Ecological Monitoring: Palabora Mining Company – Cleveland

Dr. Mike Peel

Fourteenth Annual 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 Cleveland (PMCC). We began with ecological monitoring studies on PMCC in 2000/01. 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. On a positive note a full game count was done in 2015 for the first time since 2007.

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.

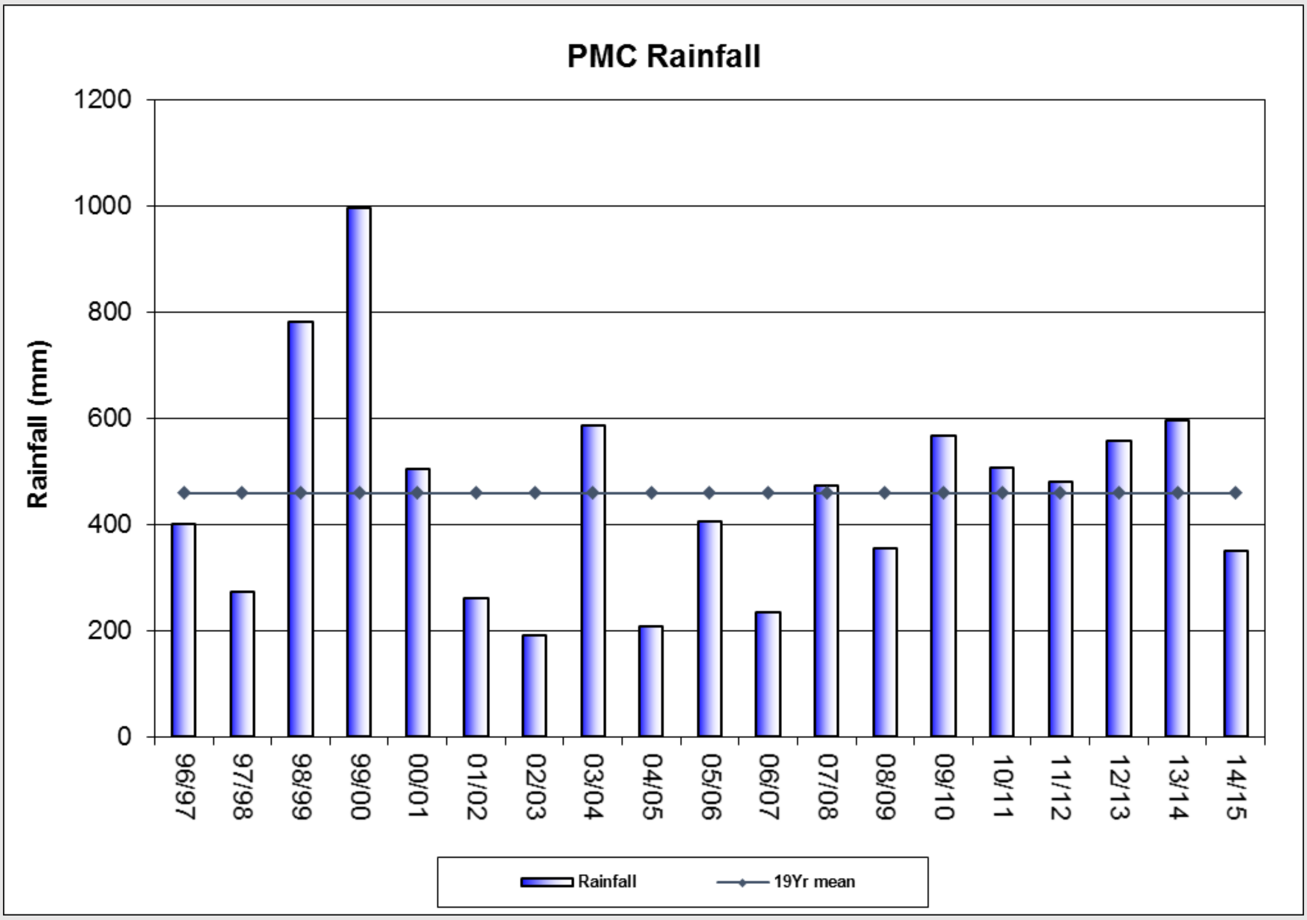
The observed effect of rainfall on the vegetation is discussed under the vegetation section of this report. The importance of careful management is emphasised as this allows for hazards (normally drought related-current) to be avoided and opportunities (following favourable seasons) to be grasped. A 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).

At the time of writing (February 2016) the PMCC area the SAEON offices at Phalaborwa Gate had received only 135 mm since June 2015 (Swemmer *pers. comm.*). Further, the early rains in September 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 dry/drought season.

Table 1 Comments on rainfall on PMCC.

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	503	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

* 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



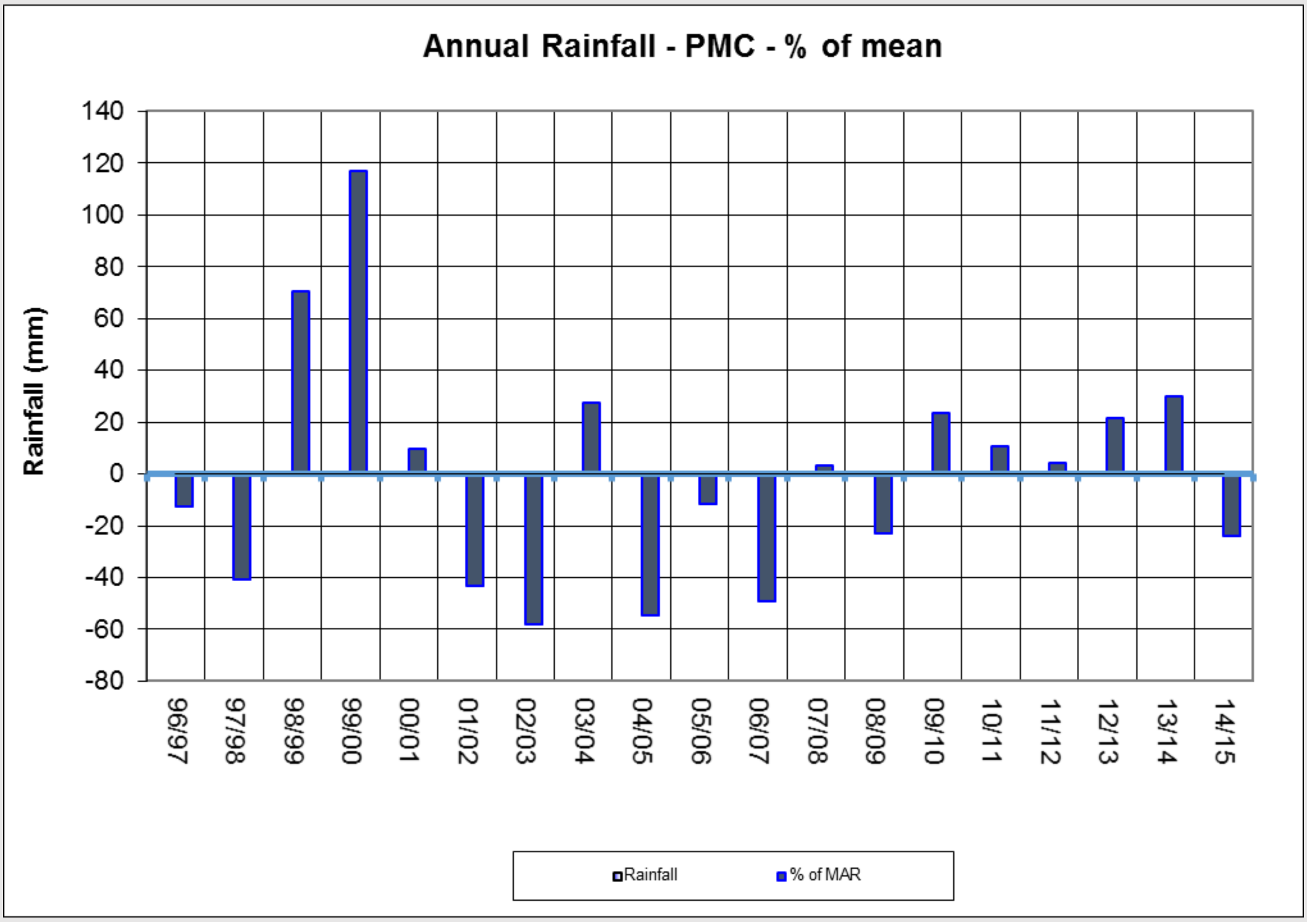


Figure 1 Annual rainfall for PMC (top) and as percentage of the mean (bottom).

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 PMCC 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 PMCC and 3 other reserves in the area.

Grass

We predicted at least maintenance in the proportion of perennial grasses and cover on 2015. There was in fact a small decline in the proportion of perennial grasses but an overall stable perennial cover (distance – decline; tuft – slight increase). Note the general lag of a season between rainfall received and response in the perennial composition in particular and cover. There continues to be a moderate-high proportion of perennial grasses. The cover measurements indicate a situation different to last year with larger tufts but further apart which is probably less desirable than having smaller tufts but closer together (grazing lawn type situation) (Figures 2 to 4).

The perennial composition and cover will probably decline in 2016 (given the current situation and even if good rainfall is received from late February 2016 onwards). 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. Fortunately the game on PMCC can move to other areas but water dependent species such as impala are sedentary and this does pose some challenges (see later in the report). The 2015 game count was critical because, as previously stated, while rainfall drives the system the animal component further modifies it.

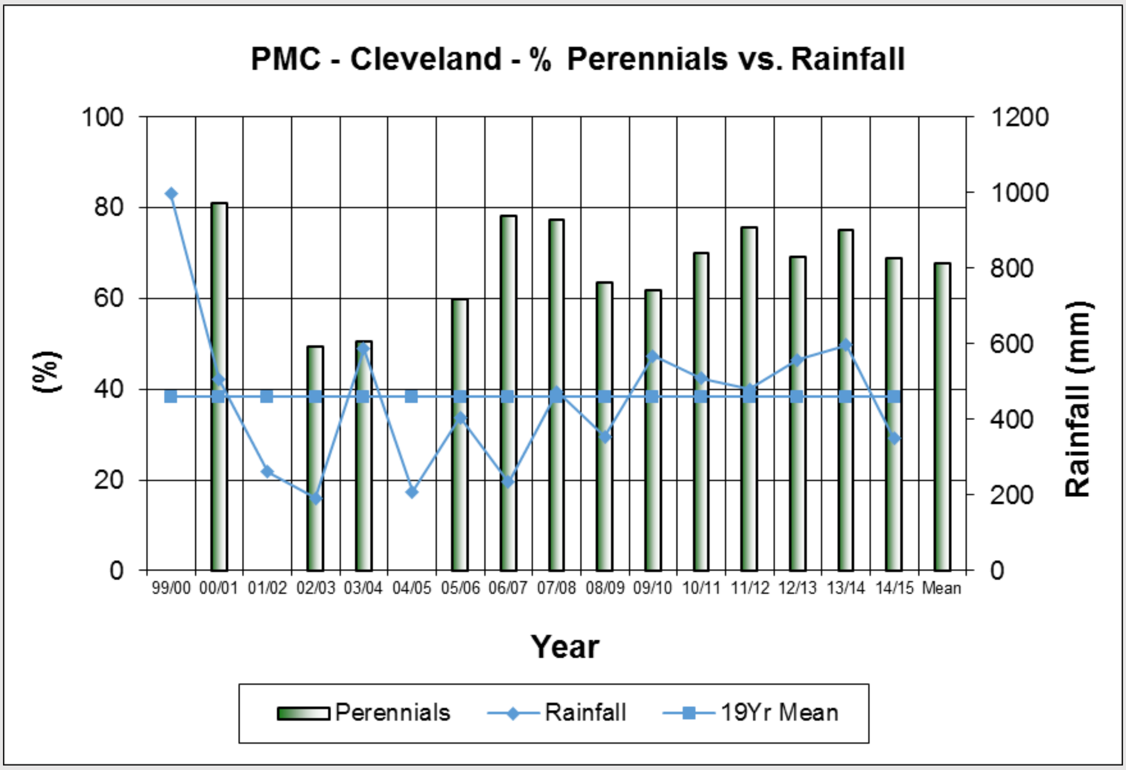


Figure 2 Percent perennial grasses present on PMCC and rainfall.

Table 2 Perennial grass trends on PMCC.

PMCC overall	General Comment **2014/15**; and Comment **Long term**
	Decline. Moderate-high proportion of perennial grasses; **Consistently moderate-high**

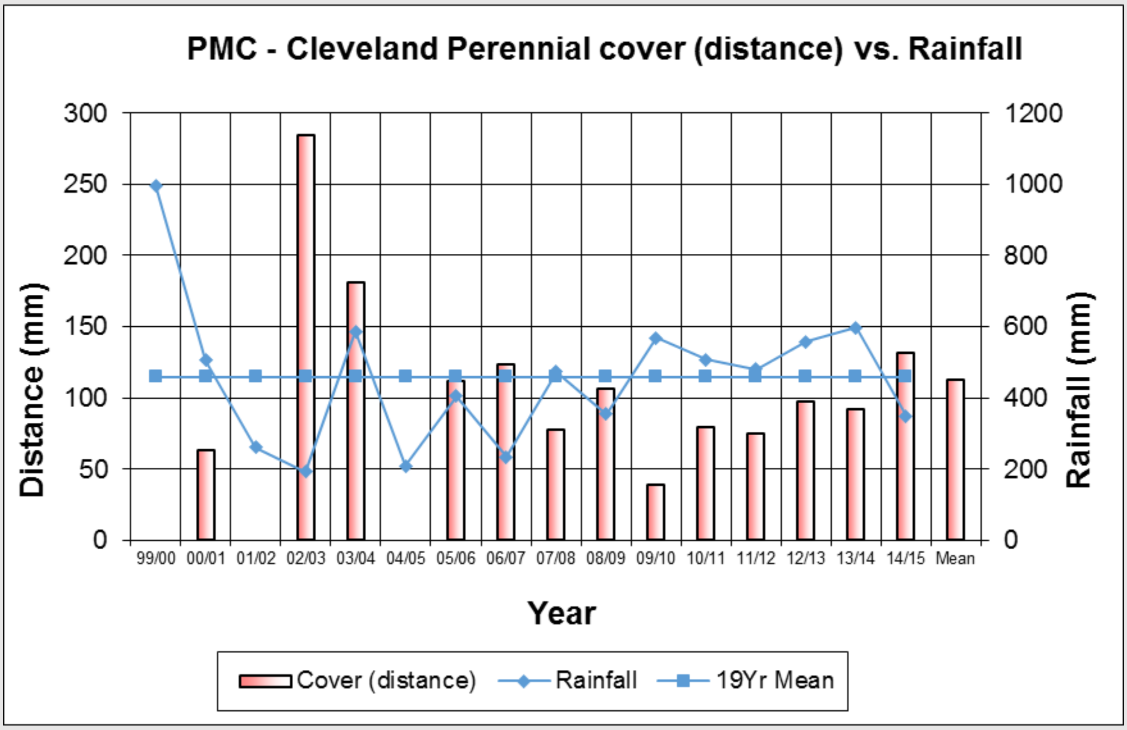


Figure 3 Mean distance to perennial grasses on PMCC and rainfall.

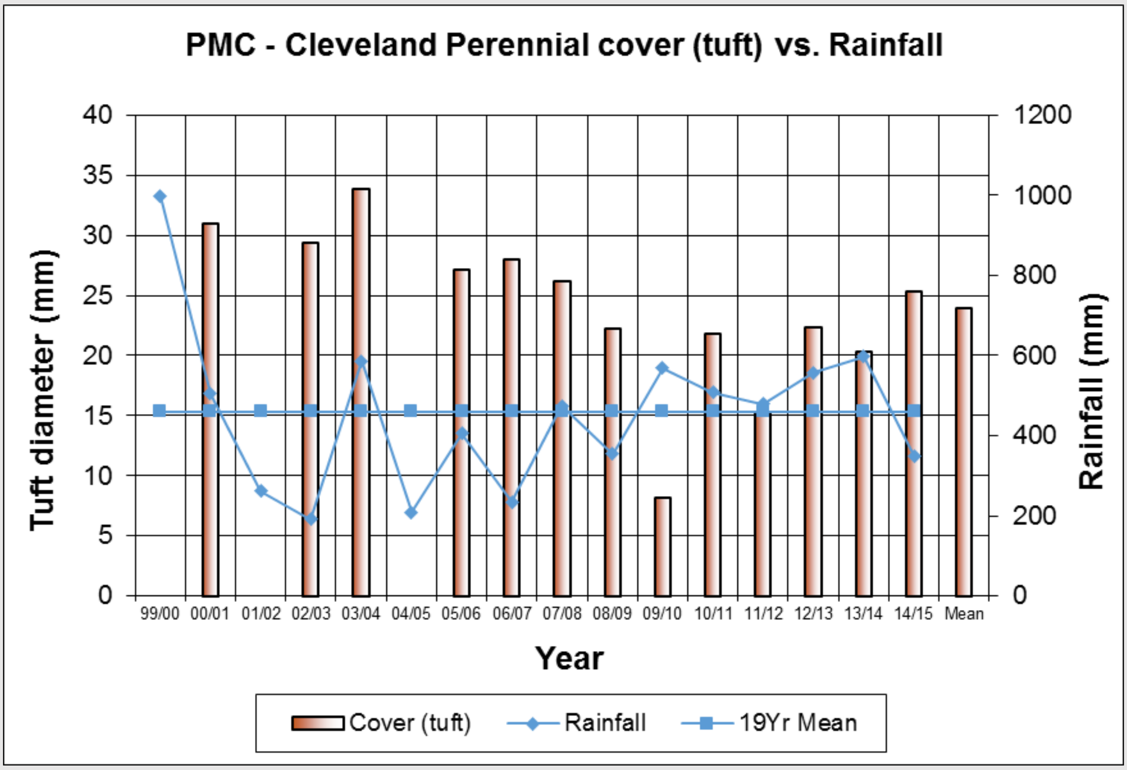


Figure 4 Mean tuft diameter of perennial grasses on PMCC and rainfall.

Table 3 Perennial grass cover trends on PMCC.

PMCC overall	General Comment **2014/15**; and **Long term;** Distance measure (top), tuft measure (bottom)
	Decline; Generally low **Improvement; Generally moderate-low**

Grass standing crop is a function of herbaceous production and represents the portion of production that remains after utilisation. The grass standing crop at the end of the 2014/15 summer season can be said to be very low when compared to recent years for PMCC (Figure 5 and Table 4). Whereas in more mesic areas to the south the dry 2014/15 season was buffered by previous favourable seasons, the comparatively dry PMCC area has much less of a buffer and has to cope with a steeper decline in soil moisture conditions that will constrain grass growth.

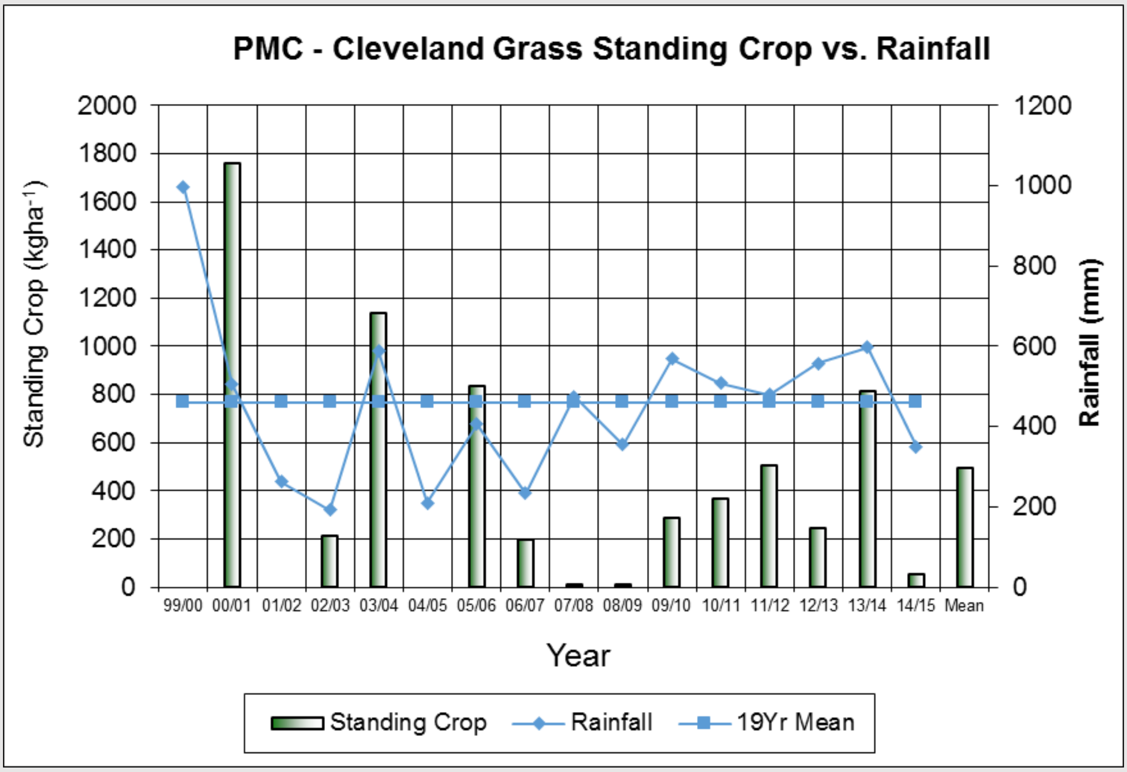


Figure 5 Grass standing crop on PMCC and rainfall.

Table 4 Grass standing crop on PMCC.

PMCC Overall	General Comment **2014/15**; and Comment **Long term**	Trend on PMCC 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
	Very low grass biomass**; Low**	M-L	V-L	V-L	V-L	V-L	L	M-L	V-L	M-L	V-L

Grass standing crop measurements have important implications for grazing and fire management. A forage flow estimate was made for PMCC based on the animal numbers from the 2015 count (Figure 6 and Table 5). Results show that there would have been **grazing stress for the whole of winter 2015**. Note again that this approximates these parameters and will be refined using energy requirements and flows (see discussion under the animal section).

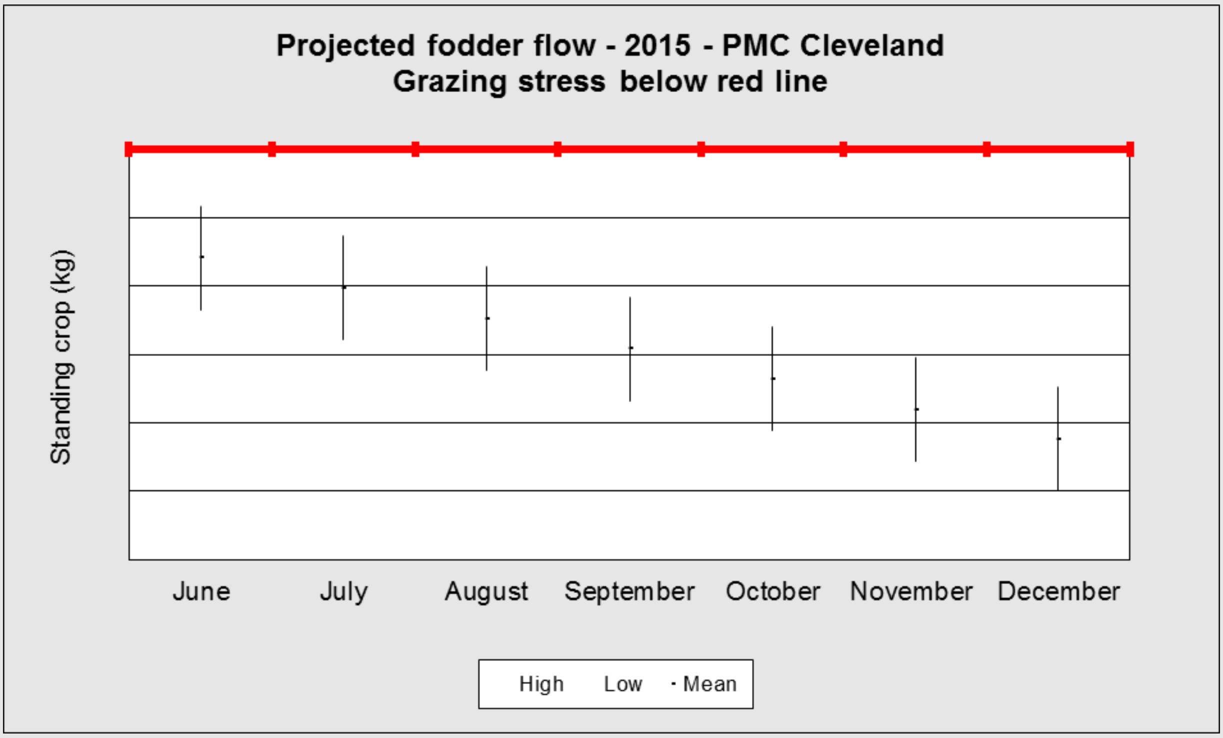


Figure 6 Projected forage flows on PMCC for winter 2015 based on 2015 game counts.

Table 5 Forage flows on PMCC.

Property	Comment
PMCC	Grazing pressure for the entire winter of 2015

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

Grass Parameter	PMC Cleveland 24	PMC Pompey 25	Res. 19 used 21 in 13/14	Res. 20	PMCC 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 (%)	69	86	53	69	1	2	1	1	3	1	1	1	1	1	2	2
Cover (distance-mm)	132	65	105	111	2	2	2	3	3	2	1	1	2	3	2	4
Cover (tuft size-mm)	25	28	23	23	1	2	2	2	3	1	4	2	2	2	2	2
Standing crop (kg/ha)	56	1 535	308	50	1	3	2	2	2	3	4	2	4	3	3	3

The above illustrates that PMCC ranks moderate when compared to three surrounding reserves. Other than the grass standing crop which is alarmingly low, the results are similar to the systems to which it is compared. There are many attractants for game on the mine property (e.g. excessive surface water) and this probably has an effect on the distribution and impact of animals on the rangelands on Cleveland.

Trees

Woody density varies across the different areas, with fluctuations broadly corresponding to 'wet' (decreased density) and 'dry' (increase in density) seasons with wet seasons generally resulting in increased competition by grasses with trees and dry seasons resulting in greater tree competition with grasses due to the trees deeper root systems – the case in 2014/15. This is illustrated by increases in the woody density at PMCC for the second year running (Figure 7). The canopy cover for PMCC is stable (Figure 8). We have started analysing tree structure data throughout the study area which will assist us in explaining the fluctuations in tree density in four height classes. We have also embarked on a 'big tree' study to determine the impact of elephant on trees larger than 5m.

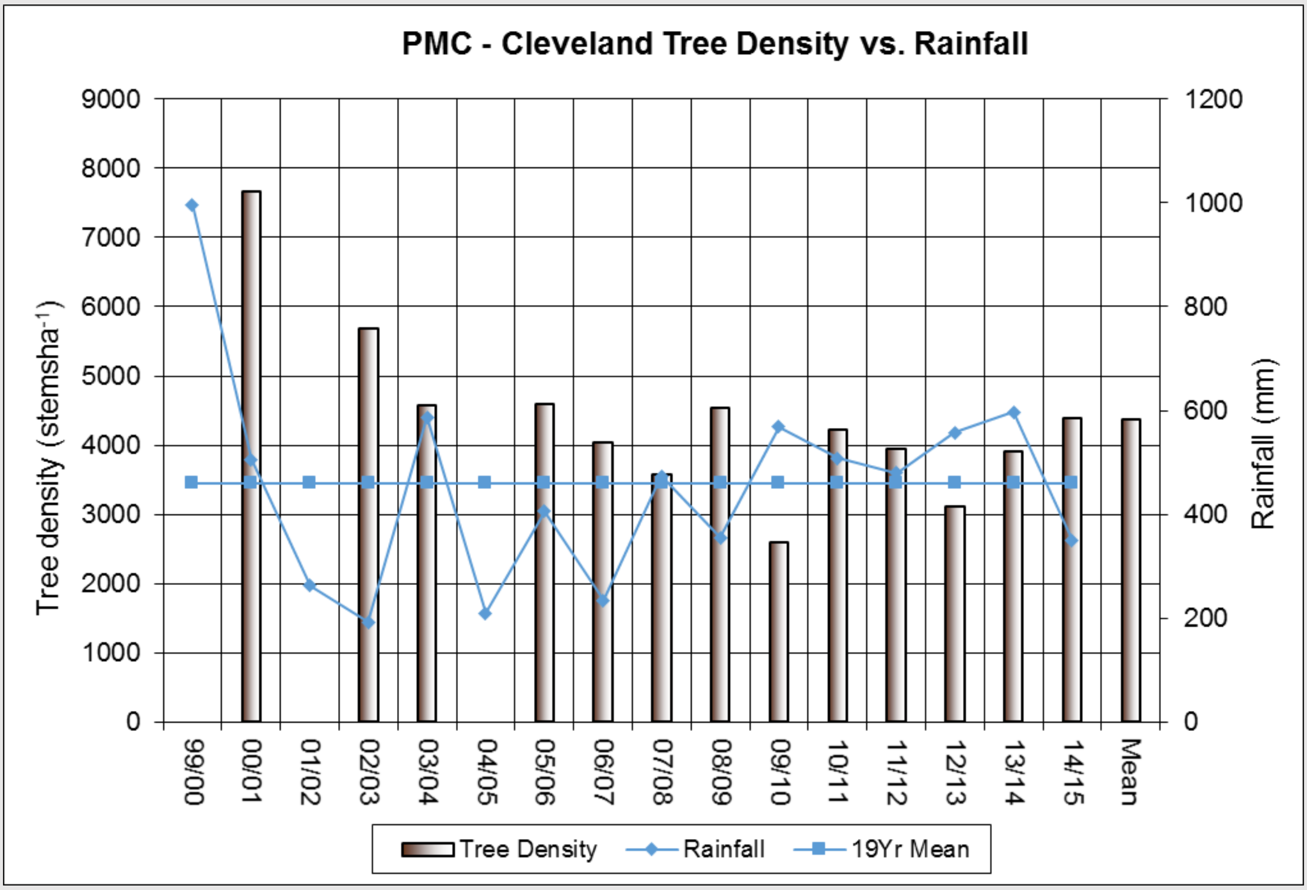


Figure 7 Mean woody densities on PMCC and rainfall.

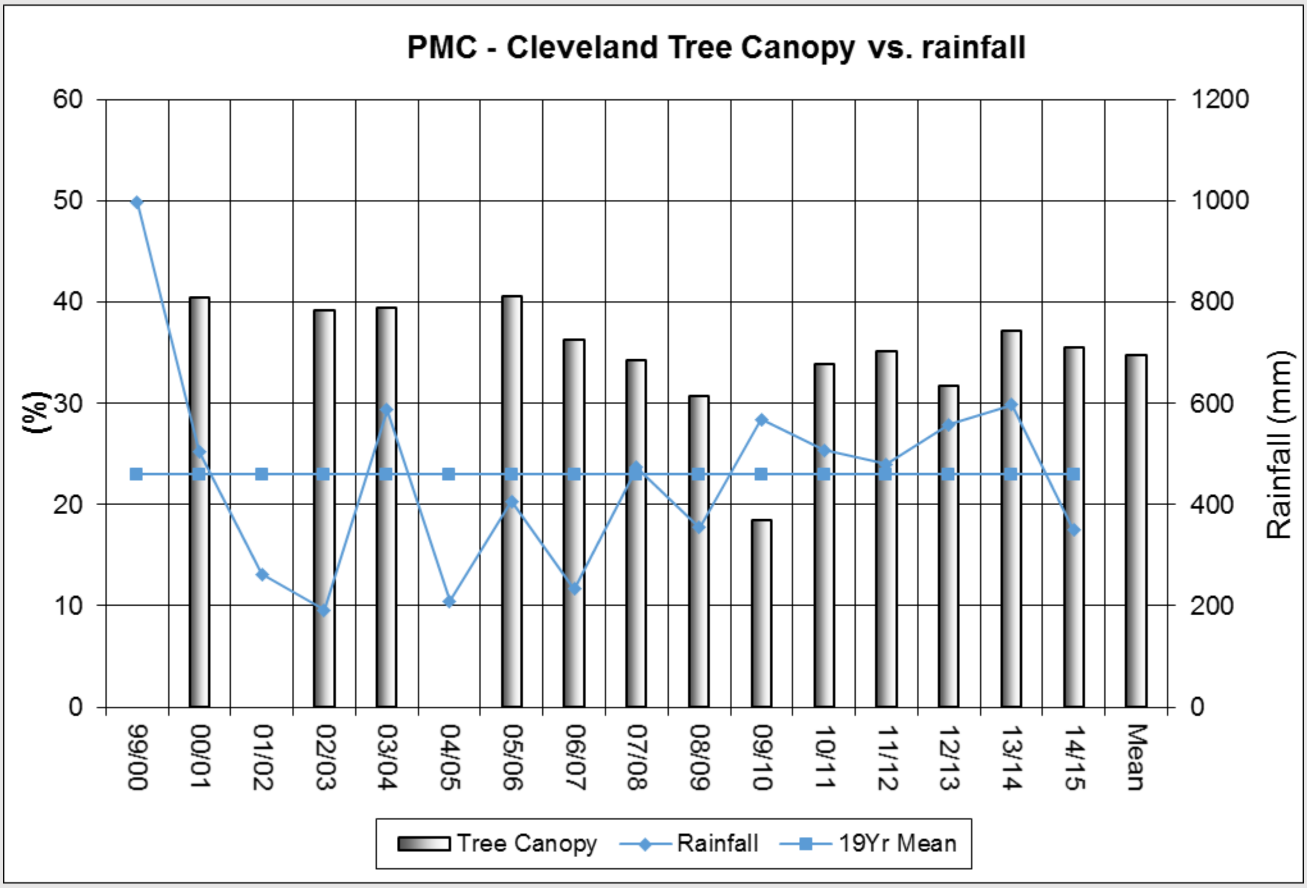


Figure 8 Mean tree canopy cover on PMCC and rainfall.

Elephant impact

Figure 9 indicates that *Colophospermum mopane* and *Combretum apiculatum* continue to be relatively the species most selected for (59% and 36% - mean 54% and 30% respectively). This shows a decline in impact in *C. mopane* and an increase in the impact on *C. apiculatum*. The other species that should be closely monitored are *Sclerocarya birrea* and *Acacia nigrescens* which are susceptible to elephant impact.

The severity of elephant impact increased from last year with 82% of trees measured showing no impact (mean 84%, range 69% and 92%). This result is probably due to the poor 2015/16 season and concomitant decline in grass species composition, cover and standing crop (Figure 10). The trend in 2014/15 again showed increases in the 38% and 63% damage midpoints. In contrast to the general increase in impact in 2014/15, tree mortality was measured at a low 0.3% (mean 1.3%, range 0.2% - 4.4%).

In terms of percentage damage per height class there was an increase in impact in the 1-2m and 2-5m classes while impact in the >5m and 1.1-2m layer was similar to 2013/14 (Figure 11). The increase in selection for the 2-5 m height class was marked (up to 30%). As previously stated, the stable/increase in impact in 2014/15 is probably linked to declining grass species composition, cover and standing crop where, as with the 2012/13 figures, there was a very low grass standing crop and hence a switch by elephant to the woody layer. It is important to monitor selection in the various height classes as similar degrees of impact may be an indication that there is increasingly a more even distribution of impact per height class. **This could be problematic if the structure becomes homogenised through elephant impact (i.e. the tree layer dominated by short trees/old elephant stunted trees).**

Figure 12 shows the percentage of trees sampled, per species that were impacted upon during the past year. There was a general increase in the percentage of impact in the dominant species, *Colophospermum mopane* 28% (mean 20%, range 7% - 33%) and *Combretum apiculatum* 19% (mean 14%, range 2% - 24%). The increase in impact is ascribed to declining grazing conditions as discussed above.

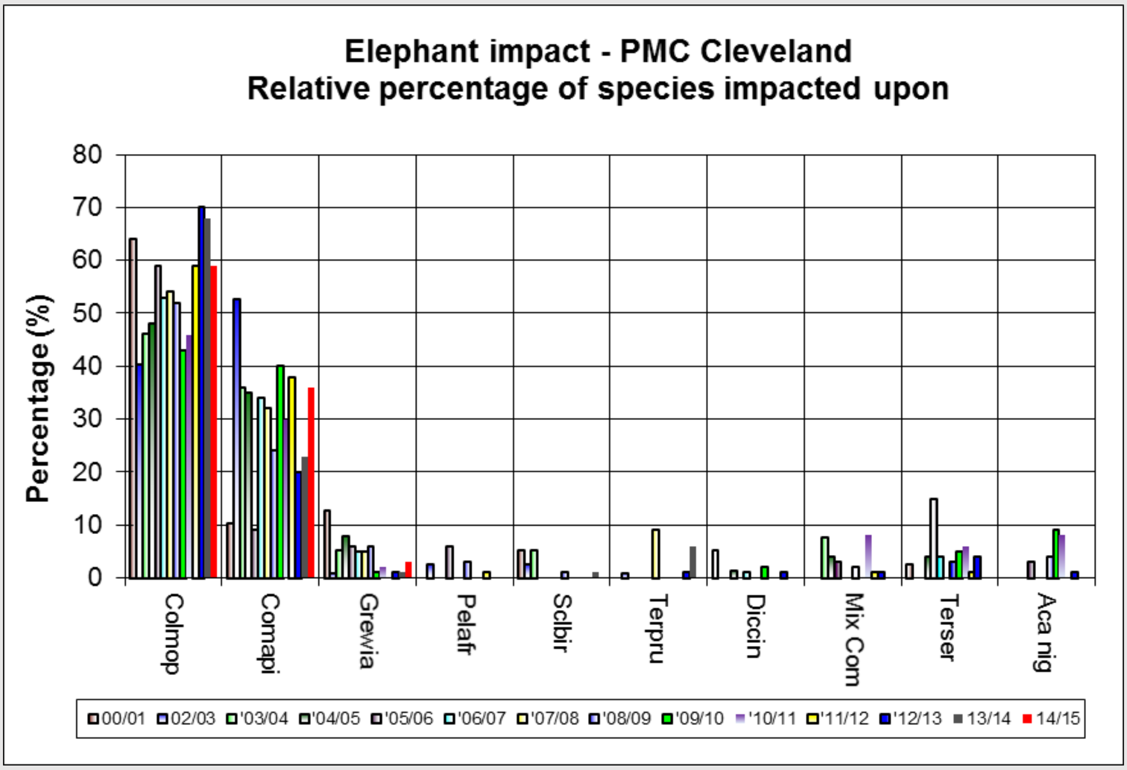


Figure 9 Relative percentage of species impacted upon on PMCC.

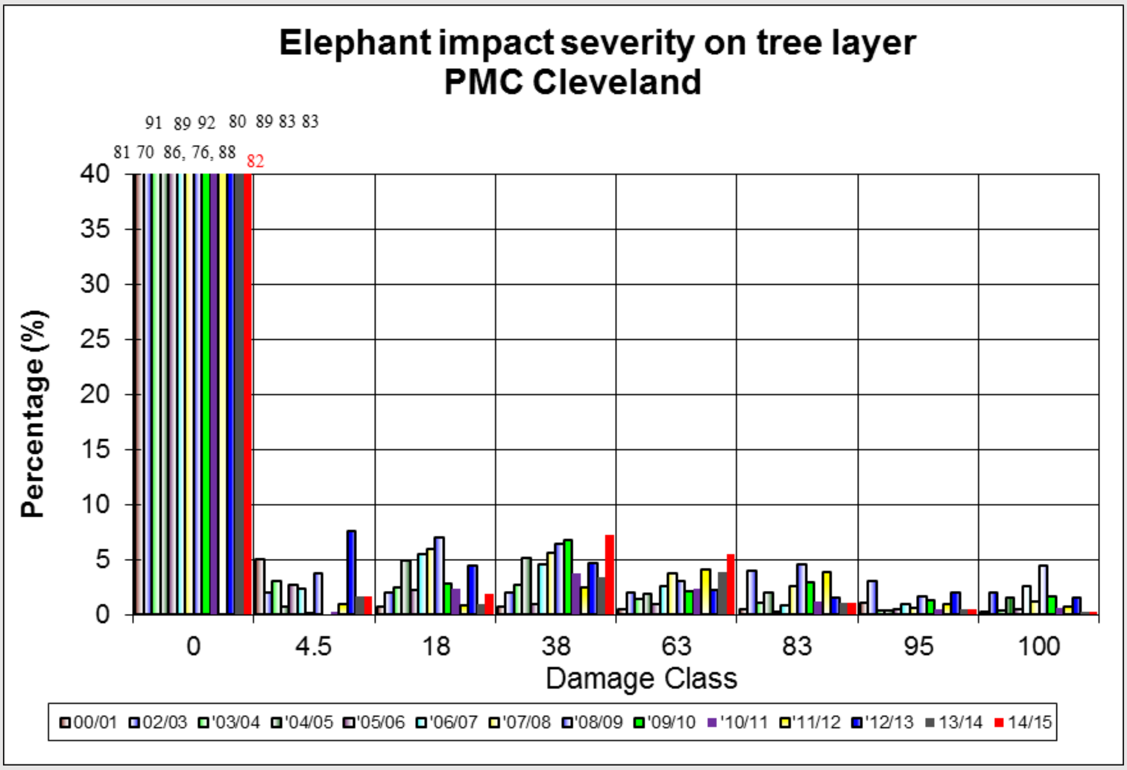


Figure 10 Severity of elephant impact on PMCC.

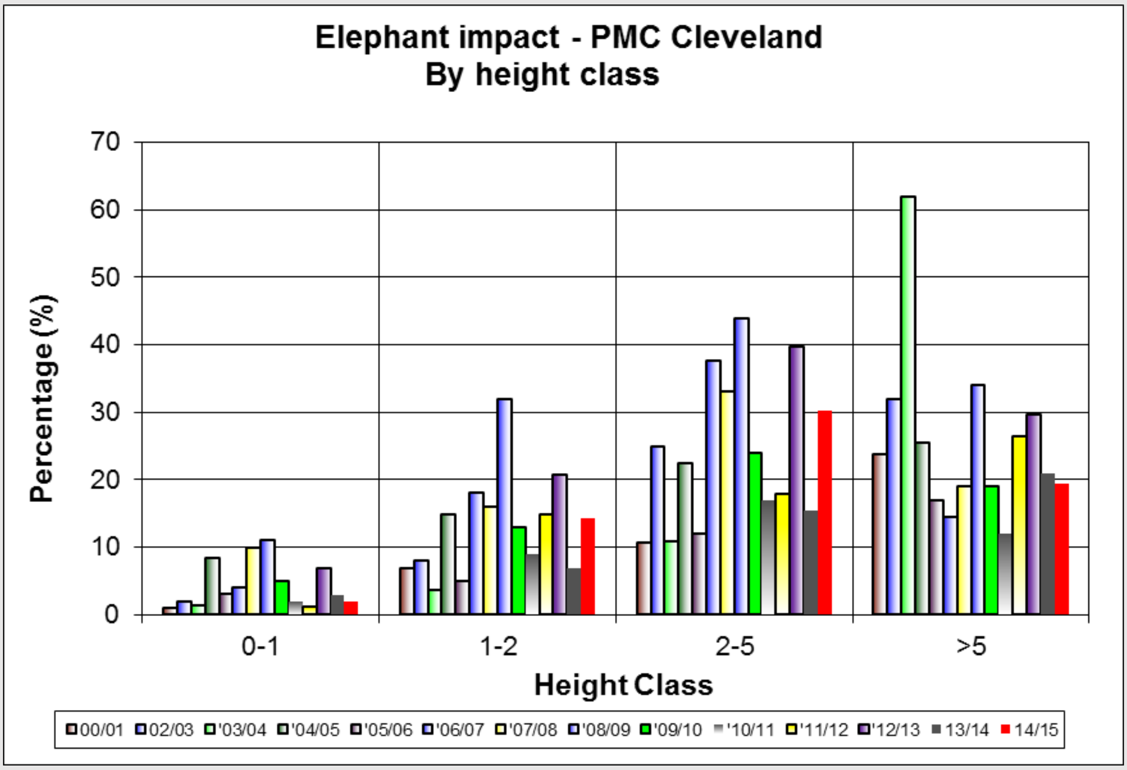


Figure 11 Elephant impact by height class on PMCC.

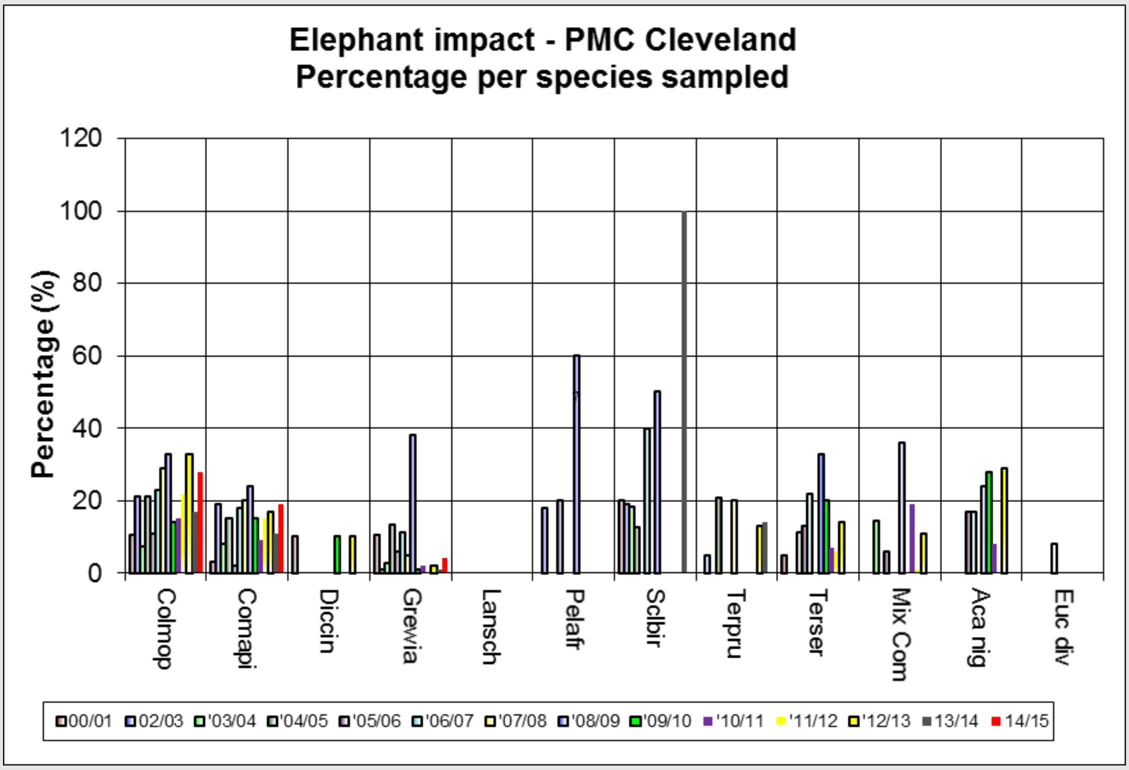


Figure 12 Percentage elephant impact per species sampled on PMCC.

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 PMCC. Appendix A presents the animal numbers from the 2015 count. PMCC is open to other areas allowing game to move during times of nutritional stress. However as previously stated water dependent species such as impala do not move and their ability to switch from grazing to browsing during times of stress means that they have the potential to overgraze areas (a function of time).

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$kgkm^{-2}$). It must 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 PMCC. The mean stocking rate for PMCC in 2015 was 8 350 $kgkm^{-2}$ which is well above the guideline (Figure 13 based on herbivore numbers – Appendix A). Less than half of the animal biomass is made up of prey species (Figure 13).

An important consideration for PMCC is the fact that we are now into the second season of drought. In addition to this, the KNP has closed water points in areas adjacent to reserves such as PMCC. This will ultimately 'force' game to enter the adjacent protected areas and while these animals may return to the KNP their presence on PMCC will add pressure to an already stressed grazing situation. Despite the system being 'open' to the Greater KNP system consideration could be given to removing some of the water dependent non-mobile game species (e.g. impala) and even some of the more mobile species such as buffalo and elephant. The situation is as one would expect really tricky because lions in particular have the ability to cause rapid population declines in prey species such as wildebeest, zebra, waterbuck and giraffe which occur in low numbers on PMCC. This is also a time when lions target the weakened buffalo population so their removal needs to be carefully considered as this may precipitate a switch in prey targets to susceptible species mentioned above. All the while the grazing resource will be stressed. So while there are no fences the fact that there is a large imbalance in the distribution of water between the KNP and PMCC means that PMCC has effectively been re-scaled to function as a small unit (much like a small protected area or farm). There are two options, remove some game or let the drought run its course and suffer losses (less of an issue than in areas where tourism is the main objective). We have started looking at grass biomass in areas to the south and we are looking at grass standing crops of less than 200 kgha-1. I refer you to the discussion under the section titled '*Energy flows and sustainability on PMCC'* for further discussion in this regard.

Figures 14 a-d (feeding classes) shows that for PMCC currently: feeding class 1 (bulk grazers) is below the guideline, feeding class 2 (selective grazers) levels remain critically low, feeding class 3 (mixed feeders) is well above the guideline and feeding class 4 (browsers) proportions are below the guideline (as previously stated is probably set too low for this class).

To enhance decision making as regards game management on PMCC, it would be useful if we could obtain the sex and age data (Cyber tracker?). This in conjunction with reliable animal number data is critical. As previously stated I would be willing assist with data analysis.

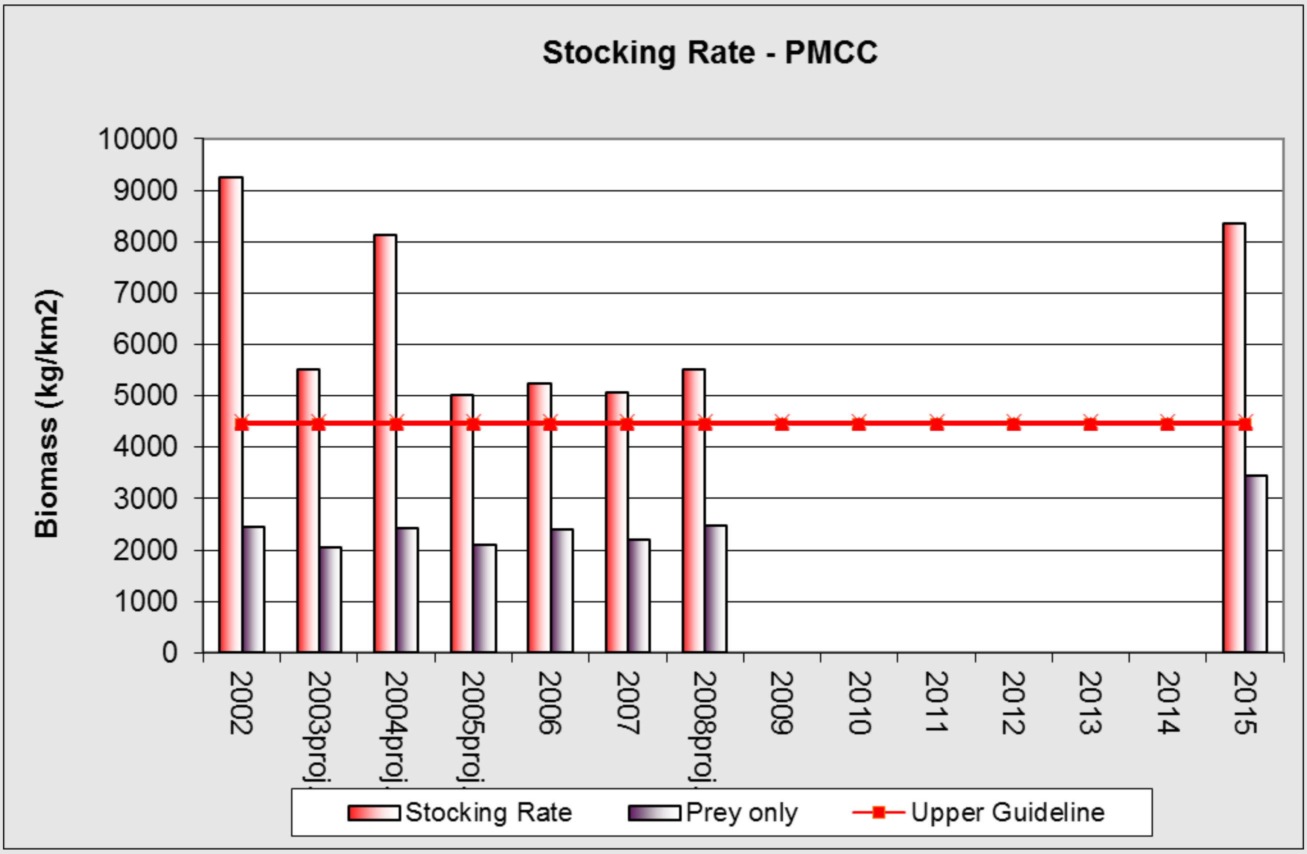


Figure 13 Herbivore biomass (kgkm^{-2}) on PMCC (2015 game count).

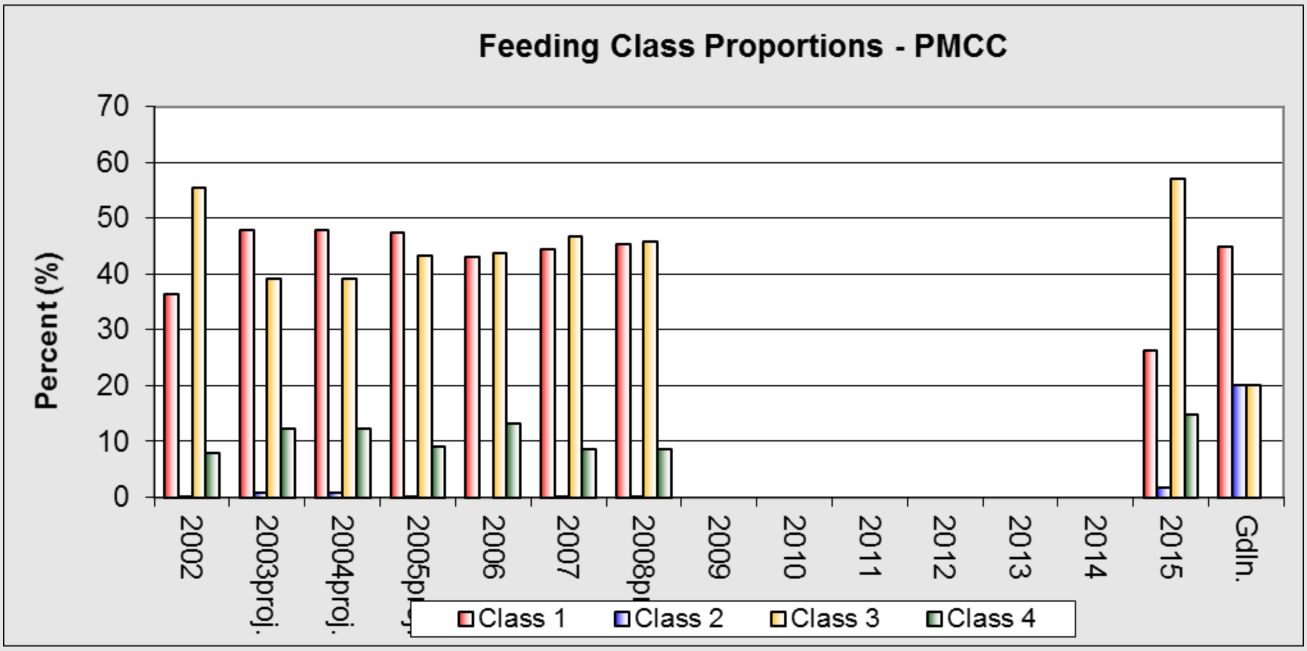


Figure 14 Feeding Class proportions on PMCC (2007 game numbers used).

Energy flows and sustainability on PMCC

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 15 shows that there would **not be** sufficient grass to satisfy the energy requirements of the game present on PMCC during the winter of 2015. This agrees with the forage flow calculations presented in Figure 6. If we do a forward projection to 2016 using the same game numbers, the standing crop required to satisfy the grazer component would need to be in excess of 400 $kgha^{-1}$ – it is unlikely that we will achieve these figures hence the management challenge set out above.

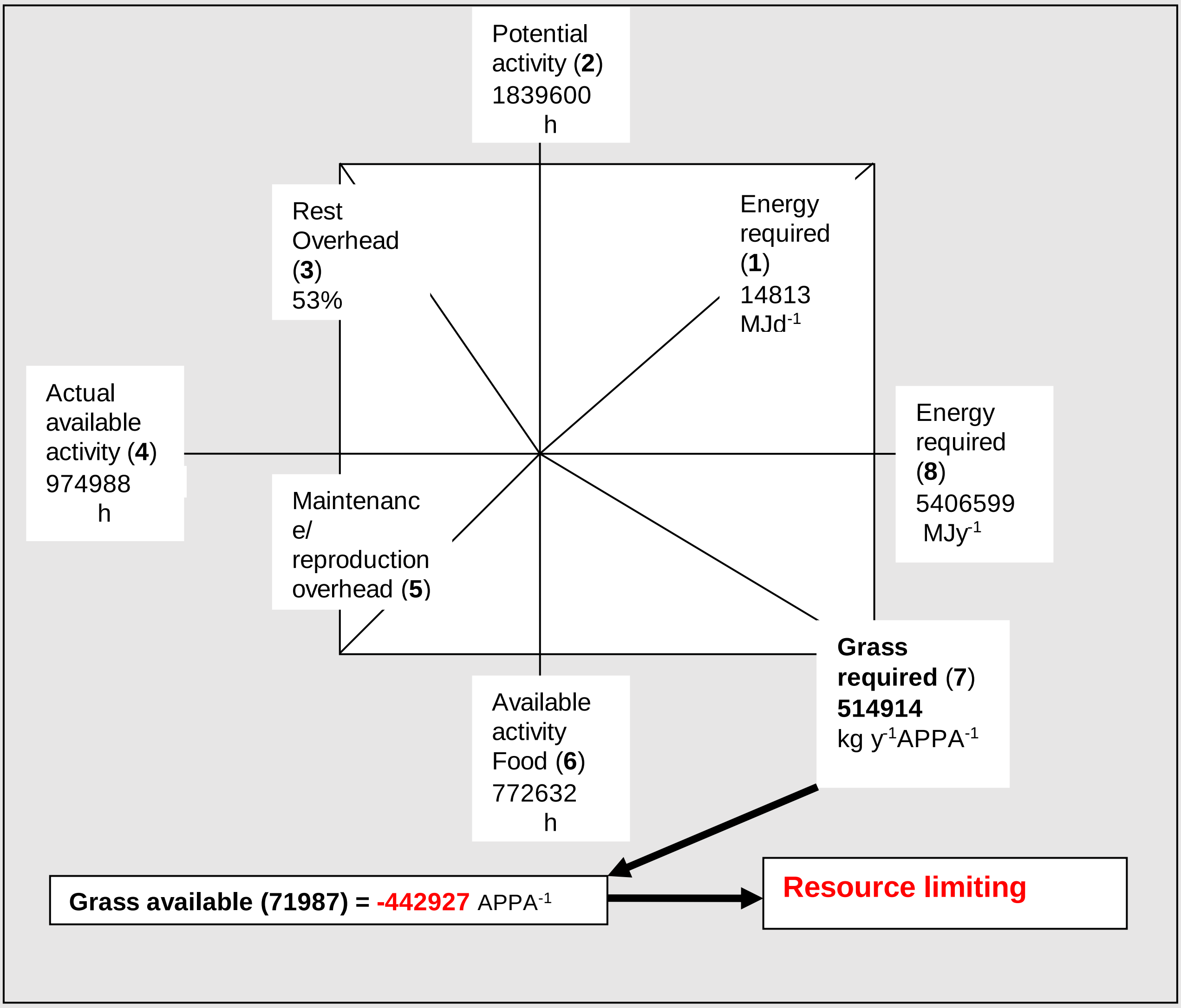


Figure 15 Resource availability in a multi-species grazing system – PMCC 2015 (2015 game count).

In terms of information available for the management of herbivores and, where reliable trends are sought, the value of consistent monitoring 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 current situation on PMCC (not including the cost of land, infrastructure etc. and using the count figures for 2015) (Table 7).

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

Species	Total Value (R)	(1) Total cost of vegetation monitoring (Exc. Vat) (R)	(2) Total cost of helicopter count @ R7 000 per hour (Exc. Vat) – say 4h including ferry (R)
	2772151	16 361	28 000
Cost of ecological monitoring (1) and (2) as percentage of value of game (%)		0.59	1.01
Cost of ecological monitoring as percentage of value of game (%)		1.6	
Recommended percentage (%)		2.0	

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

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 more palatable plants generally contain higher protein and phosphorous concentrations and digestibility. Environmental conditions affect N and P concentrations and rainfall in particular is correlated to their availability.

RESULTS AND DISCUSSION

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

1. The **N levels** for buffalo (grazer), impala (mixed feeder) and elephant (mixed feeder) 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 16).
2. The **P levels** for buffalo (grazer) and impala (mixed feeder) were above the guideline while elephant (mixed feeder) was below the guideline level (Figure 16).

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 (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 dietary deficiencies that may indicate nutritional thresholds and low reproductive rates. As previously requested sex and age data, lambing/calving rates and survival/mortality (related to sex and age) would be an important adjunct to the faecal analysis and by extension the ecological monitoring programme as a whole (Appendix B).

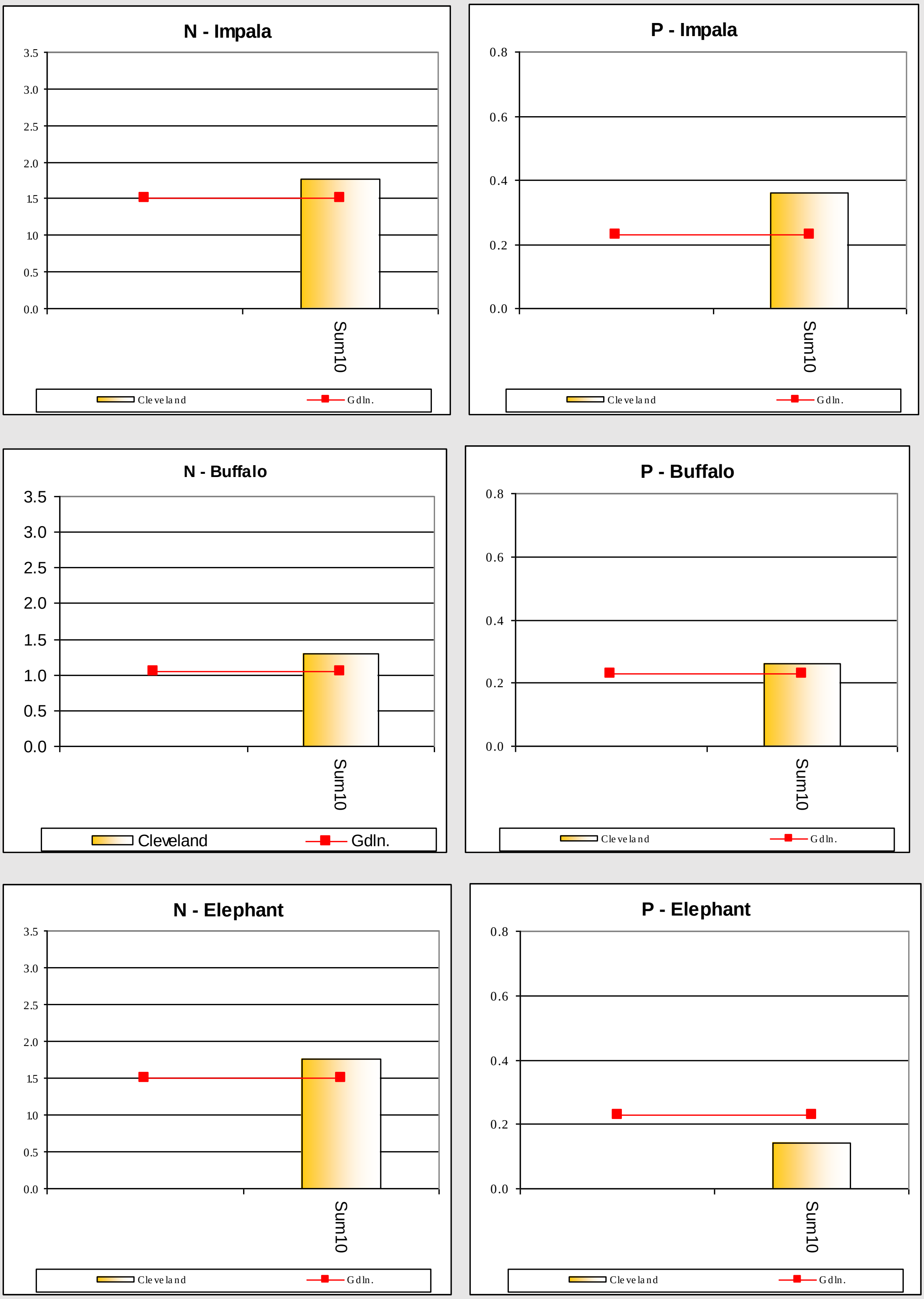


Figure 16 N and P trends in some herbivores on PMCC.

The position of PMCC 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 counting methods and teams cannot be overemphasised. Regular game counts are critical and this issue was addressed in 2015. 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 receives 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 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

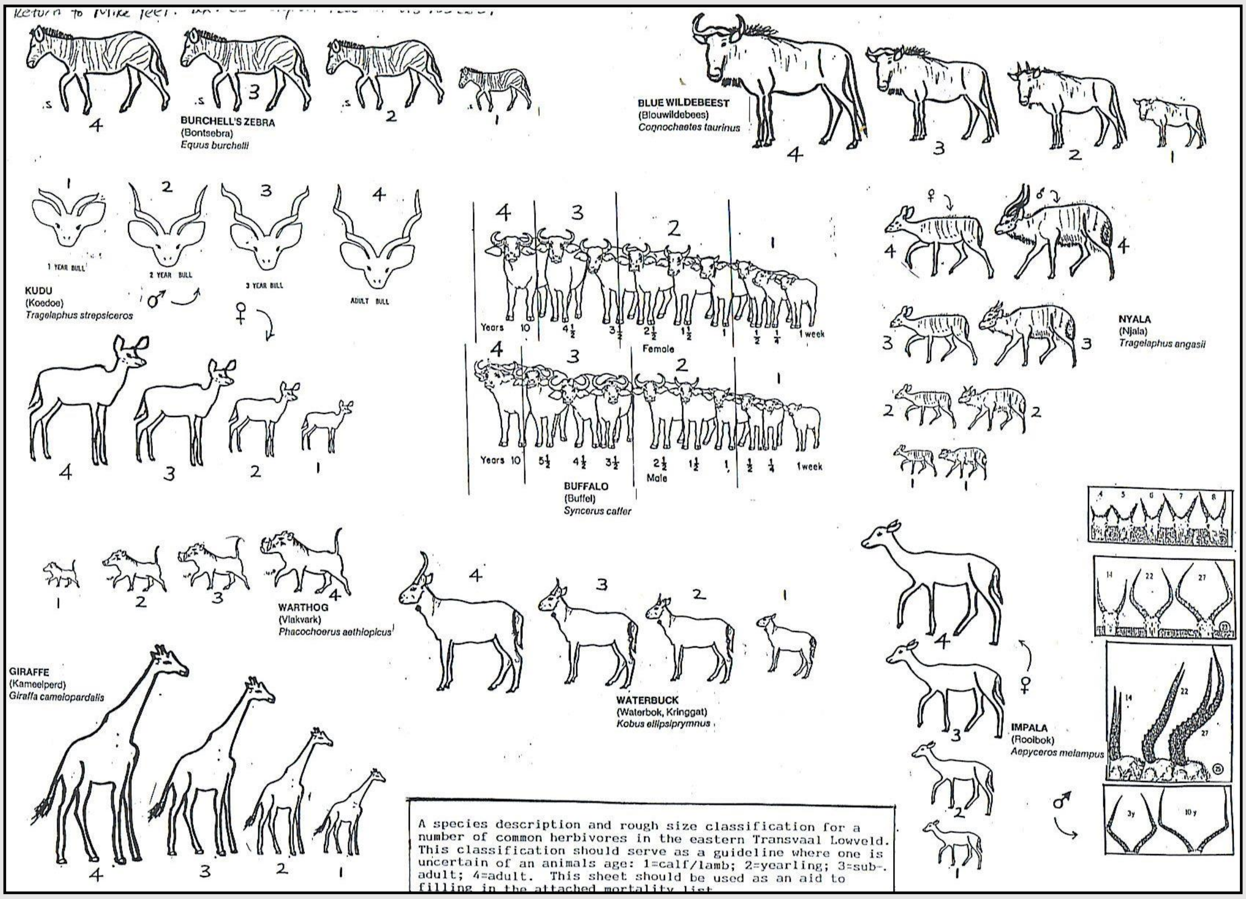
Animal numbers obtained from the 2007 and 2015 counts.

Species	2007 count	2015 count Cleveland	2015 count Vereeniging (south of Olifants River)
Blue wildebeest	-	12	0
Buffalo	179	47	0
Bushbuck	6	5	0
Crocodile	-	8	5
Duiker	-	2	1
Elephant	43	18	14
Giraffe	17	16	0
Hippo	49	5	16
Impala	343	112	148
Klipspringer	-	10	0
Kudu	23	37	12
Leopard	-	1	0
Rhino (white)	1	0	0
Sharpe's Grysbok	-	1	2
Steenbok	-	1	1
Warthog	-	0	5
Waterbuck	38	6	6
Zebra	-	10	0

Appendix B

Sex and age structures of herbivores on PMCC (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)