expected
2008/09	355	77	Dry
2009/10	568	124	Wet
2010/11	508	110	Wet
2011/12	480	104	Close to expected
2012/13	558	121	Wet
2013/14	597	130	Very wet
2014/15	350	76	Dry



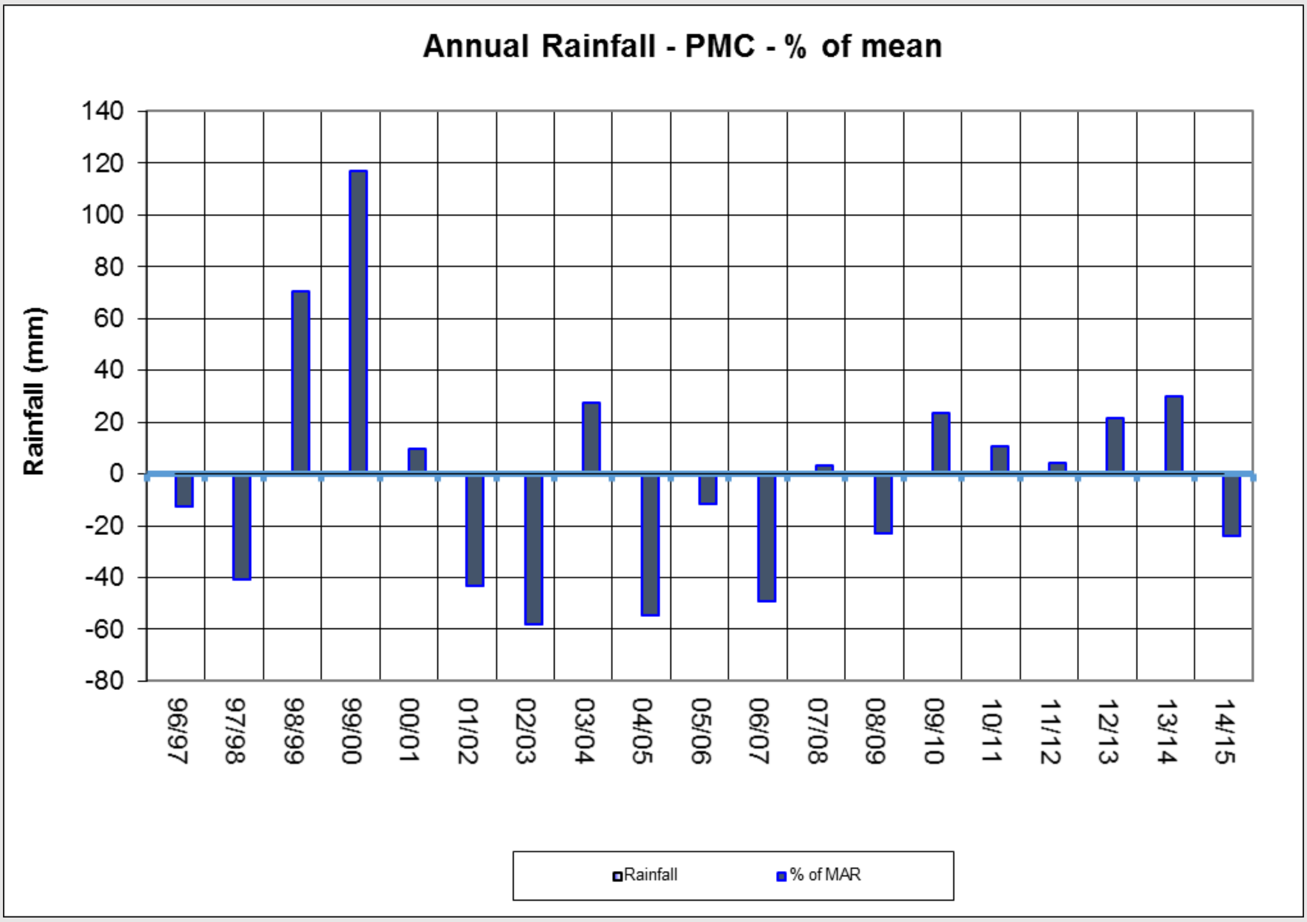


Figure 1 Annual rainfall for PMC and the mean.

THE VEGETATION

The monitoring results are discussed and presented graphically in Figures 2 to 8 and in tables 2 to 6. A discussion of the results follows in the text. Vegetation changes on PMCP 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 therefore compare important vegetation parameters among PMCP and 3 other reserves in the area.

Grass

As projected, the proportion of perennial grasses increased again while cover distance declined markedly (still better than mean 11y) while tuft size increased (marginally – better than the mean). **There is currently a high proportion of perennial grasses and moderate cover (distance and tuft).** The season lag between rainfall received and range condition is evident with increased perennial proportions and larger tufts although further apart as a result of the favourable 2013/14 season. Grasses establish following the favourable rainfall seasons (recent years) resulting in closely spaced but smaller new tufts (2013/14). As these tufts establish and increase in size (2014/15) some tufts may be competed out of the system and this was further exacerbated by the dry 2014/15 season. As previously stated the condition of the veld hints at relatively low grazer numbers and this was confirmed from the 2015 game count. (Figures 2 to 4).

The prediction is that, given the dry 2014/15 season (some 24% below the rainfall mean) and notwithstanding the relatively favourable recent seasons, the perennial composition and cover will at best be maintained but will probably decline. This is despite the current relatively low grazer stocking densities I think even if we experience a favourable 2015/16 rainfall season (lag effect - see also the discussion relating to animal numbers and drought in Appendix A). If we have another dry season the impacts will in all likelihood be more pronounced with a probable further decline in perennial composition and cover. 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.

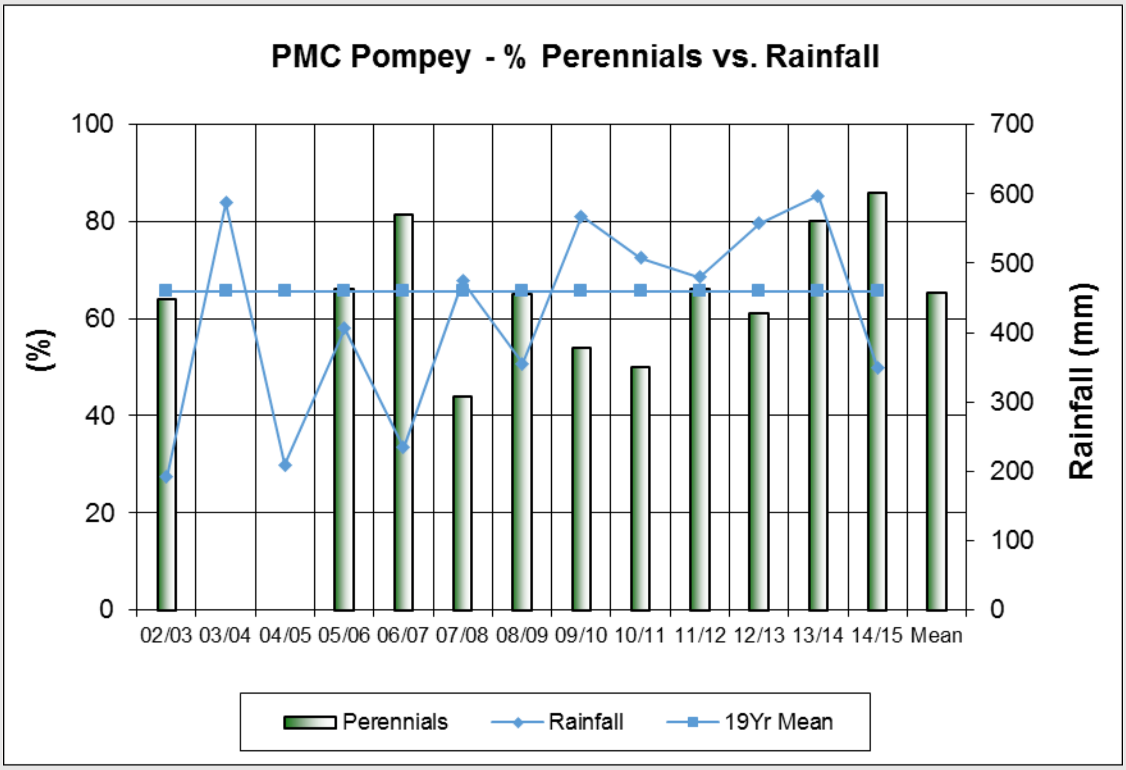


Figure 2 Percent perennial grasses present on PMCP and rainfall.

Table 2 Perennial grass trends on PMCP.

PMCP overall	General Comment **2014/15**; and Comment **Long term**
	Improved. High proportion of perennial grasses; **Consistently moderate-high**

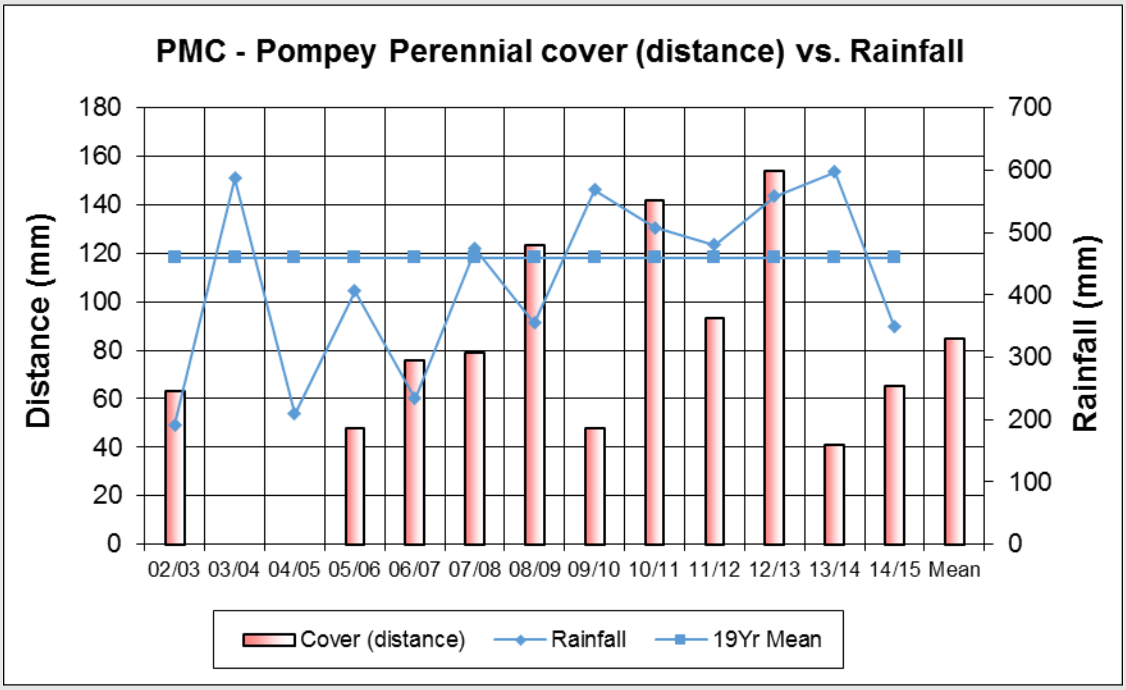


Figure 3 Mean distance to perennial grasses on PMCP and rainfall.

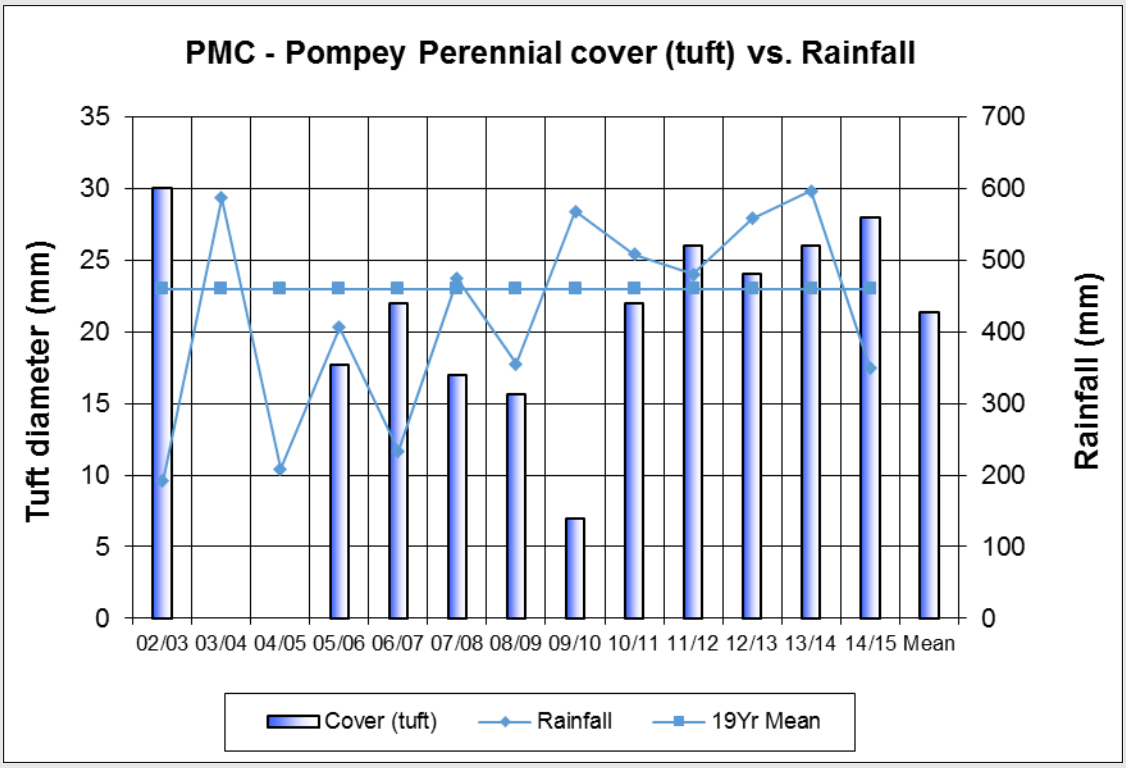


Figure 4 Mean tuft diameter of perennial grasses on PMCP and rainfall.

Table 3 Perennial grass cover trends on PMCP.

PMCP overall	General Comment **2014/15**; and **Long term;** Distance measure (top), tuft measure (bottom)
	Decline; Moderate-low **Slight increase - stable; Moderate-low**

Grass standing crop is a function of herbaceous production and represents the portion of production that remains after utilisation. This measurement is tightly correlated to the amount of rainfall received in the year of measurement although there is some carry over from previous seasons (particularly extremely wet or dry seasons). The latter is in turn a function of the rainfall received and resulting composition and related productivity of the grass sward. The grass standing crop at the end of the 2014/15 summer season can be said to have been moderate-high for KGR (Figure 5 and Table 4). The relationship between grass production and standing crop is highlighted with recent favourable rainfall seasons resulting in improved soil moisture conditions that promote grass growth, a favourable perennial composition and cover and an increase in grass standing crop. Such favourable conditions would act as a further buffer to the dry 2014/15 season. The moderate-high grass standing crop in a dry area like this further hints at light stocking rates.

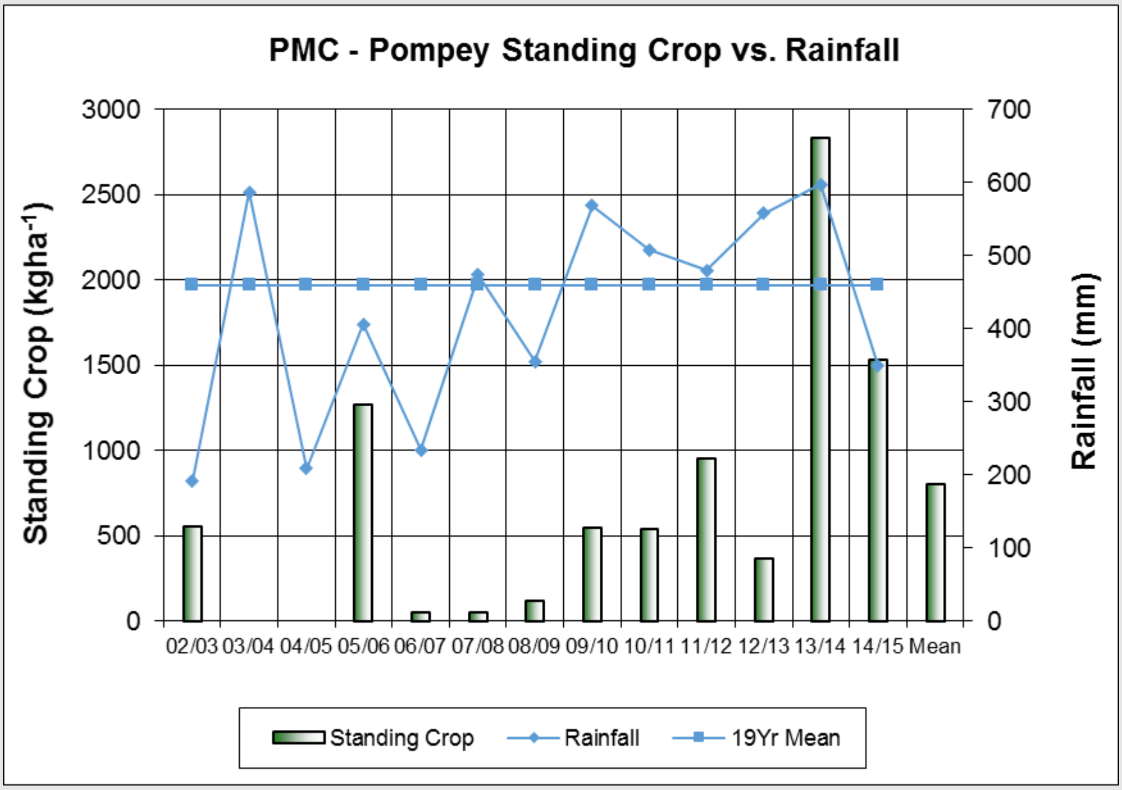


Figure 5 Grass standing crop on PMCP and rainfall.

Table 4 Grass standing crop on PMCP.

PMCP Overall	General Comment **2014/15**; and Comment **Long term**	Trend on PMCP VH=very high; H=high; M=moderate; L=Low; VL=very low									
		05/ 06	06/ 07	07/ 08	08/ 09	09/ 10	10/ 11	11/ 12	12/ 13	13/ 14	14/ 15
	Moderate high grass biomass**; Moderate-low**.	M	V-L	V-L	V-L	M-L	M-L	M-L	L	V-H	M-H

Grass standing crop measurements have important implications for grazing and fire management. A forage flow estimate was thus made for PMCP based on the animal numbers from the 2015 count (Figure 6 and Table 5). Results show that there would be sufficient **grazing** through the winter. Note again 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 pick up the faecal analysis as it provides an indication of the physical condition of the game.

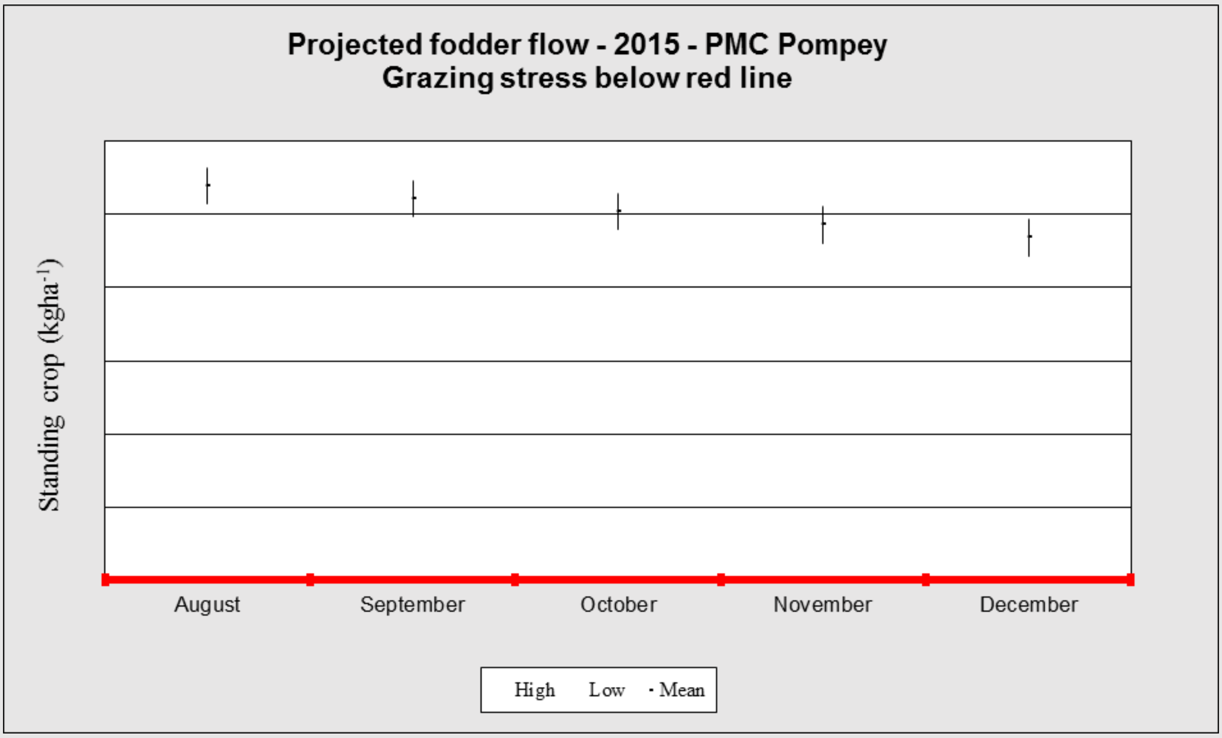


Figure 6 Projected forage flows on PMCP for winter 2015.

Table 5 Forage flows on PMCP.

Property	Comment
PMCP	Grazing sufficient through the winter.

Table 6 compares the vegetation condition of a number of important grass parameters on PMCP (mean value) and three reserves (with their property number in the larger data set) in the area:

Grass Parameter	PMC Pompey 25	PMC Cleveland 24	Res. 19 used 21 in 13/14	Res. 20	PMCP Rank (06/07 07/08 08/09 09/10 10/11 /4)											
					03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Perennial (%)	86	69	53	69	1	2	1	1	3	1	1	1	1	1	1	1
Cover (distance-mm)	65	132	105	111	2	2	2	3	3	2	1	1	2	3	1	1
Cover (tuft size-mm)	28	25	23	23	1	2	2	2	3	1	4	2	2	2	1	1
Standing crop (kg/ha)	1 535	56	308	50	1	3	2	2	2	3	4	2	4	3	1	1

The above illustrates that PMCP again ranks high when compared to three surrounding reserves.

Trees

Woody density varies across the different areas, with fluctuations broadly corresponding to ‘wet’ (normally decreased density) and ‘dry’ (normally increase in density) (Figure 7). Woody density increased in 2014/15 overall while canopy cover for PMCP has been quite variable (Figure 8). Due to some of the sites having been lost through mining operations tree densities and canopy cover means may be misleading and for this reason we are examining tree trends across the study area on a site by site basis.

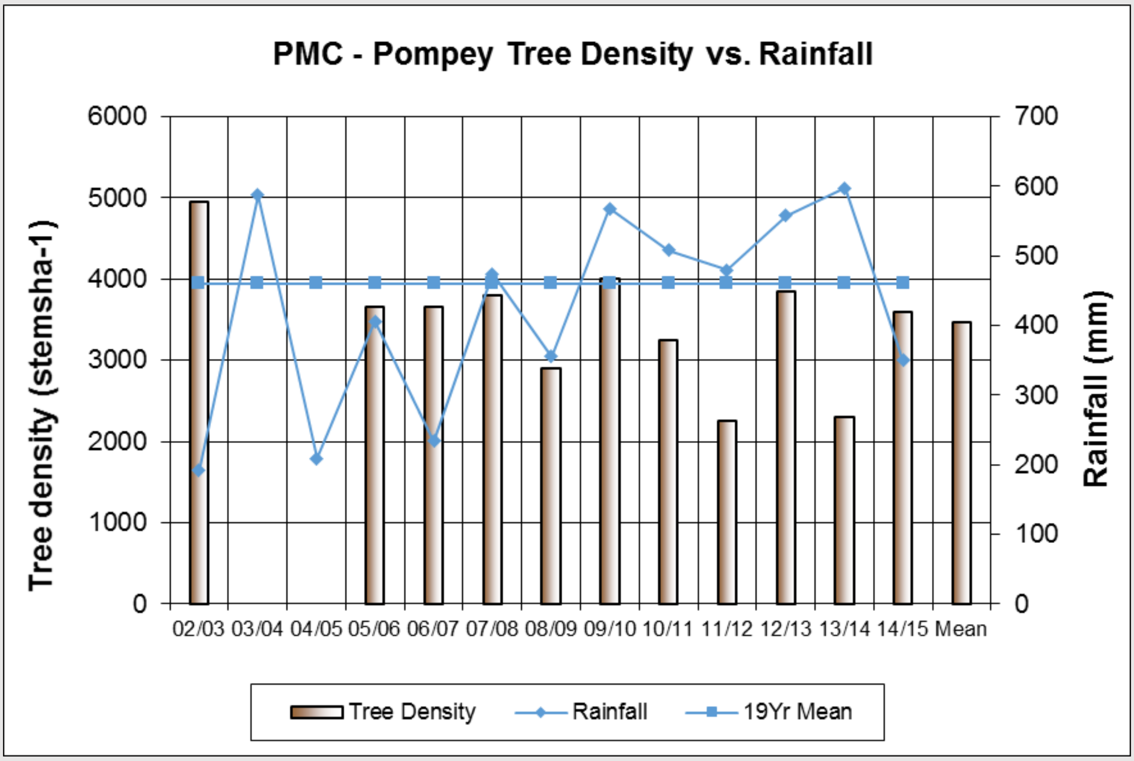


Figure 7 Mean woody densities on PMCP and rainfall.

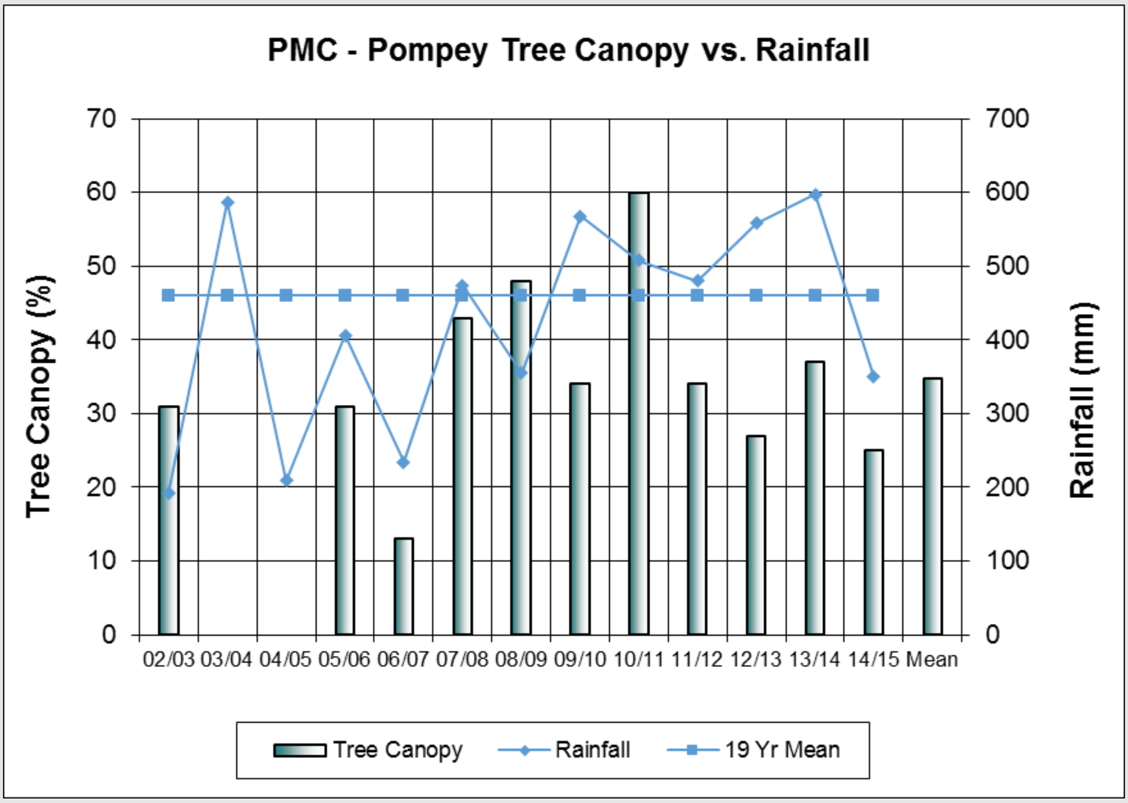


Figure 8 Mean tree canopy cover on PMCP and rainfall.

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 also important to determine the proportion of the various feeding classes on PMCP. Appendix B presents the animal numbers from the 2015 count

Work by Peel, Kruger and Zacharias (2005) shows that appropriate stocking rates, depending on veld condition, for these areas should be placed between the agricultural guideline of 4 500 $kgkm^{-2}$ and the Coe *et al.* (1976) upper guideline (4 437$kgkm^{-2}$). As we come off a run of favourable rainfall years, we sensitise landowners on fenced properties in particular to the possible effects of a dry/drought period which may result in a stressed grazing resource (see Appendix A for general discussion in this regard). It must also be noted that there is little information as to the number of animals of different species that perish due to predation on areas such as PMCP.

Using the 2015 data, we see that the stocking rate is well above the upper guideline (Figure 9). In the 2013 and 2014 reports I said I that “the stocking rate is lower than in previous years but given the current grass species trends in particular this is difficult to explain in the absence of quantitative data”. The results of the 2014/15 vegetation survey would appear to support this statement and highlights the need for consistent ongoing monitoring which helps explain such anomalies. However the total stocking rates are very high largely due to the presence of 20 elephant. When the elephant and hippo are removed (leaving only the prey biomass) it can be seen that the stocking rate, in particular the grazer stocking rate, is in fact very light.

The feeding class ratios from the 2015 count indicates a skewed distribution dominated by feeding class 3 (mixed feeders elephant and impala) with relatively low proportions of bulk and selective grazers and browsers (Figure 10). This is not ideal but the fact that the elephant population is probably highly mobile means that there will in all likelihood be less pressure on the veld (as reflected in the veld condition and grass standing crop).

Within a set of agreed upon objectives it would be very useful to plot a way forward for game management on Pompey. As previously discussed, in order to enhance the decision making process as regards game management on PMCP, sex and age data would be useful (Cyber tracker – environmental monitors?). This in conjunction with count data is critical.

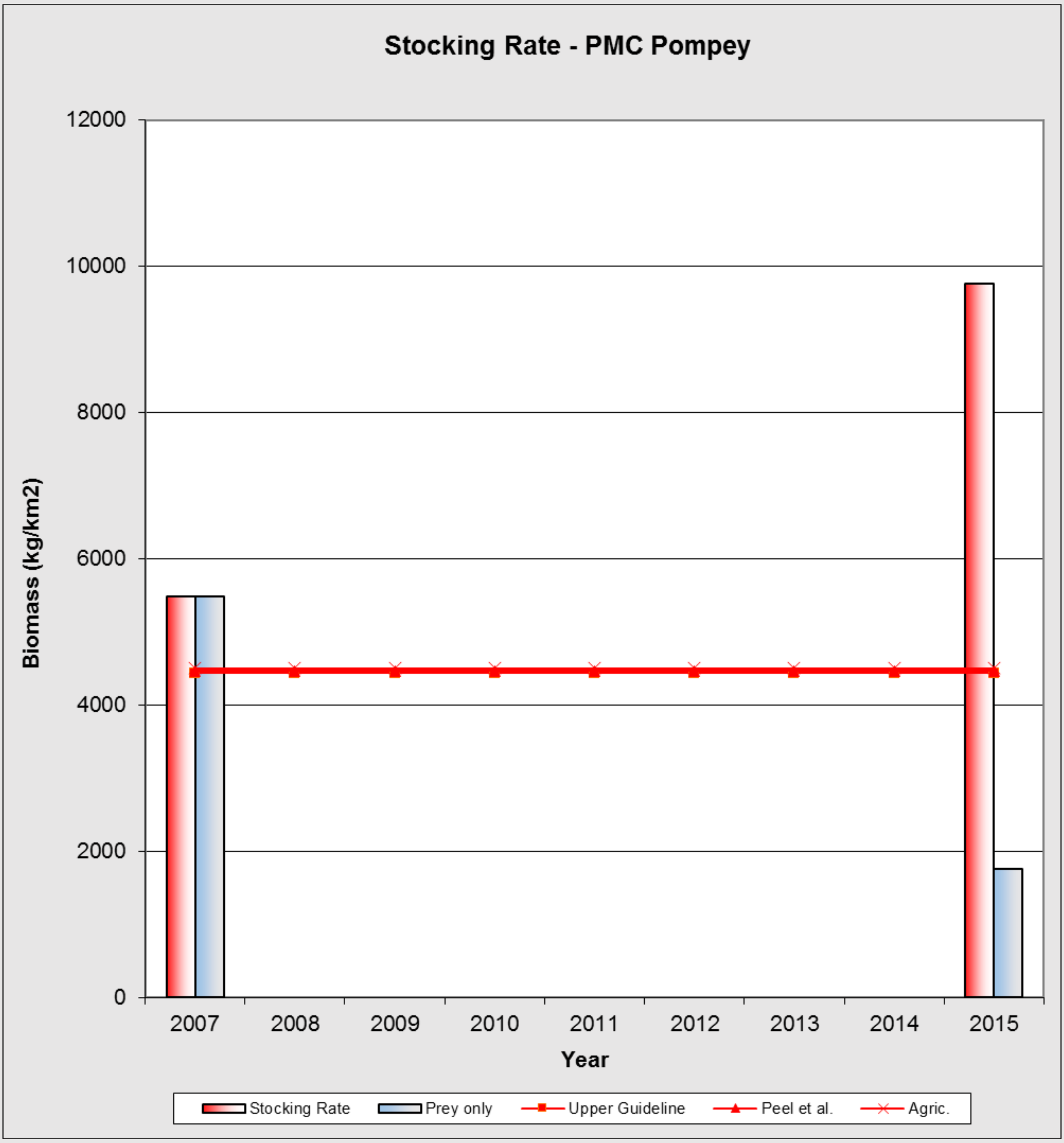


Figure 9 Herbivore biomass (kgkm^{-2}) on PMCP (2015 game numbers used).

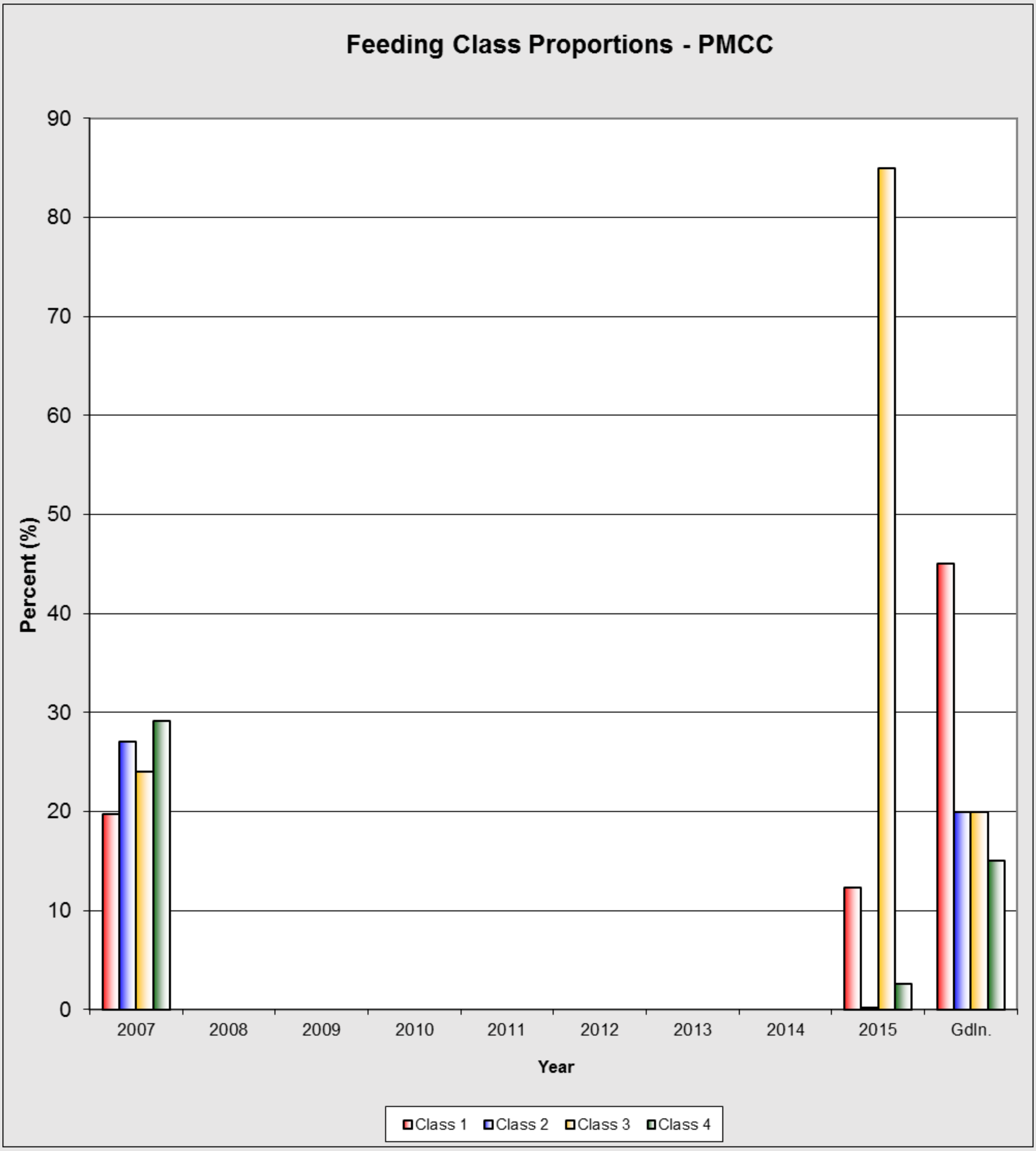


Figure 10 Feeding Class proportions on PMCP (2015 game numbers used).

Energy flows and sustainability on PMCP

I examined the effect of resource use by grazers by inserting the resource requirements for wildebeest, warthog, impala, waterbuck, zebra, buffalo, hippo, rhino and elephant and 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). Using this method, Figure 11 shows that there would be **sufficient** grass to satisfy the energy requirements of the game present on PMCP during the winter of 2015. This agrees with the forage flow calculations presented in Figure 6.

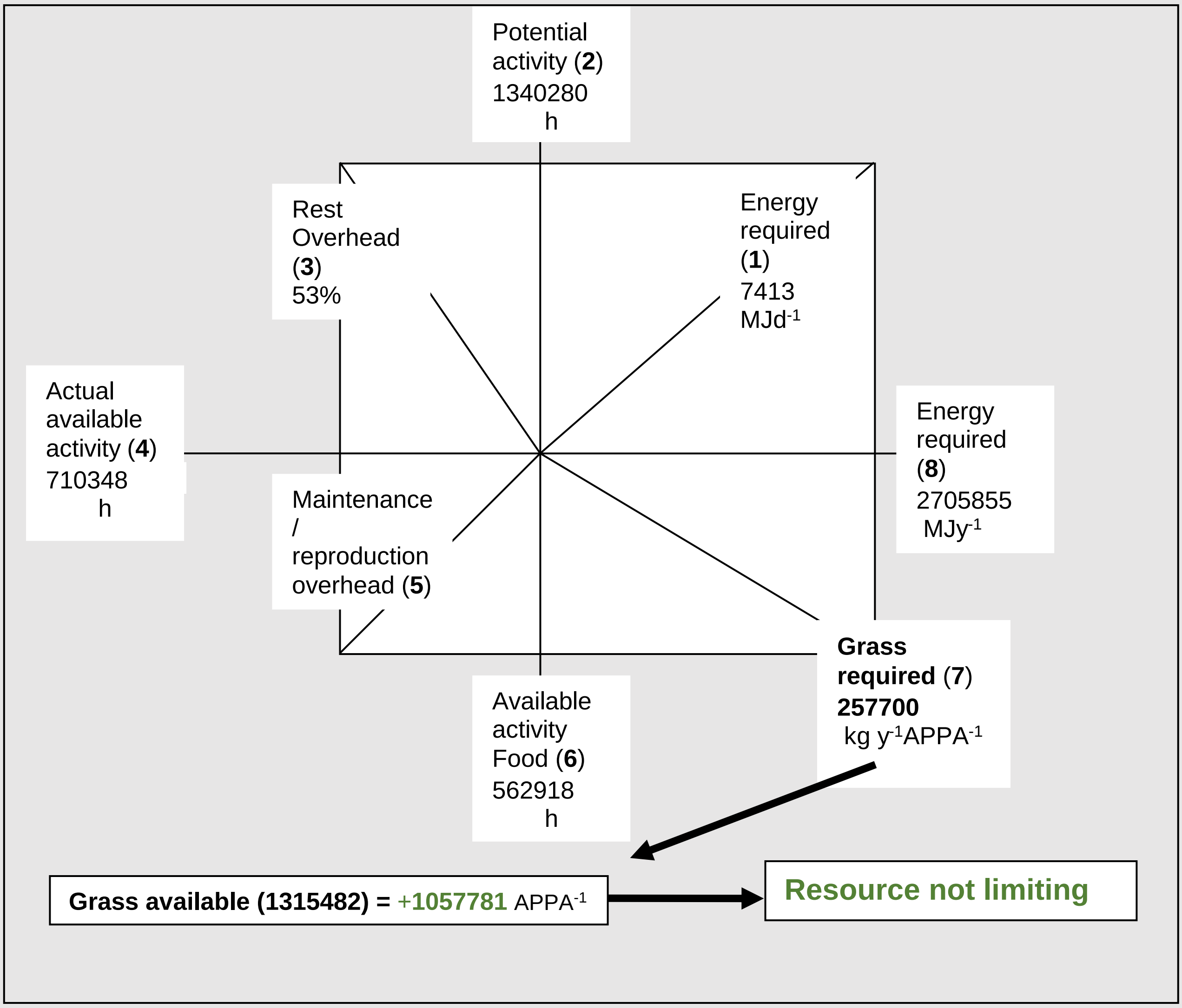


Figure 9 Resource availability in a multi-species grazing system – PMCP 2015.

In terms of information available for the management of herbivores and, where reliable trends are sought, the value of consistent counting methods and teams cannot be overemphasised. The importance of the vegetation-monitoring programme is evident. If we accept that an amount of 2 % of the total value of the **animals present** on a reserve is considered reasonable when taking a decision on ecological monitoring and annual game count (ABSA 2003) then let us look at the situation on PMCP (not including the cost of land, infrastructure etc. and using the count figures for 2015) (Table 7).

Table 7 PMCP estimate of costs as a proportion of the value of animals present

<table>
<tr><th>Species</th><th>Total Value (R)</th><th>(1) Total cost of vegetation monitoring (Exc. Vat) (R)</th><th>(2) Total cost of helicopter count @ R6 500 per hour (Exc. Vat) – say 1.5 h including ferry (R)</th></tr>
<tr><td></td><td>1018338</td><td>10 907</td><td>9 750</td></tr>
<tr><td>Cost of ecological monitoring (1) and (2) as percentage of value of game (%)</td><td></td><td>1.1</td><td>0.99</td></tr>
<tr><td>Cost of ecological monitoring as percentage of value of game (%)</td><td></td><td colspan="2">2.1</td></tr>
<tr><td>Recommended percentage (%)</td><td></td><td colspan="2">2.0</td></tr>
</table>

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

FAECAL ANALYSIS

A total of 17 reserves have extended their ecological monitoring programme to include looking at animal condition as an adjunct to the 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 deficiencies generally lead to reduced reproduction rates. The higher the palatability of the plants the higher the protein and phosphorous concentrations and digestibility. 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

I have left the end of summer 2009/10 data in for completeness. To summarise:

1. The **N levels** for wildebeest (grazer), warthog (grazer) and kudu (browser) were all above the guideline indicating no nutritional stress. This is expected at the end of the summer season. The end of winter collection is thus critical for assessing the situation at the end of winter (Figure 10).
2. The **P levels** for wildebeest (grazer), warthog (grazer) and kudu (browser) were all above the guideline (Figure 10).

The above results support the statement that in these savanna systems the grass layer is the limiting layer. 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 C).

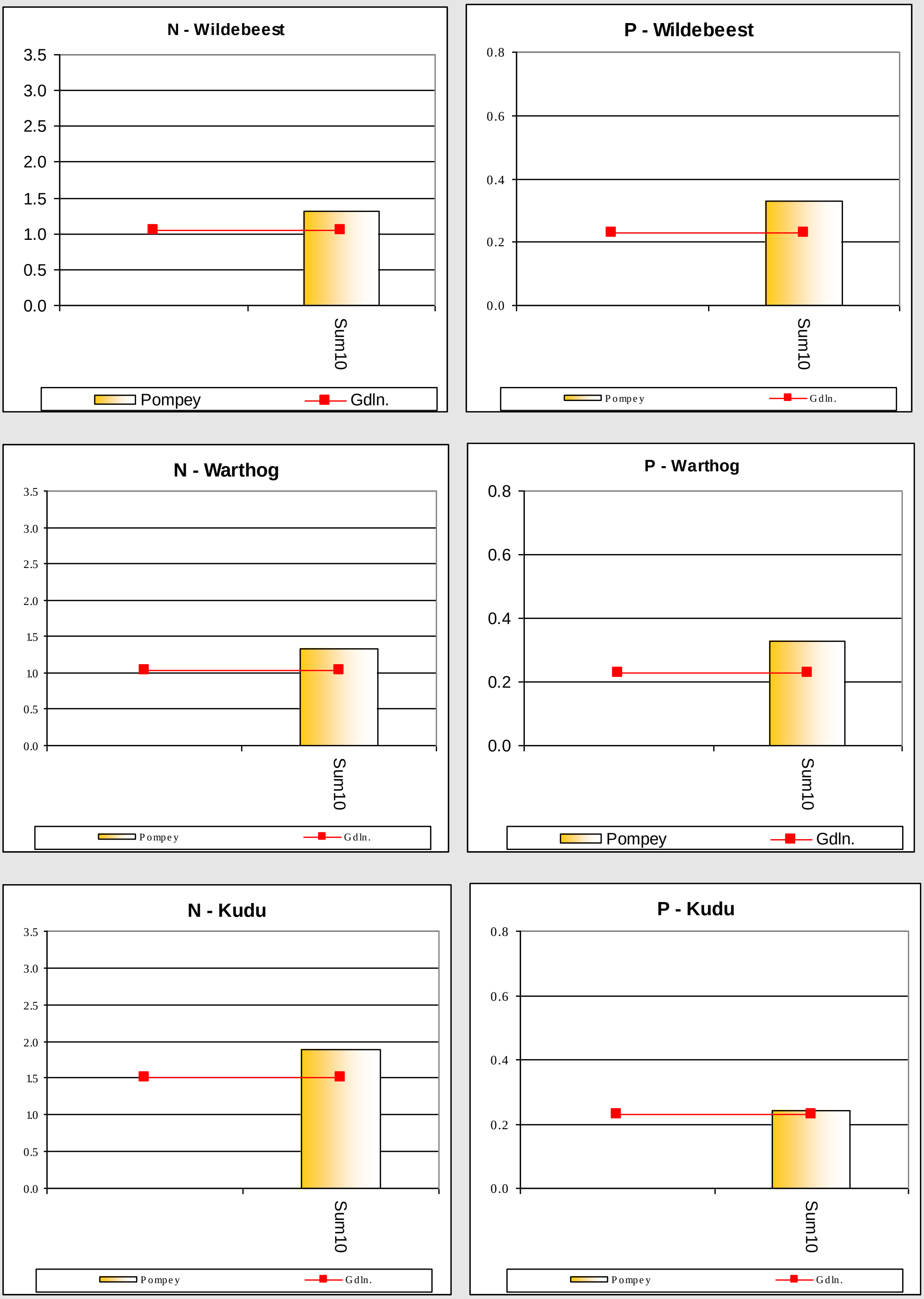


Figure 10 N and P trends in some herbivores on PMCP.

The position of PMCP in terms of information available for the management of herbivores has improved through the increasing run of vegetation data and, where reliable trends are sought, the value of regular consistent monitoring methods and teams cannot be over-emphasised. The importance of the ecological monitoring programme is apparent, as any change in management regimes will interact with climatic conditions to influence the vegetation component.

Overall, the monitoring programme continues to receive excellent support from PMC. 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 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

Lowveld Protected Areas: To Manage or Not to Manage

Mike Peel (Agricultural Research Council, Rangeland Ecology Group – mikep@arc.agric.za)

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.

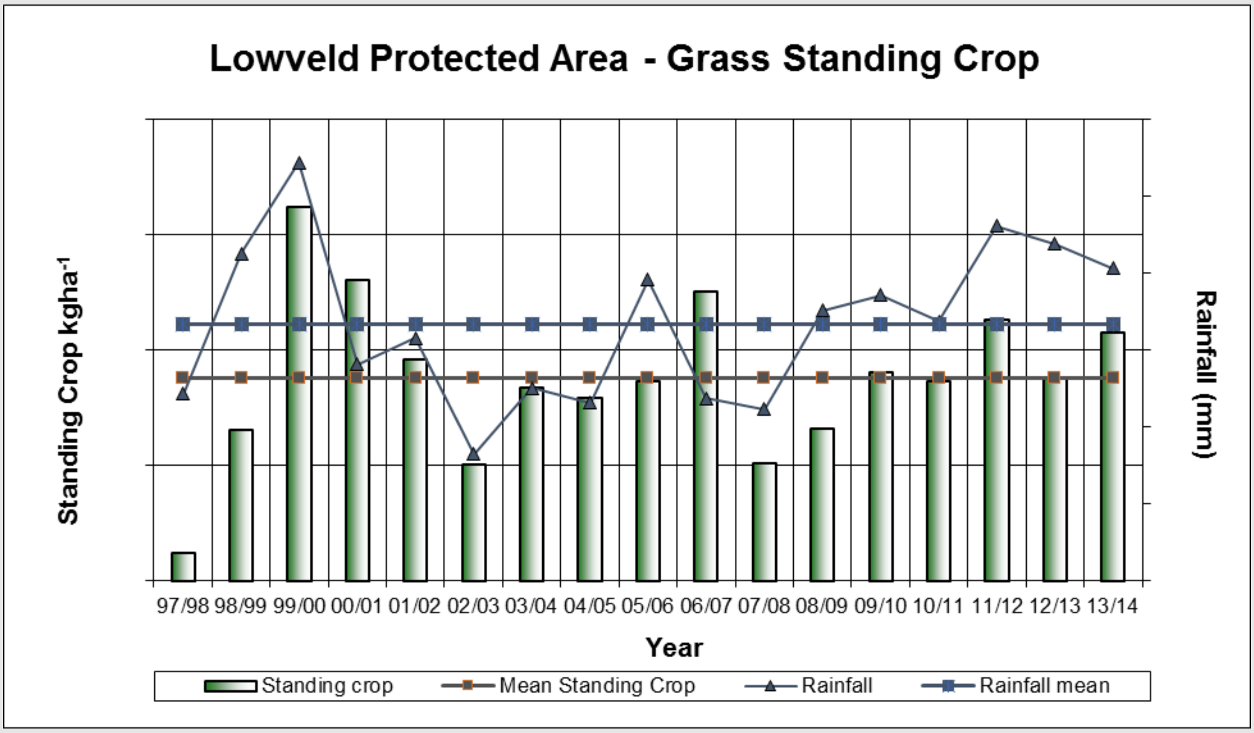


Figure 1 illustrating the favourable relationship between annual rainfall and grass standing crop (note mean or above mean rainfall since 2008/09 and above or above average grass standing crop since 2009/10 – note lag of one rainfall season before the grass response becomes clearly evident.

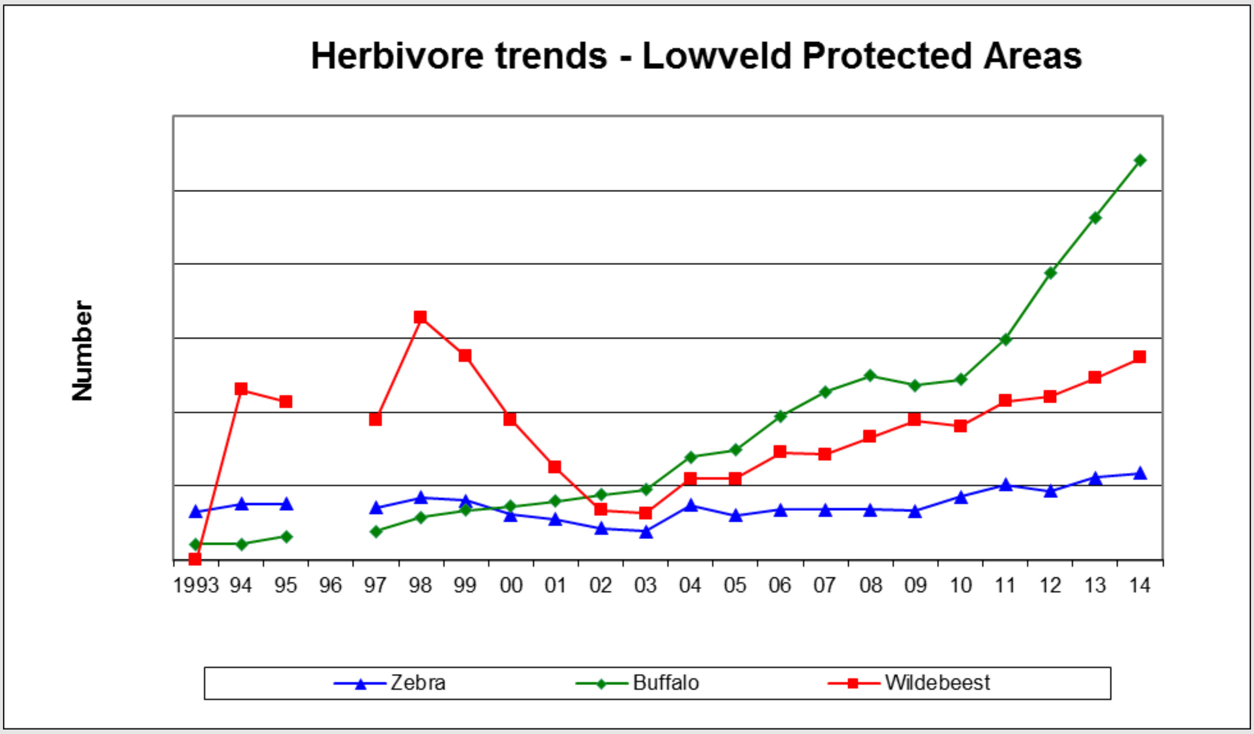


Figure 2 illustrating trends in three grazing species in the protected areas of the eastern Lowveld. Note the increases in these important grazers in response to the data shown in Figure 1 (increased rainfall and increased grass standing crop from around 2008/09 and linked increases in grazing animals)

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 (≈ 2 100$kgha^{-1}$) 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 680$kgha^{-1}$ would result in a shortage of grazing. Note: The point at which grazing stress becomes an issue increases from 600$kgha^{-1}$ to 680$kgha^{-1}$ (assuming reduced animal increment levels for the reasons given above resulting in more grass but still a stressed grazing resource to ‘break-even). At 600$kgha^{-1}$ 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 B

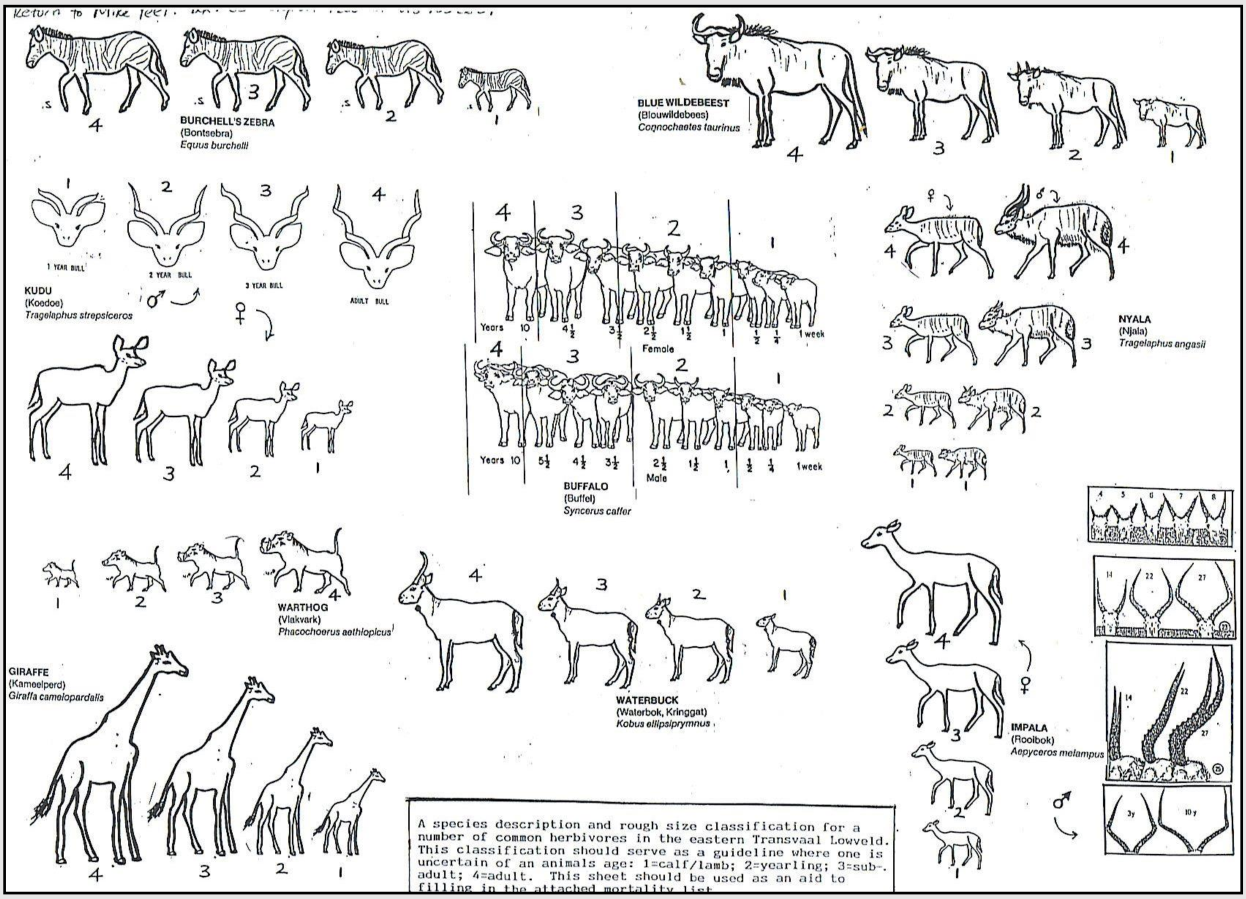
Animal numbers obtained from the 2007 estimate (Tim Paxton *pers. comm.)* and 2015 aerial count.

Species	2007 estimate	2015 count
Buffalo		20
Eland	15	0
Elephant		21
Giraffe	8	2
Elephant		21
Impala	116	102
Klipspringer		2
Kudu	67	6
Ostrich	22	0
Waterbuck	36	4
Warthog	32	5
Wildebeest	77	0
Zebra	16	0

Appendix C

Sex and age structures of herbivores on PMCP (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)