REPORT ON THE FIELD TESTING OF INTER-OBSERVER VARIABILITY IN THE APPLICATION OF THE STANDARDISED BROWSE AVAILABILITY ASSESSMENT METHOD USED IN BLACK RHINO CARRYING CAPACITY EVALUATION
(Task 4.2-2.4)

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SUMMARY OF FINDINGS

Browse availability was identified as a separate variable with among the strongest influences on black rhino carrying capacity in the RMG Black Rhino Carrying Capacity Model Version 1 (Adcock 2001). The BrCC Model User Guide had contained the initial description of how to approach browse availability estimation for black rhino carrying capacity assessment. In 2003, a standardised technique of assessing black rhino browse availability (BA) was developed based on the initial approach, as a supplement to the User Guide. This report was commissioned by the SADC Regional Programme for Rhino Conservation to test the inter-observer variability and practical application of the standardised technique.

1. For the visual browse availability (BA) assessment technique to be useful and reliable in black rhino carrying capacity assessment, specialists agreed it needs to produce field BA estimates for each and every vegetation type in an area to within 1 score class either side of the true BA value. The technique should also not be consistently biased to over- or under-estimation.

2. During the May 2004 field test of inter-observer variability, 91.6% of observer BA assessments were within 1 score category of the true (measured) BA score categories.

3. Overall, the technique seems only marginally upwardly biased - on average the observers' combined data deviated from the true BA score category by only 0.03 of a category. However, there is an upward bias of 0.23 of a BA category among denser sites on average, while low BA areas show a bias towards under-estimation to a smaller degree, possibly due to problems of small plant visibility in grass.

4. Using the test sites as it they were vegetation types, and each observer's BA assessments run through the RMG BrCC model using Weenen's climate and soil data, very similar estimates of black rhino carrying capacity were obtained across observers (observer range 0.24 to 0.26 rhino/km^2, averaging 0.25, while the measure plot data produced a CC estimate of 0.24 rhino per km^2).

5. Observers thus overestimated black rhino carrying capacity by 0.01 rhino per km2 on average. Their overall (simulated) browse availability ratings for the reserve showed a coefficient of variation of 4.53%, and their estimated carrying capacities showed a coefficient of variation of 3.70%. (This contrasts with the coefficient of variation of 25,5% in ECC estimates made by 9 different experts, using their experience only, in assessing the same 2500 ha subsection of Pilanesberg National Park in the 1993 RMG black rhino property assessment Workshop.

6. Using the absolute (non-categorized) BA estimates to estimate carrying capacity produces very similar results to using the BA Score classes. The coefficients of variation are very slightly smaller than with using categorisation. However, one benefit of using categories is that field sample size requirements are reduced.

7. Observers on average underestimated plot canopy cover, and overestimated % vertical fill, but the biases in estimating these components tended to cancel each other out to give BA estimates in the right ballpark. Methods to give improvements in observer BA estimates should thus focus on aiding better estimation of each of these components.

8. In testing the use of the calibrated BA photographs from Adcock (2003) on their own to estimate a BA score for each plot, 78.8% of BA scorings from photographs were within +or - 1 BA score category of the measured BA. Thus BA assessment from photographs alone was upwardly biased by on average 0.5 of a category. The bias did appear to be greater among denser plots. ECC was overestimated by 0.03 rhino per km2 on average, with a larger % coefficient of variation of 5.9%. Photographs alone thus do need to be used with caution. However, a correction factor on photo-based ratings of -½ a class may alleviate the bias. More work is needed on this, as the advantages in terms of speed of application of the %BA rating method would be considerable.

9. Assessments of herb availability suffered from the same issues as woody assessments: more and better example graphics of %canopy cover arrangements are needed to help observers.

10. The sample sizes needed within each vegetation type to obtain reliable average browse availability scores were found to vary. These depend on the region of browse availability one was working with (very low through to high very high), and the degree of variability in amounts of browse from patch to patch within a vegetation type. Sample sizes would range from <10 to 30 or so plots if one could stratify for extreme variations within a vegetation type, such as thicket patches. Thicket patches are best assessed separately, by estimating their proportional area within vegetation types, and their average browse availability.

11. The clarity of the browse availability assessment manual needs to be improved, to ensure that operators can reliably learn and implement the method. Better aids to explain and improve assessments of % canopy cover and of average % vertical fill were needed in particular.

12. The specialist felt strongly that field survey and sampling procedures remained important issues in establishing realistic BA estimates for each vegetation type in an area. Better guidelines on these aspects are needed in the manual.

INTRODUCTION

In 2003, a standardised technique of assessing black rhino browse availability (BA) was developed ("VISUAL ASSESSMENT OF BLACK RHINO BROWSE AVAILABILITY" (Adcock 2003)) as a supplement to the "User Guide to the Rhino Management Group Black Rhino Carrying Capacity Model, Version 1 (Adcock 2001, *SADC Regional programme for Rhino Conservation*). The user guide contained the initial ideas on how to approach browse availability estimation for black rhino carrying capacity assessment.

Assessments of available rhino browse are integral to carrying capacity assessments that assist in deciding potential rhino densities and rhino introduction numbers for new areas. They also aid in the describing or ongoing monitoring of habitat conditions in existing rhino areas, under conditions of changing climate, vegetation and competing browser densities. Standardising browse availability assessment across all southern African black rhino areas also assists in developing our understanding of contrasting black rhino habitat conditions and related population performances across the sub-continent.

In May 2004, a field test of the inter-observer variability in this technique for assessment of black rhino browse availability (BA) was undertaken. The objectives were to…

1. determine the required degree of precision needed for the technique to be useful and reliable in black rhino carrying capacity assessment;

2. determine the degree and nature of variation between observers in assessing browse availability using the technique; and

3. improve the clarity of the manual, improve the field implementation procedures of the technique, and consequently improve the ease of implementation and reliability of black rhino browse availability assessments in the field.

Participants

Three professional vegetation scientists ("specialists") participated in the field tests. They also assisted with establishing the degree of precision required by the technique, and produced brief reports each with critiques and recommendations on the BA assessment manual and the field assessment procedures (see appendix 5). These were Dr Tim O'Connor (Ecological Consultant), Bruce Page (Botany Dept., University of KwaZulu-Natal, Durban) and Dr Kevin Kirkman (Head of the Grassland Science Dept, University of KwaZulu-Natal, Pietermaritsburg).

In addition, the following people also participated in the field tests:
John Llewellyn and Gordon Smith (Wardens, Ezemvelo-KZN-Wildlife), Caiphus Khumalo (Scientist, Ezemvelo-KZN-Wildlife), and Tanya Smith, Michelle Payne and Caryn Rauff (Grassland Science students).

THE DEGREE OF PRECISION REQUIRED IN BROWSE AVAILABILITY ASSESSMENTS FOR BLACK RHINO CARRYING CAPACITY DETERMINATION.

The consultant met with the 3 specialist participants prior to the field tests, to establish the required degree of precision needed for the technique to be useful and reliable in black rhino carrying capacity assessment. The way in which BA for a reserve/property was estimated and used was first explained to the specialists, as this had bearing on the limitations in performance of the measure in carrying capacity assessment. In addition, the potential natural seasonal change in available browse was considered, as this also has a bearing on how accurately one can and needs to estimate available browse .

Recapping on the technique: Browse availability (BA) as amount of browse canopy fill in browse space.

The Browse Availability Score scale was as follows (after Adcock 2003):

TABLE 1: BA Score Class Boundaries	BA Mid classes	Times More Available Browse
0.00%		
{	0.25%	
0.50%		
{	0.75%	X 3.00
1.00%		
{	1.50%	X 2.00
2.00%		
{	3.50%	X 2.33
5.00%		
{	7.50%	X 2.14
10.00%		
{	12.50%	X 1.67
15.00%		
{	17.50%	X 1.40
20.00%		
{	25.00%	X 1.43
30.00%		
{	35.00%	X 1.40
40.00%		
{	45.00%	X 1.29
50.00%		
{	55.00%	X 1.22
60.00%		
{	65.00%	X 1.18
70.00%		
{	85.00%	X 1.31
100.00%		

The visual browse availability assessment technique assesses the degree (%) to which the 0-2m browse space layer over a given land area is filled by browse (woody plant canopies and herbs). For example, an area of land filled solidly with browse from 0 to 2m would contain the highest possible "% fill" of available browse, or 100% browse availability. In most situations, the browse space (or 0-2m area above a site) is not filled entirely with plant canopies or herbs. In this case the summed volumes of individual plant canopies in the site, expressed as a % category of the total browse space, provides a relative estimate of available browse.

Use of BA Scores in black rhino carrying capacity assessment

In the assessment of black rhino carrying capacity by means of the RMG Black Rhino Carrying Capacity Model (BrCC Model), an average BA score is determined for each vegetation type within the conservation area by means of a field survey. The overall BA score for the protected area can be calculated as….

> the sum of…. the mid-point value of each vegetation type's BA score (expressed as a proportion from 0-1) x by the proportional area of each vegetation type]
>
> $$\sum (BAmid_a \times PArea_a)$$
>
> for vegtypes a,bc….i

e.g. (scoremid$_a$ 0.25 x area$_a$ 0.1) + (scoremid$_b$ 0.035 x area$_b$ 0.65) + (score$_c$ 0.175 x area$_c$ 0.25) =0.093 or overall 9.2% BA.

The square root of this % is used as the variable value for the variable Browse Availability in the BrCC model.

The effects of over- or under- estimating browse availability on model CC estimates

There are commonly several vegetation types in any reserve, each making up a different proportion of the total land area. Each vegetation type can have it's average browse availability over- or under-estimated, or correctly estimated. If the error in the technique is random, then each type has an equal chance of being over- or under-estimated. These types of error would tend to cancel each other out to some degree, depending on the relative size of the vegetation types involved.

If the technique or a particular observer is consistently biased one way or the other in the rating of BA, this would lead to the more serious problem of wrongly estimating BA in all vegetation types in an area. The effects of such scenarios on the resulting estimates of carrying capacity were determined, and shown to the 3 specialists.

The effects over- or under-estimating are not equal across the range of browse availabilities, because the BA score categories are not all of equal "size" (see table 1). Among the low BA's, the change from one category to the next highest category represents between 2 and 3 times more available browse (up to the 5%-10% category). Thereafter, the successive categories represent between 1.67 and 1.18 times more browse.

Based on the author's experience in the field during BA assessments of the probability of making wrong estimates; plus considering likely natural annual and seasonal fluctuations in available browse (figure 1b); and based on modelling the effects of wrongly estimating BA by varying amounts and for varying proportions of the total land area (see appendix 1 an for example), the following was proposed: ….

The technique needs to produce field BA estimates for each and every vegetation type to within 1 score class either side of the true BA value to be acceptable. The technique should also not be consistently biased to over- or under-estimation.

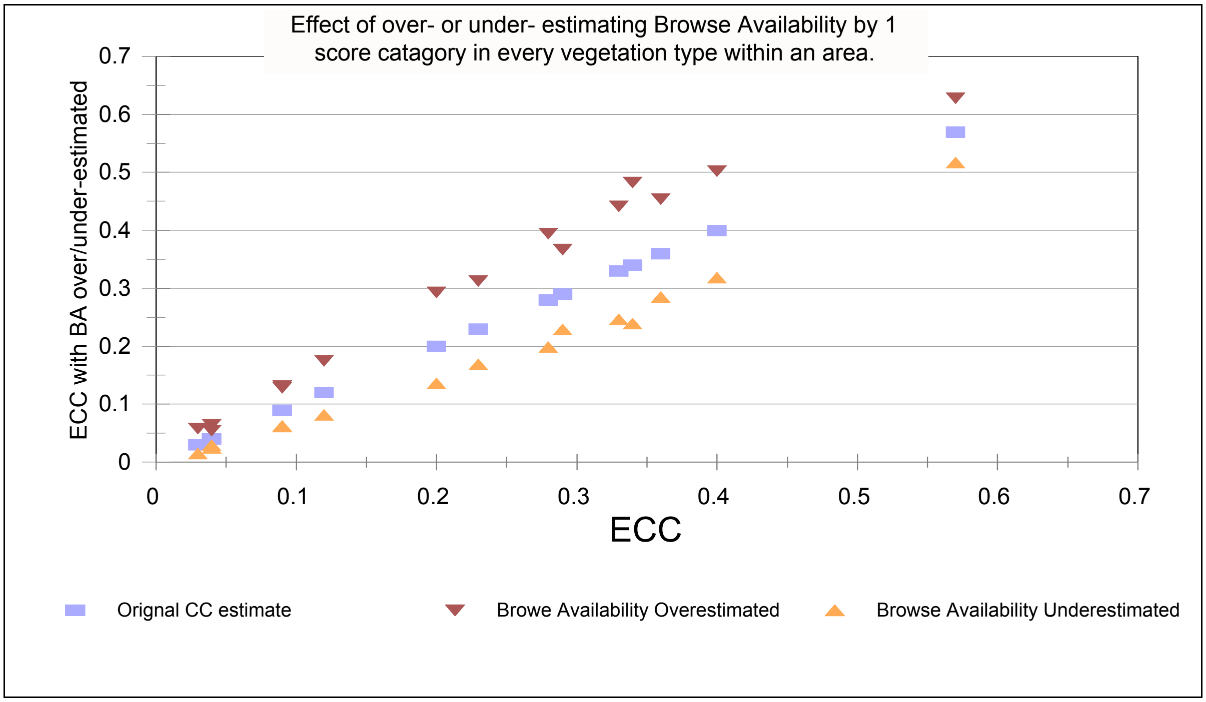


Figure 1a. The effects on estimated black rhino ecological carrying capacity of over- or under-estimating browse availabilities in every vegetation type within a rhino area by 1 score category (i.e. worst-case scenarios).

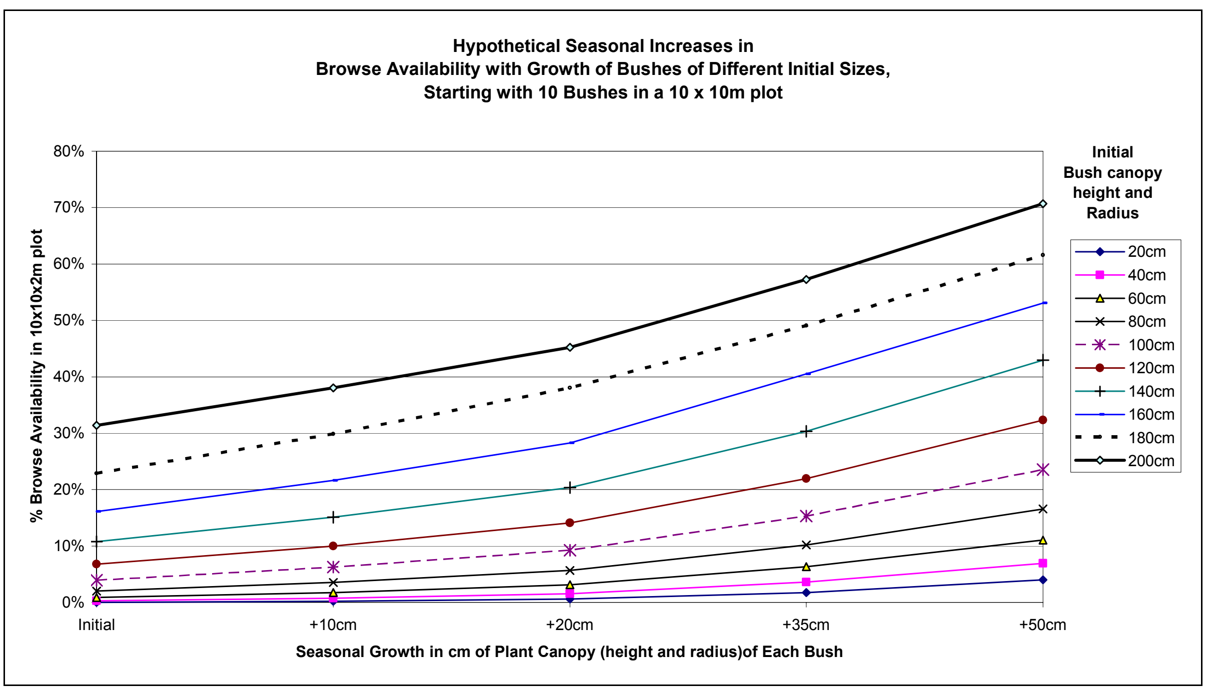


Figure 1b. Natural potential annual variation in available browse, and hypothetical effects on site browse availability.

Survey (sampling) procedures in BA assessments

The specialist felt strongly that the more important issues in establishing realistic BA estimates for each vegetation type had do with field survey and sampling procedures.

Although developing detailed guidelines on this aspect was not originally an objective of this field test and report, their concerns were heeded, and on day 2 of the field tests, the four dominant vegetation types within Weenen were "surveyed" using the technique. Three teams of observers carried out surveys in different sub-areas, attempting to assess BA at 20 plots within each vegetation type among the 3 teams. These data were then used to produce guidelines on survey sample sizes required for statistically reliable estimation of the average BA scores of vegetation types within a property to be assessed.

METHODS

1. During 5 and 6 May 04, Caiphus Khumalo and I set up and measured 10 test plots within Weenen Nature Reserve, KwaZulul-Natal, South Africa. The canopy depth and average canopy diameter of each woody / semi-woody plant canopy available to black rhino was measured, and the species recorded. The availability of herbs was rated as per the original BA scoring technique: by estimating the total % canopy cover of all herbs and multiplying this by half the estimated weighted average height of the herbs in the plot (i.e. the % vertical fill of the 0-2m layer by herbs).

   The total measured browse availabilities for each plot were not calculated until after the observer variability tests later in May, so that neither Khumalo or I, not knowing the test plots' true browse availabilities, could subconsciously influence other observers during the test.

2. Around this time, each of the future test participants was provided with a copy of the BA assessment manual ("VISUAL ASSESSMENT OF BLACK RHINO BROWSE AVAILABILITY" (Adcock 2003), and asked to read it and attempt to understand the BA assessment technique. They were asked to note down any queries they had on the manual.

3. In mid May, the observers and I met at Weenen. To assess the degree to which observers understood the technique before the field tests, each participant was asked to complete a questionnaire (see appendix 2). The aspect of the clarity of the manual was thus assessed separately from the inter-observer-variability of the technique itself.

4. Prior to starting the field test, I gave a quick briefing / overview of the technique, showed them the data sheets to be used, and had a question-answer session with the participants. This was to make sure that they were all in principle capable of correctly carrying out the required steps of the technique, so that problems due

to not properly understanding what was required did not become confounded with the inter-observer variability being tested.

5. We made the decision during the field tests to exclude potential available browse sitting over 2m above ground, even though black rhino do push over some tree species to access this browse. Firstly, it was known that such browse would not contribute significantly to intake levels; and secondly, most such browse would not be available to younger rhino , which are the ones most likely to suffer from browse limitations in the 0-2m height range, affecting survival and future population growth rates.

6. The test plots were then visited and assessed. All participants visited the plots together, but each made their own assessments by filling in data sheets (see appendix 3 for details). Herbs were rated separately from woodies. Each observer was also asked to separately use the calibrated browse availability photographs to assign an overall BA score to the plot. This allowed us to test the utility of the photographs on their own in BA assessment.

7. Results (estimated canopy cover, and estimated average canopy depth) were briefly exchanged among participants after each plot assessment. Data sheets were handed to me after every 2 plots (there were 2 plots per data sheet).

> The brief exchange of results was only used twice to adjust an observer's approach, but *no actual assessment results of any observer were changed during these discussions*:
>
> On the first occasion, involving the first assessment plot, an observer made a very conservative canopy cover estimate for the dense vegetation. The other observers had been discussing on the way to the plot how observers tend to always over-estimate canopy cover, and this observer had then tried to really be conservative. In discussions afterwards he agreed to let his own impressions and the canopy cover charts guide him more.
>
> On the second occasion, after assessments of plot 6, one observer had rated the average canopy depth to be much greater than any other observer. The plot had two discrete types of browse – low browse bushes in the grass layer, and then small clumps of browse at 1.7-2m occurring on the lower branches of tall trees. The participant said that he suddenly thought (during the assessment) that the height of the low-growing browse needed to be added to the height of the upper-layer browse to get the average. After discussions they realised this was a mistake.

8. On the second day, the observers were split into 4 teams. Each team was assigned a section of the reserve, and proceeded to systematically assess plots within the major vegetation types within their section (only 4 of the major vegetation types within Weenen were surveyed). This data was used to determine the number of plots needed to obtain reliable estimates of average browse availability for such types. Open *Acacia seberiana* Woodland, Mixed Veld (=Bushveld and Mixed Veld), Thornveld and Riverine Thornveld were surveyed by the 4 teams.

RESULTS

1. Can the technique score vegetation types to within 1 category either side of their true browse availability scores?

Figure 2 shows the frequency distribution of category deviations from actual BA score categories across the 10 plots and 10 observers (95 observations – one observer was absent for 5 plot assessments). 91.6% of the observations were within 1 score category of the true BA score categories.

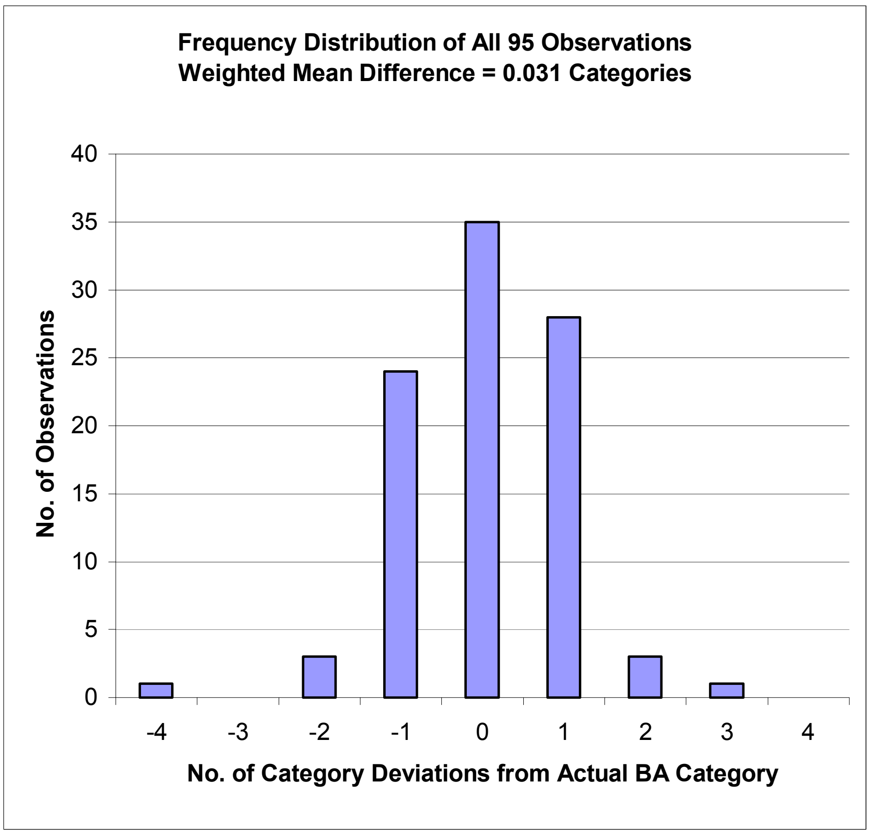


Figure 2. The frequency distribution of observer score category deviations from actual plot BA scores. E.g. "–1" means the observers scored a site one score category lower than the actual BA score category.

2. Does the technique show bias, and consistently over- or under-estimate browse availability?

Overall, the technique appears to marginally upwardly biased - on average observers deviated overall from the true BA score category by only 0.03 of a category (figure 2).

Is there bias in high versus low availability plots?

There is some indication from figure 3 that the technique may be slightly biased towards overestimation of BA for higher overall browse availabilities (from the 15-20% score category up). The degree of bias is 0.23 of a category (i.e. nearly a quarter of a category). This may have resulted because usually in denser plots, many plants have canopies that extend above 2m, possibly giving the visual impression of greater amounts of available browse? This kind of bias, if it is a consistent feature of the technique among all observers, may elevate carrying capacity estimates to a small degree (see question 3 below).

Browse availability assessment could also be biased towards under-estimation to a smaller degree in low BA areas (figure 4). Unless the plots are really well searched, observers tend to miss many small plants, which do contribute to slightly higher available browse than is usually visually apparent.

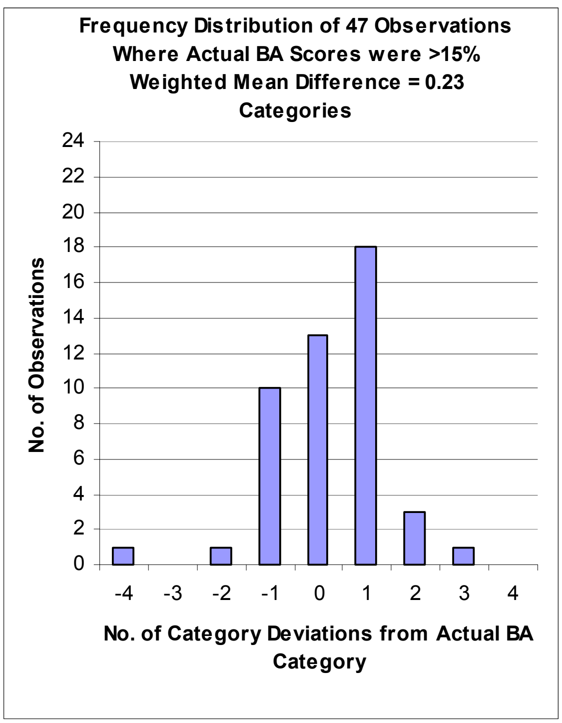


Figure 3. The frequency distribution of observer score category deviations from actual plot BA scores among plots with BA score of 15-20% or greater.

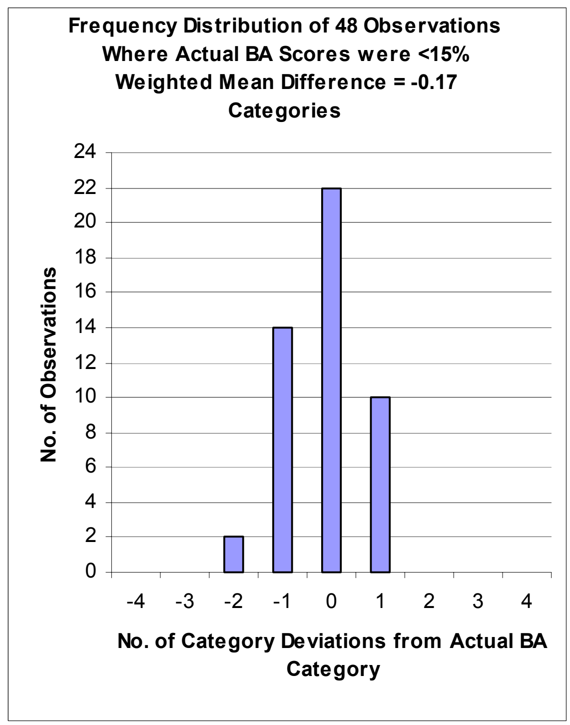


Figure 4. The frequency distribution of observer score category deviations from actual plot BA scores among plots with BA score of 10-15% or less.

3. Can the calibrated BA photographs be used on their own to score vegetation types to within 1 score category either side of their true browse availability scores?

During the field tests, observers also used the calibrated BA photographs (from Adcock 2003) on their own, to estimate a BA score for each plot. This was done by attempting to obtain the nearest visual match between the plot itself and the vegetation shown in the photographs. 78.8% of BA scorings from photographs were within +or - 1 BA score category of the measured BA.

BA assessment from photographs alone was upwardly biased by on average 0.5 of a category. The bias did appear to be greater among denser plots. Observers found it difficult to use to photographs at times, occasionally feeling they could not find any suitable matching photos. Sometimes they neglected altogether to use the photos (although this may have been because only 5 sets of photos were available among the 10 observers).

This finding substantiates the statement in Adcock (2003) that the photos should only be used as a backup, not a primary approach to BA scoring. However, the photos do have some advantages (namely speed of use, although sacrificing accuracy), and it was felt among observers that photos could prove a useful approach provided that each rhino area developed its own set of calibrated photos specific for each of its vegetation states.

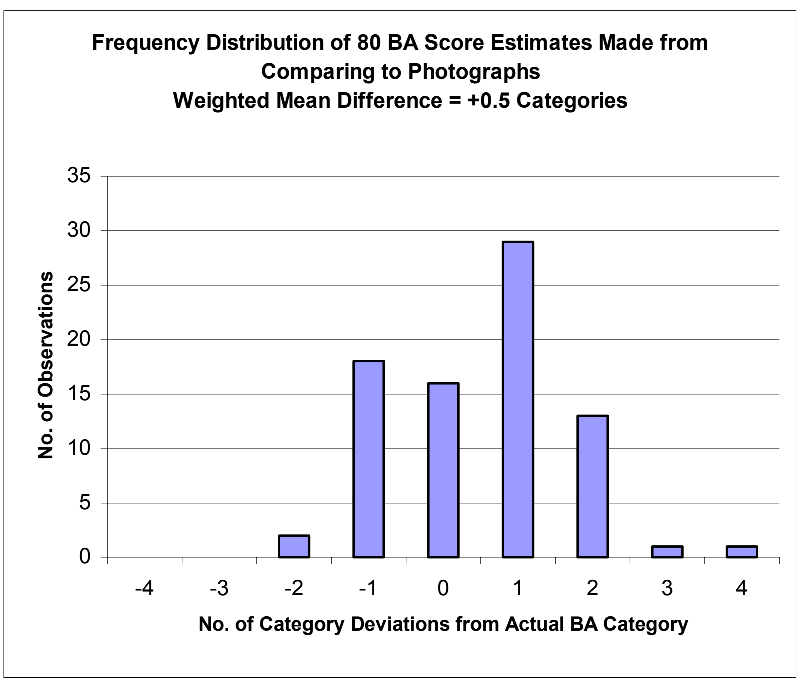


Figure 7. The frequency distribution of observer score category deviations from actual plot BA scores, for scores assessed using the calibrated browse availability photographs alone.

4. How does observer variation impact estimation of black rhino ecological carrying capacity?

It is important to look at how observer variability in BA assessment impacts final estimation of black rhino carrying capacity. To do this, observer assessments of each of the 10 plots were used in the RMG black rhino carrying capacity model, as if they were the scores for 10 different entire vegetation types in Weenen Nature Reserve. Each "vegetation type" was assigned to make up 10% of the reserve. Data are presented in appendix 4, and results shown in the tables (2 and 3) below.

Table 2. Results of a simulation of 10 vegetation types (from the Score categories of the 10 test plots) in Weenen NR, showing the overall browse availability %'s, model variable values, and the resulting estimated ecological carrying capacities from each observer and from the actual measured BA's categories (real BA).

	OBSERVERS										REAL
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	***Obs. Mean***	
Overall Browse Availability (%):	16.90	17.60	18.18	17.43	19.00	18.05	18.48	16.85	16.68	*17.68*	16.63
Model Variable: Square Root of BA	4.11	4.20	4.26	4.17	4.36	4.25	4.30	4.10	4.08	*4.20*	**4.08**
Model Est. ECC (Rhino per Km^2)	0.24	0.25	0.26	0.25	0.26	0.26	0.26	0.24	0.24	*0.25*	**0.24**

Table 3. Summary of observer variation effects on ECC.

	REAL	Observer Mean	Observer Std.Dev.	% Coefficient of variation
Overall Browse Availability (%):	**16.63**	17.68	0.80	4.53%
Model Variable: Square Root of BA	**4.08**	4.20	0.10	2.26%
	Model est. ECC			-
(Rhino per Km^2)	**0.24**	0.25	0.01	3.70%

Based on the test results, observers overestimated black rhino carrying capacity by 0.01 rhino per km2 on average. Their overall (simulated) browse availability ratings for the reserve showed a coefficient of variation of 4.53%, and their estimated carrying capacities showed a coefficient of variation of 3.70%

How do observer estimates of ECC using absolute % BAs (not BA score categories) compare?

Could the placing of observer BA estimates into categories cause a bias or increase in variation in overall estimates of browse availability? What if the observers' actual % BA estimates (not the BA Score classes / categories) were used in the estimation of carrying capacity?

Table 4 shows that using the absolute (non-categorised) BA estimates produces very similar results to using the BA Score categories (i.e. the category mid-classes). The coefficients of variation are very slightly smaller than with using categorisation (compare table 3 versus table 5)

The pro's and con's of using BA categories need more thought. It may be that this increases error, as observer estimates may be actually close to the real %BAs but they fall more often into different categories (e.g. when the real BA s are near one or other end of each given BA category range.). This can be seen to some extent in figure 5 (1-10), which shows the actual BA data from each plot in graph form, plotted against the relevant regions of the overall BA scale. One benefit of using categories is that sample size requirements are reduced (seen when comparing CVs of absolute versus category mid-class values from sets of sample plots in different vegetation types, section 5 data).

Table 4. Results of a simulation of 10 vegetation types (from the 10 test plots' actual observer estimated % BAs) in Weenen NR, showing the estimated browse availability %'s, model variable values, and the resulting estimated ecological carrying capacities from each observer and from the actual measured plot BA's.

	OBSERVERS										REAL
	A	B	C	D	E	F	G	H	I	Obs. Mean	
Overall Browse Availability (%)	**16.42**	**16.53**	**17.01**	**16.89**	**18.24**	**17.65**	**17.98**	**17.24**	**15.97**	***17.10***	**16.17**
Model variable: Square Root of BA	**4.05**	**4.07**	**4.12**	**4.11**	**4.27**	**4.20**	**4.24**	**4.15**	**4.00**	***4.13***	**4.02**
											Model est. ECC
Model Est. ECC	**0.24**	**0.24**	**0.25**	**0.24**	**0.26**	**0.25**	**0.25**	**0.25**	**0.24**	***0.25***	**0.24**

Table 5. Summary of observer variation effects on ECC.

	REAL	Observer Mean	Observer Std.Dev.	% Coefficient of variation
Overall Browse Availability (%):	**16.17**	**17.10**	**0.75**	**4.39%**
Model Variable: Square Root of BA	**4.02**	**4.13**	**0.09**	**2.19%**
Model Est. ECC	**Model est. ECC**			
(Rhino per Km^2)	**0.24**	**0.25**	**0.01**	**2.83%**

How do observer estimates of ECC based on rating %BA by photographs only compare?

When participants rated plot %BA using the photographs alone, much more inter-observer variation was found, and observers tended to over-estimate available browse far more often. This had a much larger impact on carrying capacity estimates derived from photograph-rated plots alone. *ECC was overestimated by 0.03 rhino per km2 on average, with a larger % coefficient of variation of 5.9%.*

Photographs alone thus do need to be used with caution. It is unlikely that a way can be found to help observers not to over-estimate availability using the photos. However, some form of correction factor on photo-based ratings could be developed to account for over-estimation – for example correcting each vegetation type's final BA rating by -½ a class – which means taking the lower boundary of each class rather than the mid-class value. *More work may be needed on this. The advantages in terms of speed of application of the %BA rating method would be considerable.*

Table 6. Results of a simulation of 10 vegetation types in Weenen NR (using observer estimated % BAs made from photographs alone in the 10 test plots), showing the overall estimated browse availability %'s, model variable values, and the resulting estimated ecological carrying capacities from each observer and from the actual measured plot BA's. (In 8 out of 80 cases, observers did not make a %BA rating using the photographs. In such cases, observers' rating for the plot made using the main technique was used for the relevant plot in this simulation of ECC estimation).

	OBSERVERS										REAL
	A	B	C	D	E	F	G	H	I	*Obs. Mean*	
Overall Browse Availability (%)	20.45	19.63	22.4	21.38		17.83	18.83	20.83	19.55	*20.11*	16.625
Model variable: Square Root of BA	4.52	4.43	4.73	4.62		4.22	4.34	4.56	4.42	*4.48*	4.08
											Model est. ECC
Model Est. ECC (Rhino per Km^2)	0.28	0.27	0.3	0.29		0.25	0.26	0.28	0.27	0.27	0.24

	REAL	Observer Mean	Observer Std.Dev.	% Coefficient of variation
	16.625	20.11	1.46	7.25%
Overall Browse Availability (%)	4.08	4.48	0.16	3.63%
Model variable: Square Root of BA	Model est. ECC			
Model Est. ECC (Rhino per Km^2)	0.24	0.27	0.02	5.94%

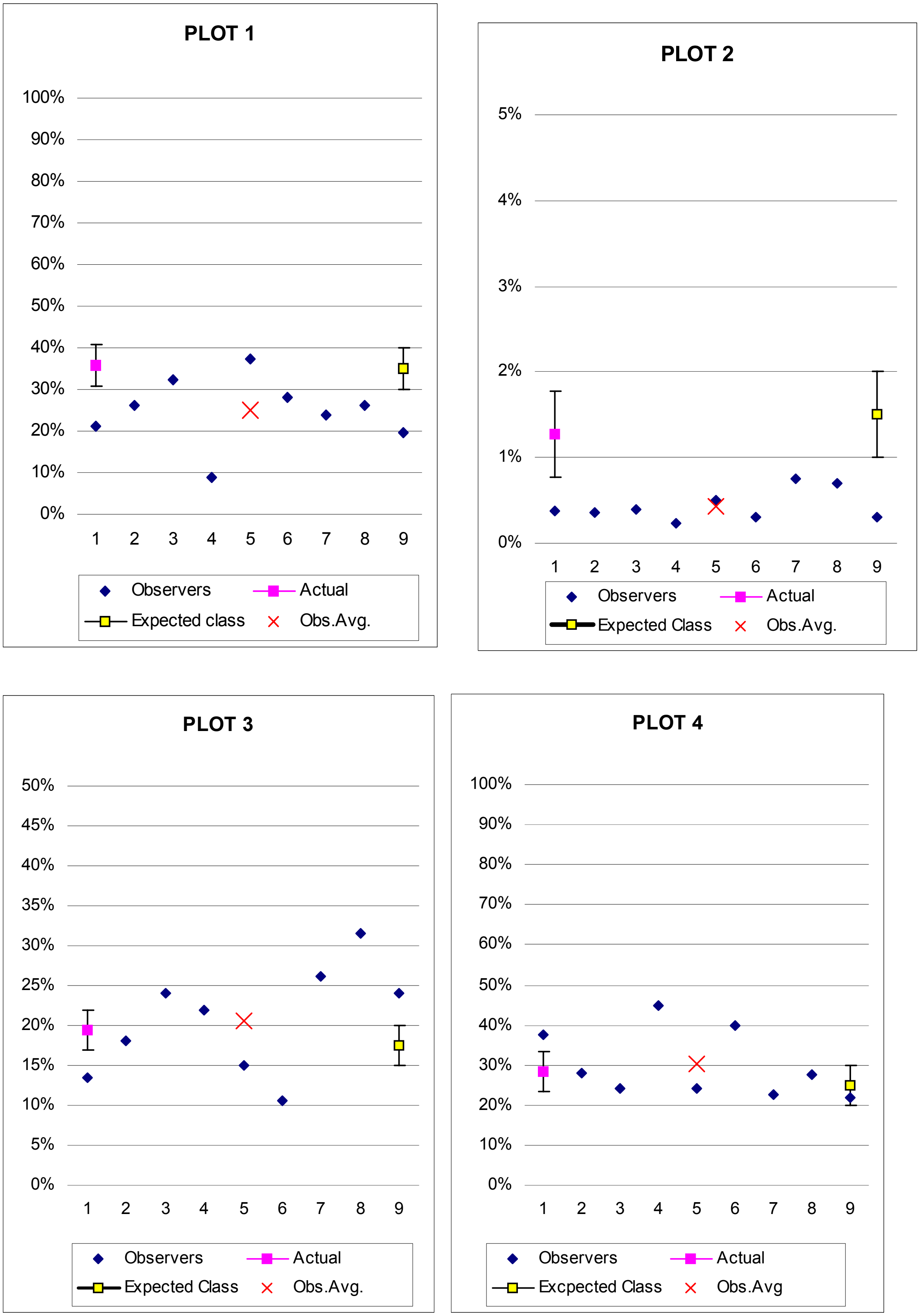


Figure 5 (1-4). Charts showing the BA estimation results of each observer in plots 1-4, with the actual measured BA, (left hand squares with bars indication imaginary category spans around them), and measured BA score class (right hand square with actual category range bars).

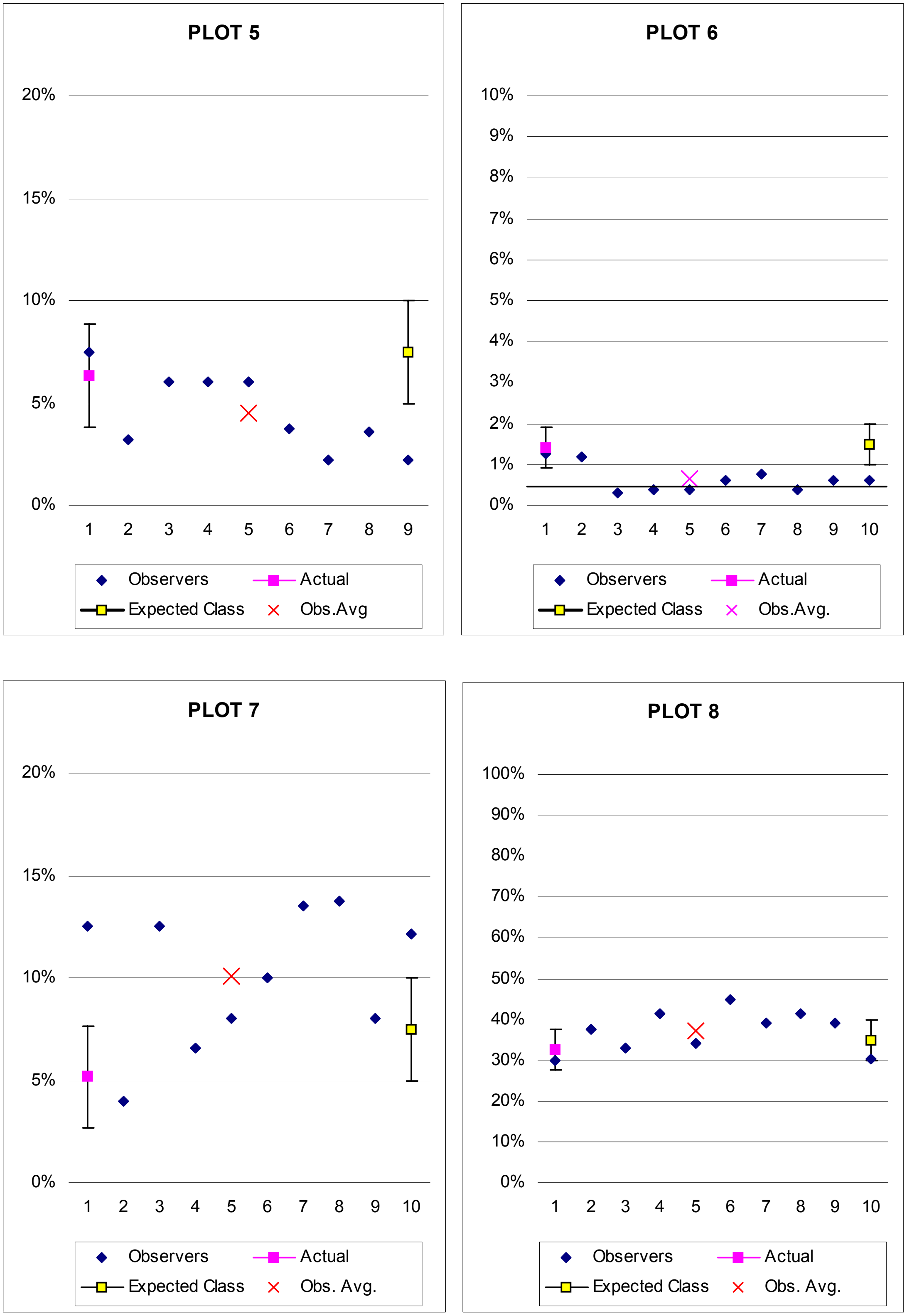


Figure 5 (5-8). Charts showing the BA estimation results of each observer in plots 5-8, with the actual measured BA, (left hand squares with bars indication imaginary category spans around them), and measured BA score class (right hand square with actual category range bars).

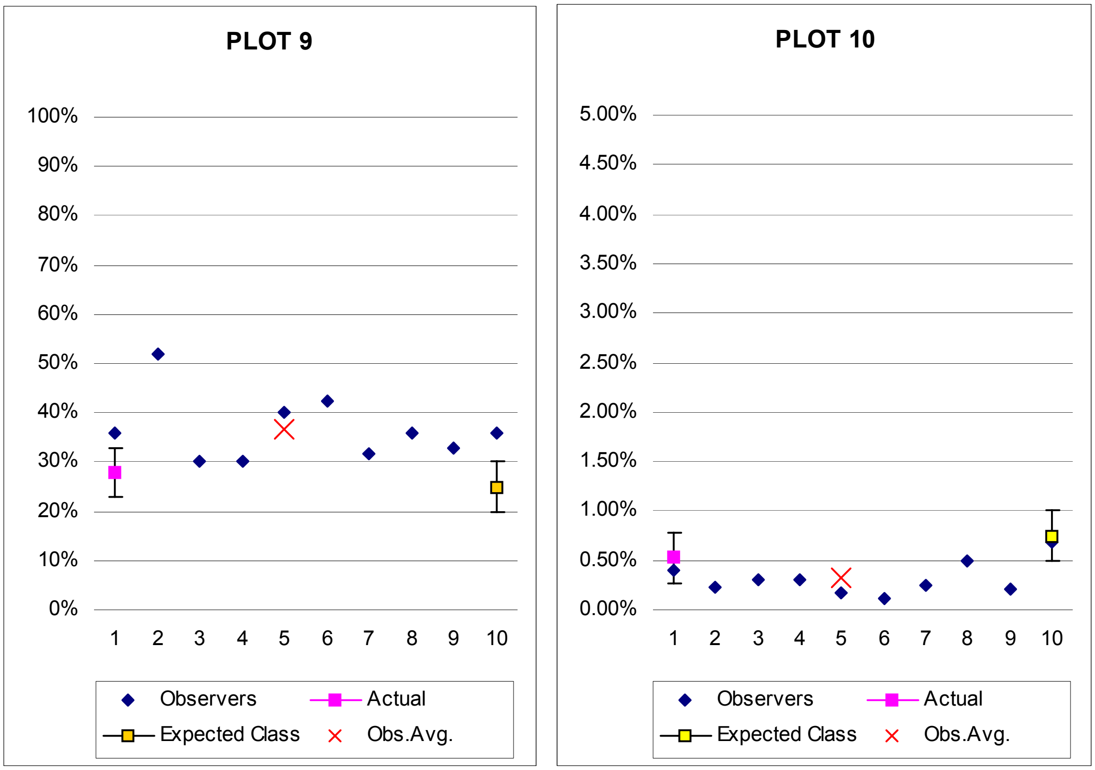


Figure 5 (9-10). Charts showing the BA estimation results of each observer in plots 9-10, with the actual measured BA, (left hand squares with bars indication imaginary category spans around them), and measured BA score class (right hand square with actual category range bars).

5. What is the variation and bias in the estimation of each of the woody BA assessment components: woody % canopy cover and % vertical fill.

This section looks in more detail at the two main components of BA assessment, %canopy cover estimation and % vertical fill, for the woody plant component of available browse.

From figure 6 (plots 1-10) it appears that observers on average underestimated plot canopy cover, and overestimated % vertical fill, and that the biases in estimating these components most often tended to cancel each other out to give BA estimates in the right ballpark.

% canopy cover was on average underestimated by -16.3 in denser plots (from 15-20% BA or more), and by –0.61 among more open plots with BAs of 10-15% or less. % Vertical fill was on average overestimated by 17.5% in denser plots (from 15-20% BA or more), and by 1.87% among more open plots with BAs of 10-15% or less.

Methods to give improvements in observer BA estimates should thus focus on aiding better estimation of each of these components.

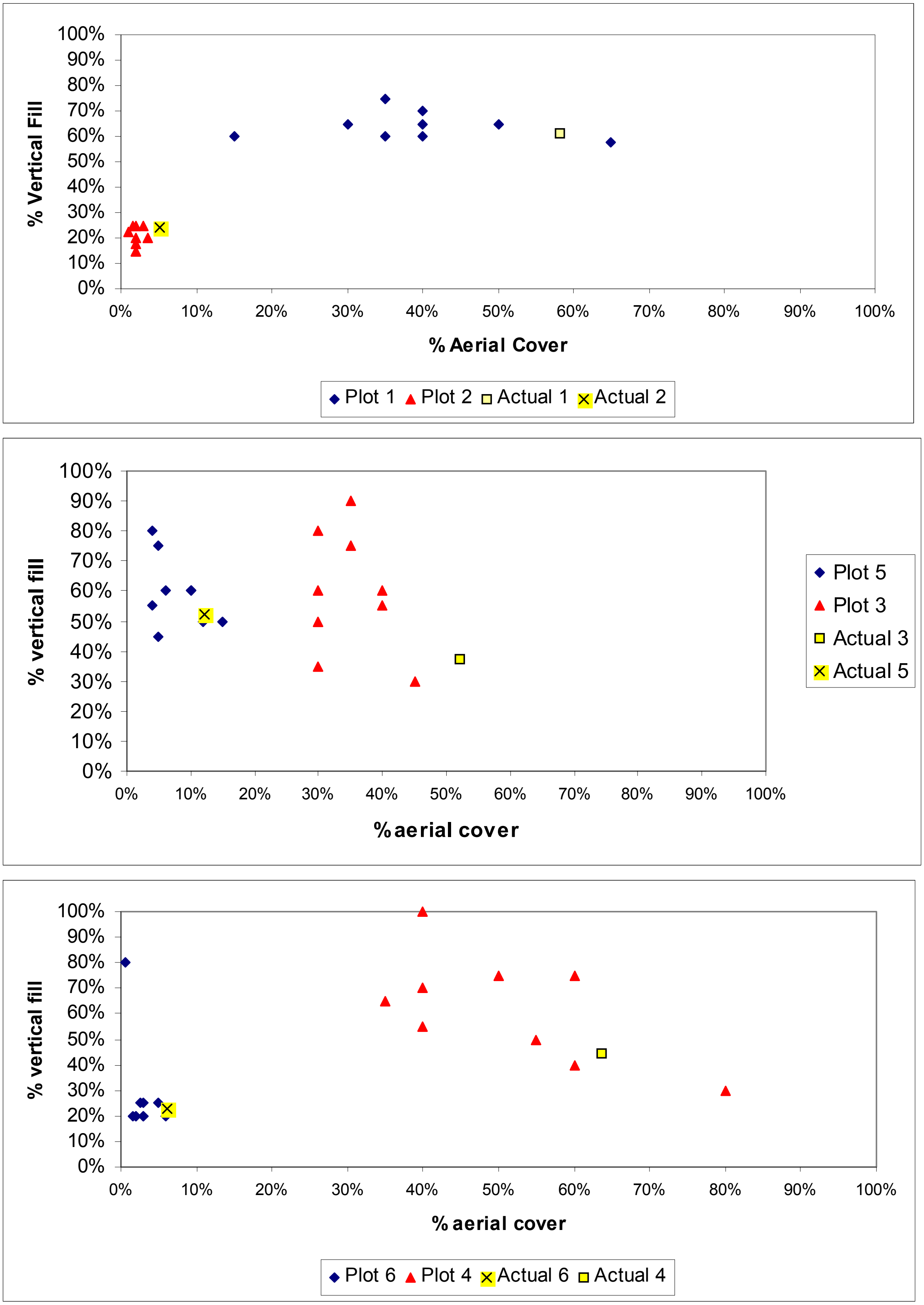
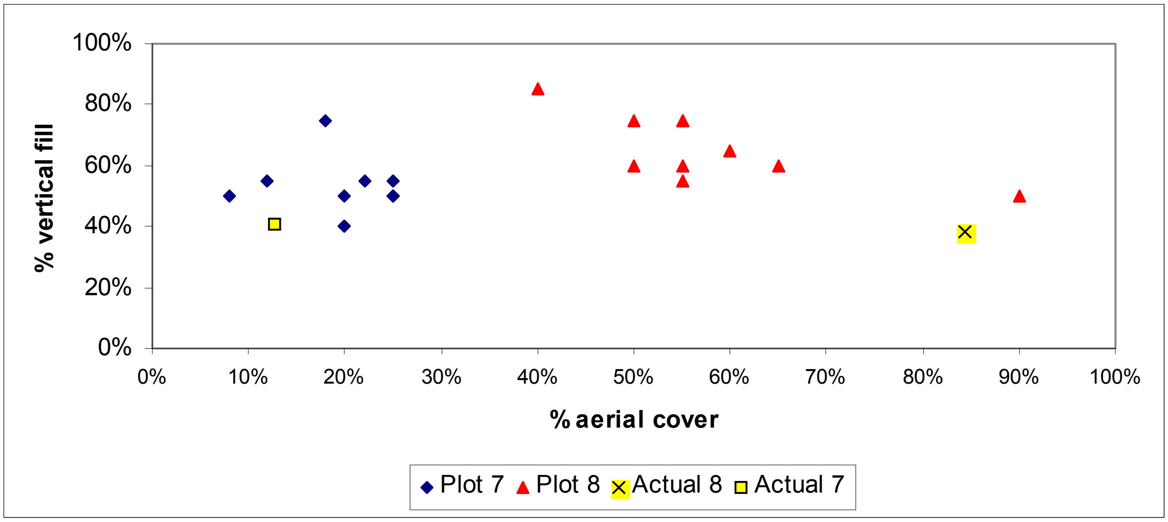


Figure 6 (showing plots 1 to 6). (Woody component only – excluding herbs) Observer estimates of % canopy cover and % vertical fill, versus the measured values for these components in each plot.



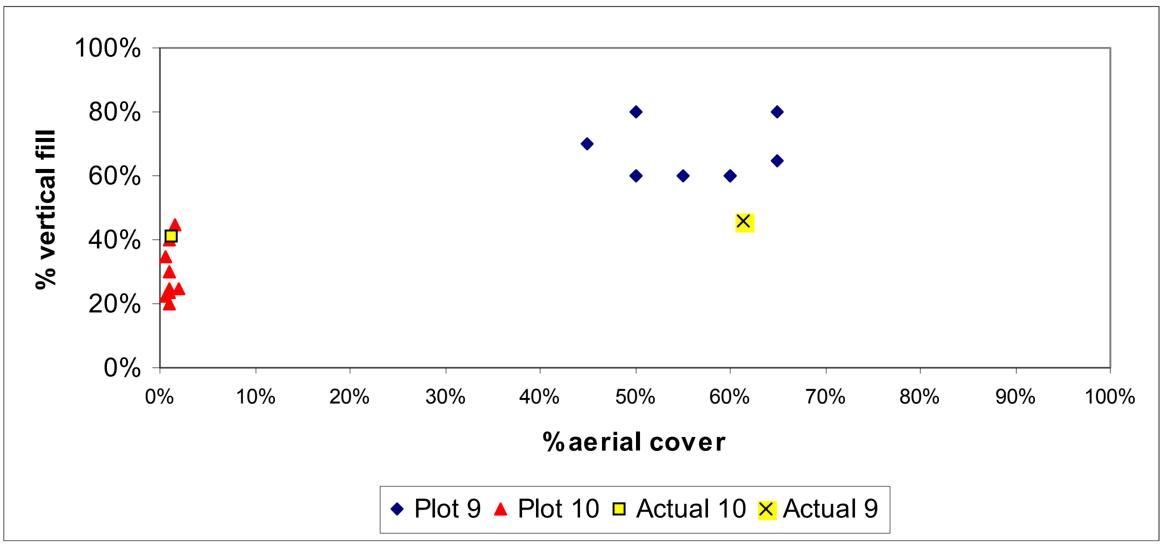


Figure 6 (showing plots 7 to 10). (Woody component only – excluding herbs) Observer estimates of % canopy cover and % vertical fill, versus the measured values for these components in each plot.

6. How accurately can the availability of the Herb component be estimated?

The abundance of the herb component is estimated separately from the woody component in BA assessment. The percentages of herbs and woodies are added together to produce a plot BA score. The herb component is thought to play a special, important role in black rhino carrying capacity and possibly performance. In the next version of the black rhino carrying capacity model, the use of the herb score as a separate variable in the model needs to be investigated.

In this observer test, herbs were not very abundant, and in most cases scored < 1% availability. However, even small amounts were important in contributing to BA scores in very open habitats. Riverine and more heavily wooded areas tended to have higher herb loads. Average herb height (to give % vertical fill) was fairly easily estimated by observers. However, herb % canopy cover seems to be difficult to estimate accurately. As for woodies, more and better example graphics of canopy cover arrangements are needed to help observers.

7. Sample size - how many plots need to be assessed in different types of vegetation to get acceptably precise estimates of average browse availability for each type?

Sample size (N) requirements can be estimated using the formula: $N = t^2 \times S^2 / E^2$ (t = t-table value for $\alpha = 0.05(2)$, S^2 = variance (std.dev. squared), and E = the required confidence interval (+ or – E). In the context of estimating mean BA for carrying capacity assessment, controlling for type-two error as well by specifying β is probably unnecessary "overkill".

Table 6. Summary of results of plots surveys in 4 Weenen vegetation types. By excluding patches of thicket (and treating them separately, i.e. by stratifying within vegetation types), variance and required sample sizes are drastically reduced.

Browse Availability	**Open A.seb. Woodland**	**Mixed Veld**	**Riverine**	**Thornveld**
Mean	0.43%	8.09%	14.51%	8.29%
Std. Deviation (in BA %)	0.39%	8.16%	8.73%	9.37%
No of Plots Assessed	22	14	23	24
Range	0.25-1.5%	0.25-25%	0.75-35%	1.5-35%
Required Sample Size Including thicket patches	**3**	**50**	**52**	**60**
Required Sample Size with thicket patches excluded	***na***	***13***	***17***	***15***
Mean BA without thicket patches	na	5.27%	10.22%	5.86%
Std. Deviation without thicket patches	na	4.24%	4.95%	4.71%
no. of thicket spots excluded	na	2	6	2
% area of thickets within veg. type		14.3%	26.1%	8.3%
Thicket Mean BA		25.00%	26.70%	35%
Thicket Std. Deviation		0.00%	+ or - 4.08%	0.00%

The survey exercise done at Weenen within 4 of the major vegetation types helped to show the kind of variation that can exist within a vegetation (see figure 8), and also highlighted the need to control for this by *additional stratification where possible within vegetation types*.

For example, as shown in table 6 above, by treating thicket patches within an otherwise more open a vegetation type as a separate entity, the standard deviations and sample size requirements for obtaining acceptable estimates of mean BA scores become quite reasonable (13-17 samples + a smaller amount in the thicket patches where variance is proportionally lower). One would need to makes an estimate the proportional area comprising thicket within such vegetation types, which could be done from aerial photos, or visually in the field during the survey.

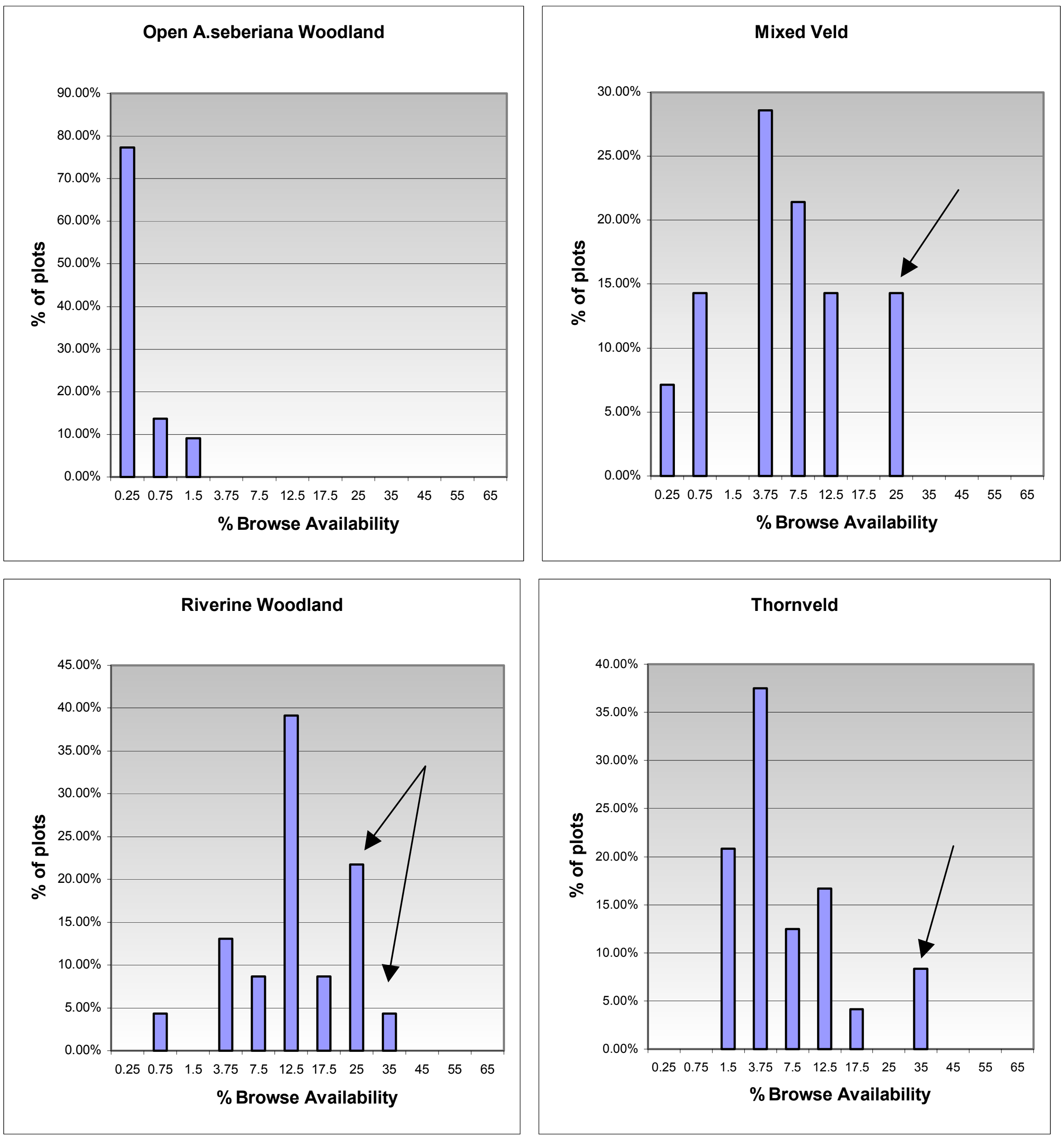


Figure 8. The frequency distribution of assessed plot BA scores in 4 different vegetation types in Weenen Nature Reserve. Variance can be reduced greatly by stratifying for thicket patches within vegetation types (as indicated by arrows).

Graphs to estimate sample size requirements

To be able to estimate how many samples would be required for a vegetation type, one would need to get a rough initial impression of the likely average BA score for that type (the size of required confidence intervals varies with different BA scores, affecting sample size requirements – see table 7).

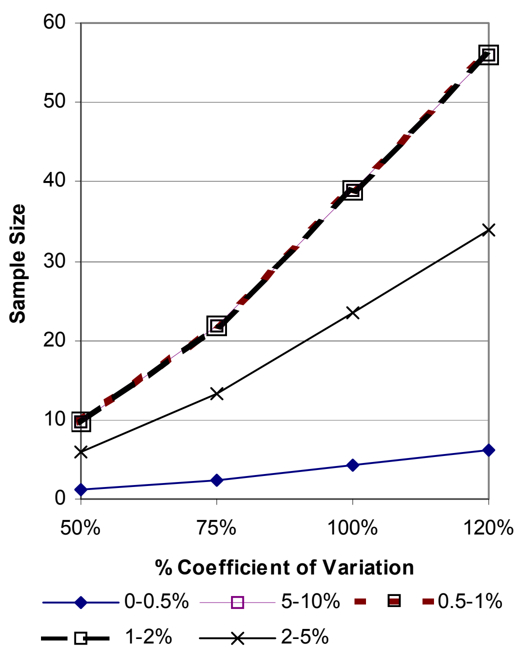
Table 7: Variation in the relative and absolute size of required confidence intervals for different BA Score categories.

Likely Avg. BA Score	BA Mid-Class	Required BA Conf. Interval (+ or -)	CI as a % of MidClass
0-0.5%	0.25%	0.25%	100%
0.5-1%	0.75%	0.25%	33.3%
1-2%	1.5%	0.50%	33.3%
2-5%	3.5%	1.50%	43%
5-10%	7.5%	2.50%	33.3%
10-15%	12.5%	2.50%	20%
15-20%	17.5%	2.50%	14.3%
20-30%...60-70%	25…65%	5%	20, 14.3, 11.1, 9.1, 7.7%
70-100%	85%	15%	17.7%

One also needs to estimate the likely % coefficient of variation likely to be encountered within the type, preferably after first stratifying to account for obvious patchiness such as thickets. Table 8 shows the % CV's found at Weenen. *Armed with likely average BA score and likely %CV, the required sample size can be read off the graphs below'*.

Table 8: % Coefficients of variation obtained at Weenen in 4 vegetation types.

	Open A.seb. Woodland	Mixedveld	Riverine	Thornveld
Avg. BA Score,	0-0.5%	5-10%	10-15%	5-10%
Mid-Class	0.25%	7.5%	12.5%	7.5%
%CV with thickets	90%	101%	60%	113%
%CV without thickets		80%	48%	80%
Sample size needed	c.5	c.25	c.25	c.25



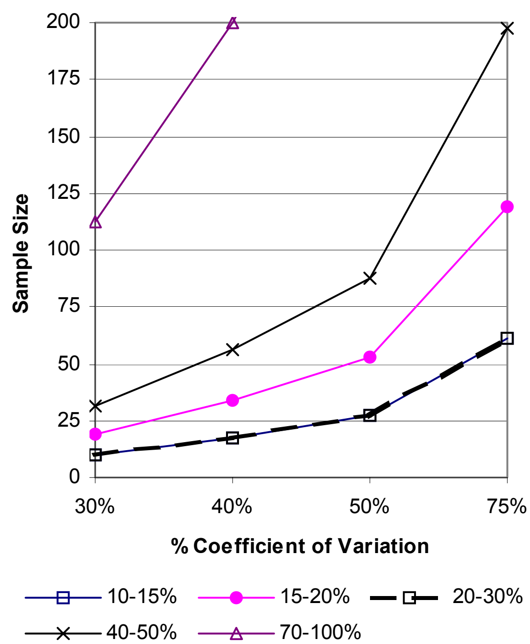


Figure 9. Sample sizes requirements for a range of average BAs and % CV s

8. How easily did participants understand the BA assessment manual?

The effectiveness of the BA assessment manual "VISUAL ASSESSMENT OF BLACK RHINO BROWSE AVAILABILITY" (Adcock 2003) in providing effective training of potential browse assessors, was assessed by

- a questionnaire (see appendix 2) completed by 7 participant prior to the field tests,
- feedback provided by the specialist participants
- Dr Craig Morris of Univ. KwaZulu-Natal, Pietermaritzburg, who reviewed the manual in some detail, and
- by issues raised by the participants during the field test, while implementing the technique and assessing particular arrangements of browse.

On average, participants got 72 % of the questions correct (appendix 2 provides the tabulated observer results). This highlighted the need to clarify some of the technique descriptions in the manual, and in particular to use better layout to make things easier to understand quickly (however, some observers did admit that they had not really read the manual thoroughly before the field test!).

The field tests (and questionnaire etc) gives some indication that even if the clarity of the manual could be greatly improved, for a new operator to use the technique reliably, some form of training will be needed. The options for this are…

- to include a self-training procedure and questionnaire in the manual, that new operators must complete properly before they commence with field work,
- a computer training video could be developed to accompany the manual, which would also have a brief self-training procedure in it
- Formal training courses could be given to suitable wildlife personnel likely to be involved in black rhino habitat work or management.

One main issue that needed clarifying in the manual was how to assess the % vertical fill. It was not specified in the manual that one needed to estimate the *weighted* mean depth of the browse canopies. More details on how this should (and should not) be approached, along with special chart, have been developed to update the manual.

The need for more visual aids and approaches to help assess % canopy cover also became apparent in the field. These have been developed for the updated manual.

The issue of the plot size and shape was of concern to the specialists. I do not think this is of great concern, but the rule should be that the plot size should be kept the same within one vegetation type. A general consensus is that a plot of 20 x 20 m or 20 m diameter plot is useful. (The specialists preferred the idea of a square plot. My own feeling is that a circular area is better – one can easily learn to visualise 10 m out from a central point all around one. The centre point is where the observer starts off, and then ends standing at while finalising the canopy assessments. The corners of a 20 x 20 m plot are not easily pictures from a centre point).

ACKNOWLEDGEMENTS

Acknowledgements go to the SADC Regional Programme for Rhino Conservation, which provided essential funding for the standardised development and testing of this technique.

Craig Morrison of the University of Natal, Pietermaritzburg, is also gratefully acknowledged for his input during various stages of this project. The valuable review comments of Tim O'Connor, Bruce Page and Kevin Kirkman are also acknowledged, and thanks go to them and to Caiphus Khumalo, John Llewellyn and Gordon Smith, Tanya Smith, Michelle Payne and Caryn Rauff for assisting with the field trials into inter-observer variability. Manythanks also to Caiphus Khumalo who also assisted with measuring of actual available browse within the Weenen plots.

APPENDIX 1: Simulation of scenarios of wrongly rating the Browse Availability of all vegetation types in a reserve with 4 vegetation types making up equal proportions of the property (=25% each).

BA Score Midclass as a Proportion

	0.0025	0.0075	0.015	0.035	0.075	0.125	0.175	0.25	0.35	0.45	0.55	0.65	0.9
Proportion of Reserve / Property Rated in a Given BA Score Category	0.25	0.25	0.25	0.25									
		0.25	0.25	0.25	0.25								
			0.25	0.25	0.25	0.25							
				0.25	0.25	0.25	0.25						
					0.25	0.25	0.25	0.25					
						0.25	0.25	0.25	0.25				
							0.25	0.25	0.25	0.25			
								0.25	0.25	0.25	0.25		
									0.25	0.25	0.25	0.25	
										0.25	0.25	0.25	0.25

	BA Score Midclass x Vegetation type Area (as a Proportion) giving weighted contribution to the overall BA score by each vegetation type													∑ =Overall BA Score	Times Higher than prev. Score	Times Lower than next Score
Weighted BA Score by vegetation Type	0.000625	0.001875	0.00375	0.00875	0	0	0	0	0	0	0	0	0	1.50%		X 0.453
	0	0.001875	0.00375	0.00875	0.01875	0	0	0	0	0	0	0	0	3.31%	X 2.208	X 0.53
	0	0	0.00375	0.00875	0.01875	0.03125	0	0	0	0	0	0	0	6.25%	X 1.887	X 0.61
	0	0	0	0.00875	0.01875	0.03125	0.04375	0	0	0	0	0	0	10.25%	X 1.640	X 0.656
	0	0	0	0	0.01875	0.03125	0.04375	0.0625	0	0	0	0	0	15.63%	X 1.524	X 0.694
	0	0	0	0	0	0.03125	0.04375	0.0625	0.0875	0	0	0	0	22.50%	X 1.440	X 0.7347
	0	0	0	0	0	0	0.04375	0.0625	0.0875	0.1125	0	0	0	30.63%	X 1.361	X 0.7656
	0	0	0	0	0	0	0	0.0625	0.0875	0.1125	0.1375	0	0	40.00%	X 1.306	X 0.8
	0	0	0	0	0	0	0	0	0.0875	0.1125	0.1375	0.1625	0	50.00%	X 1.250	X 0.785
	0	0	0	0	0	0	0	0	0	0.1125	0.1375	0.1625	0.225	63.75%	X 1.275	

Appendix 2. QUESTIONAIRE ON THE MANUAL

"VISUAL ASSESSMENT OF BLACK RHINO BROWSE AVAILABILITY" (Adcock 2003)

1. What is your Name?
2. Which mammal species' habitat is assessed in this method? – tick the correct picture

3.. The visual assessment method described in the manual assesses which 1 of the following?
   1. The suitability of plant species for black rhino
   2. The space available for black rhino
   3. The amount of browse potentially available for black rhino
   4. The vegetation structure in rhino habitat

4. Up to what height level do black rhino do most of their feeding?
   1. 2m
   2. 1m
   3. 3m
   4. 8m

5.The technique focuses on which aspect of vegetation?
   a. The stem diameter of plants
   b. The height of trees
   c. The canopy diameter of plants
   d. The volume of browsable plant canopies

6. What is generally the optimal feeding height of black rhino?
   e. From 1.5-2m
   f. From 1-1.5m
   g. From 0.5 to 1m
   h. From 0-0.5m

7. Up to approximately what twig diameter can rhino bite off browse?
   1. 0.5 cm
   2. 1cm
   3. 1.5cm
   4. 2cm
   5. 2.5cm
   6. 3cm

8. Do rhino eat dead sticks?

9. How is the rhino's browse space defined (i.e. the "rhino's pie")?

10. What does the visual technique try to assess about the "rhino's pie"?

11. Which two plant canopy attributes are taken into account during the visual assessment?

12. What two things do you need to translate these (above) into to estimate the browse availability score?
   a) total plant height
   b) % vertical fill
   c) % suitable browse
   d) % canopy cover
   e) Average canopy diameter

13. How does one deal with forbs in browse availability assessment?

14. What do you do if you are assessing a site containing woody species/ shapes that rhino routinely pushes over to access browse above two meters off the ground?

15. If you had an estimated vertical fill of 50%, and an estimated canopy cover of 30% at a site, how would you calculate a Browse Availability Score?

16. If each vegetation type in a reserve was assessed and given the average BA scores below, show how you'd calculate the overall BA score for the reserve:

Vegetation Type	**Proportion of reserve**	**Score**	**(middle of score class as a proportion)**
A	**0.25**	**1-2%**	**0.015**
B	**O.50**	**20-30%**	**0.25**
C	**0.25**	**10-15%**	**0.125**

Show here: (write out the proper calculation – don't need to work out the answer)….

RESULTS QUESTION #	A	D	H	B	F	G	I	Answer	# Observers Correct	Out of	% Correct	Avg.
1												
2	B	B	C	B	C	B	A	B	4	7	57.1%	
3	3	3	3	3	3	3	3	3	7	7	100.0%	
4	1	1	1	1	1	1	1	1	7	7	100.0%	
5	D	D	D	D	D	D	D	D	7	7	100.0%	
6	B	C	C	C	C	C	B	C	5	7	71.4%	
7	4	5	6	3	6	5	6	6	3	7	42.9%	
8	YES	YES	NO	NO	NO	NO	NO	NO	5	7	71.4%	All 77.6%
	Degree of correctness											
9	0	1/2	1/2	1	0	1/2	0		2.5	7	35.7%	
10	3/4	3/4	1	1	1/2	1	1/2		5.5	7	***78.6%***	
11	1/2	0	1/2	1	3/4	1/2	3/4		4	7	57.1%	
12	1/2	1/2	1	1	1	1	1		6	7	***85.7%***	
13	1/2	0	1	1	1/2	1/2	1		4.5	7	64.3%	
14	1/2	1/4	1/2	1	1/2	1	1		4.75	7	67.9%	
15	1	0	1	1	1	1	1		6	7	***85.7%***	***76.8%***
16	1	0	1	0	0	1	1		4	7	***57.1%***	All 66.5%
									OVERALL AVERAGE		**71.7%**	

Appendix 3. Data sheet used in the field tests.

Site No.		**notes:**
Photo-based Est. BA		
< 0.5%		
0.5-1%		
1-2%		
2-5%		
5-10%		
10-15%		
15-20%		
20-30%		
30-40%		
40-50%		
50-60%		
60-70%		
>70%		

Calculations for "woody"browse availability:

subtype A %	**Avg.Ht (m)**		**divide by 2**		**calc. BA %**
	% cover		**as proportion:**		
subtype B %	**Avg.Ht (m)**		**divide by 2 =**		**calc. BA %**
	% cover		**as proportion:**		
FORBS %	**Avg.Ht (m)**		**divide by 2**		**calc. BA %**
	% cover		**as proportion:**		

Top Species in terms of Weight (contribution to BA)	**Rank**	**%**	**Top Species in terms of Weight (contribution to BA)**	**Rank**	**%**

Appendix 4. Data from observer assessments of each test plot used to estimate ECC at Weenen NR , showing their exact calculated estimates of %BA for each "vegetation type' (plot), and the resulting BA score classes for each type, along with the results from the actual (real) measured plot browse availabilities.

		OBSERVERS										
	Calculated BA % (exact)	A	B	C	D	E	F	G	H	I	OBS.AVG	REAL % BA
"Vegetation types"	1	21.50%	26.23%	32.70%	9.20%	37.38%	28.23%	24.23%	26.81%	19.80%	***25.12%***	**36.00%**
	2	1.00%	0.50%	0.70%	0.53%	1.13%	0.40%	0.90%	1.08%	0.45%	***0.74%***	**1.77%**
	3	13.50%	18.04%	24.00%	22.00%	15.00%	10.50%	26.25%	31.55%	24.00%	***20.54%***	**19.50%**
	4	38.50%	40.00%	27.75%	48.00%	24.75%	46.00%	31.75%	27.70%	31.00%	***35.05%***	**30.00%**
	5	7.50%	3.20%	6.00%	6.00%	6.00%	3.75%	2.20%	3.70%	2.25%	***4.51%***	**6.30%**
	6	2.00%	1.30%	0.63%	0.93%	0.60%	1.75%	1.60%	0.64%	1.83%	***1.25%***	**1.51%**
	7	12.50%	12.50%	6.60%	8.06%	10.00%	13.50%	13.88%	8.20%	12.33%	***10.84%***	**5.60%**
	8	30.20%	33.20%	41.25%	34.00%	45.00%	40.25%	41.75%	39.20%	30.55%	***37.27%***	**32.50%**
	9	36.50%	30.05%	30.00%	40.00%	42.25%	31.63%	36.10%	33.20%	36.08%	***35.09%***	**28.00%**
	10	1.03%	0.31%	0.45%	0.18%	0.31%	0.48%	1.13%	0.35%	1.43%	***0.63%***	**0.50%**
	BA Scores (MidClasses)	OBSERVERS SCORES (MIDCLASSES)										REAL
		A	B	C	D	E	F	G	H	I	OBS.AVG	MidClass
"Vegetation types"	V1	25.00	25.00	35.00	7.50	35.00	25.00	25.00	25.00	17.50	***24.44***	**35.00**
	V2	1.50	0.75	0.75	0.75	1.50	0.25	0.75	1.50	0.25	***0.89***	**1.50**
	V3	12.50	17.50	25.00	25.00	17.50	12.50	25.00	35.00	25.00	***21.67***	**17.50**
	V4	35.00	45.00	25.00	45.00	25.00	45.00	35.00	25.00	35.00	***35.00***	**35.00**
	V5	7.50	3.50	7.50	7.50	7.50	3.50	3.50	3.50	3.50	***5.28***	**7.50**
	V6	3.50	1.50	0.75	0.75	0.75	1.50	1.50	0.75	1.50	***1.39***	**1.50**
	V7	12.50	12.50	7.50	7.50	12.50	12.50	12.50	7.50	12.50	***10.83***	**7.50**
	V8	35.00	35.00	45.00	35.00	45.00	45.00	45.00	35.00	35.00	***39.44***	**35.00**
	V9	35.00	35.00	35.00	45.00	45.00	35.00	35.00	35.00	35.00	***37.22***	**25.00**
	V10	1.50	0.25	0.25	0.25	0.25	0.25	1.50	0.25	1.50	***0.67***	**0.75**

Appendix 4 continued. Data from observer assessments of each test plot used to estimate ECC at Weenen NR. The first table shows the weighted contribution of each "vegetation type' (plot) to overall observer browse availability score s for Weenen, versus the results form the actual measured plot browse availabilities. The second table shows the difference between observer estimates of absolute % BA for each plot and the actual (measured) % BA for each plot.

		Weighted contribution of vegetation type to overall BA Score										
		A	B	C	D	E	F	G	H	I	OBS.AVG	REAL
"Proportion of Area"	V1 (10%)	2.5	2.5	3.5	0.75	3.5	2.5	2.5	2.5	1.75	***2.44***	**3.5**
	V2 (10%)	0.15	0.075	0.075	0.075	0.15	0.025	0.075	0.15	0.025	***0.09***	**0.15**
	V3 (10%)	1.25	1.75	2.5	2.5	1.75	1.25	2.5	3.5	2.5	***2.17***	**1.75**
	V4 (10%)	3.5	4.5	2.5	4.5	2.5	4.5	3.5	2.5	3.5	***3.50***	**3.5**
	V5 (10%)	0.75	0.35	0.75	0.75	0.75	0.35	0.35	0.35	0.35	***0.53***	**0.75**
	V6 (10%)	0.35	0.15	0.075	0.075	0.075	0.15	0.15	0.075	0.15	***0.14***	**0.15**
	V7 (10%)	1.25	1.25	0.75	0.75	1.25	1.25	1.25	0.75	1.25	***1.08***	**0.75**
	V8 (10%)	3.5	3.5	4.5	3.5	4.5	4.5	4.5	3.5	3.5	***3.94***	**3.5**
	V9 (10%)	3.5	3.5	3.5	4.5	4.5	3.5	3.5	3.5	3.5	***3.72***	**2.5**
	V10 (10%)	0.15	0.025	0.025	0.025	0.025	0.025	0.15	0.025	0.15	***0.07***	**0.075**

Differences of observer % BA versus Actual % BA		OBSERVERS										
		A	B	C	D	E	F	G	H	I	OBS.AVG	REAL % BA
"Vegetation types"	1	-14.50%	-9.78%	-3.30%	-26.80%	1.38%	-7.78%	-11.78%	-9.19%	-16.20%	***-10.88%***	**36.00%**
	2	-0.77%	-1.27%	-1.07%	-1.25%	-0.65%	-1.37%	-0.87%	-0.70%	-1.32%	***-1.03%***	**1.77%**
	3	-6.00%	-1.46%	4.50%	2.50%	-4.50%	-9.00%	6.75%	12.05%	4.50%	***1.04%***	**19.50%**
	4	8.50%	10.00%	-2.25%	18.00%	-5.25%	16.00%	1.75%	-2.30%	1.00%	***5.05%***	**30.00%**
	5	1.20%	-3.10%	-0.30%	-0.30%	-0.30%	-2.55%	-4.10%	-2.60%	-4.05%	***-1.79%***	**6.30%**
	6	0.49%	-0.21%	-0.89%	-0.59%	-0.91%	0.24%	0.09%	-0.87%	0.32%	***-0.26%***	**1.51%**
	7	6.90%	6.90%	1.00%	2.46%	4.40%	7.90%	8.28%	2.60%	6.73%	***5.24%***	**5.60%**
	8	-2.30%	0.70%	8.75%	1.50%	12.50%	7.75%	9.25%	6.70%	-1.95%	***4.77%***	**32.50%**
	9	8.50%	2.05%	2.00%	12.00%	14.25%	3.62%	8.10%	5.20%	8.07%	***7.09%***	**28.00%**
	10	0.53%	-0.20%	-0.05%	-0.33%	-0.19%	-0.03%	0.63%	-0.15%	0.93%	***0.13%***	**0.50%**

Appendix 5. Specialist reports on the Visual Browse Availability Assessment Technique.

CRITIQUE OF BROWSE AVAILABILITY ASSESSMENT
Dr Tim O'Connor

The observations listed below are intended to assist in refining an approach for estimating the availability of browse for black rhino. The approach was examined during a two-day field exercise in Weenen Nature Reserve.

1. The protocol of visually estimating the volume of available browse based on the percentage aerial cover and the percentage depth of fill is deemed to be the most cost- and time-effective approach for gaining a value of this nature. I cannot conceive of an alternative approach that would yield the same returns for the time invested. Comment about the approach therefore focuses on issues requiring consideration in order to ensure that maximum accuracy and efficiency is achieved.
2. The two-day exercise concentrated on the mechanics of visual estimation, ignoring, in my opinion, critical issues about sampling protocol that will ultimately determine the success or failure of the technique. The next few points address some sampling considerations that are expected to have a major bearing on the outcome.
3. First, the area to be sampled has to be stratified, which was achieved in this exercise through the use of a pre-existing map of very broad vegetation types. I suggest the map used was of an insufficient resolution for black rhino habitat. It was a very simplified map of the vegetation types identified by Breebaart et al. It is suggested that important habitats for browsers may often be communities of limited areal extent, which are usually not mapped in broad approaches. An obvious omission for this exercise was that of higher order drainage lines within another vegetation type. Another example was of bush clumps within otherwise open savanna. The point is that a comprehensive list of habitats requiring sampling needs to be devised before fieldwork commences.
4. An approach to the siting of sample plots was not formalized, but it is the most critical issue influencing bias. Thought needs to be given to whether representative plots are acceptable, as they violate assumptions for statistical analysis, whether random sampling has to be used despite its inefficiency in terms of time, or whether systematic samples (at what spacing) can be considered random enough (i.e. what degree of spatial autocorrelation exists). It is recommended that systematic sampling is most appropriate with, if need be, formal incorporation of spatial auto-correlation into the analysis.
5. Plot size and shape require further consideration. The introductory session used circular plots of variable size. I prefer square plots because the observer can usually better adjudge abstract cover. Ideally plot size should vary in relation to the nature of the vegetation being sampled, especially its grain size and its visibility. It might prove prudent to have a uniform plot size, at least for similar vegetation types such as savanna. I doubt whether anyone can effectively integrate spatial information at a scale of greater than 20 by 20 m in savannas, and would recommend this as a ceiling size for this vegetation. By contrast, a greater plot size could probably be easily achieved in desert and semi-desert conditions such as those prevailing in Namibia.
6. The two days were invaluable for gaining an impression of the degree of inter-observer variability in estimating both cover and vertical fill. Consistency in cover was approached among our team of observers when using a square 20 by 20 m plot because it was easy to calculate the area covered by bushes, e.g. 4 square metres is 1 % cover of the plot, 8 is 2 % etc. Bushes can be easily 'packed' in bundles of 4 square metres. There was a subjective feel that the estimation of cover was reasonably accurate over the range we estimated, although observers could still differ by 0.5 % to 1 % - a difference of 100 %. Most of our plots were of low cover, which probably influenced the ease with which this was achieved. Estimations among observers tended to diverge at higher values, probably owing to the difficulty of integrating complex information over a large area. The accuracy of estimates of vertical fill was more difficult to assess. The height of a unit has to be weighted by the volume it encloses in order to gain realism, but observers apparently vary markedly in defining three-dimensional units. Where plots consisted of an array of many small and a fair number of large individuals, I gained the impression that estimates of

vertical fill tended to a convenient compromise of about half the possible height, i.e. they were centred on 1 m. Thus I suggest that, if a large error is present, it is primarily as a result of variation in the estimation of percentage vertical fill, which brings me to my next point.

7. The method does not appear to have been calibrated against plots of a known volume of available browse, although apparently some of the Weenen plots have been measured and can be thus used. I recommend the data from this exercise be scrutinised in terms of the measured volume contributed by plants of different height classes. In addition, the real measured data should be analysed for the relation between vertical height per individual plant and its supported volume of browse, as I imagine it is probably markedly non-linear (a volume relationship should be cubic in nature).
8. I suspect that the apparent contribution of larger individuals to available browse is over-estimated because the apparent volume of a larger individual is comprised mostly of non-edible large branches and air, whereas the volume of a smaller individual contains proportionately far more foliage.
9. A calibration exercise that has not been mentioned is that of the true amount of browse available (as dry weight) in relation to volume. This cannot be conducted for every area under examination, but an exercise across the major biomes and vegetation structures of relevance would be necessary in order to evaluate more rigorously measures of available browse based on volume.
10. I feel more critical thought needs to be given on the time of sampling. If the potential of an area to support black rhino is being assessed, then the most limiting conditions of available browse should be measured, i.e. at the height of the dry season. Nutritional opportunities at this time should determine both mortality/survival and reproductive success. Data collected during the growing season can be used if the deciduous character of a species is taken into account, although this would pre-suppose knowledge of which twigs are consumed in winter.
11. Size (number) of sample should be decided independently for each application. Obtain a first set of about 10-20 values through (pseudo-) random sampling.

Sample size can be calculated using the formula:

$N = t^2 S^2/E^2$

where N = the number of samples required,

t = values from the t-table at the desired level of predictability (generally 0.05 %),

S^2 = the variance, and

E = the required confidence interval, e.g. if the mean of the test samples is 150 and a confidence interval of 10 % either side of this mean were required, then E would be 30 (do not forget to square E).

Summary

The method seems sound but could probably be refined through some of the recommendations listed above.

Sampling issues are likely to be more important than the method itself.

Calibration at a number of scales is essential.

BLACK RHINO CARRYING CAPACITY ASSESSMENT REPORT

Prof. K P KIRKMAN

EASE OF APPLICATION

1. Manual
    a. The manual has been written in a suitable style and was easy to understand.
    b. One of the few aspects that was not too clear was that of plot size. While this became clear in the field, the principle of variable plot size and shape could be clarified in the manual.
2. Training
    a. Training was relatively easy and quick. Once the first site was evaluated it was easier to relate to the manual. In future training sessions it may be useful to formally go back to the manual once the individuals being trained have evaluated one or two sites. This may assist in getting a better perspective on the procedure as outlined in the manual.
    b. It will probably be necessary for operators to be trained formally or work with a previously trained person. It would be rather difficult to study the manual and then commence the fieldwork without any training. The main purpose of the training is for calibration purposes.
    c. A training video may be an option that could be explored for situations where formal training is not possible.
    d. It may be useful to schedule another evaluation session where operators are given the updated manual to study and then tasked with evaluating sites with no training, and comparing the results with previously trained and experienced operators.
3. Data sheets were adequate.
4. It was easy to conceptualise the browse volume, but not quite as easy to estimate the quantity. In particular, changing vegetation types from sparse to dense browse seemed to confuse some of the operators.
5. Knowledge of the vegetation was important, particularly for noting the major component of the browse. This should not prove problematic if the assessments are routinely carried out by operators familiar with the specific area. Forb identification is somewhat more specialised than tree identification and may prove problematic in some areas.
6. Canopy cover projection was conceptually easy and with practice became easy to assess relatively consistently. Where it became more difficult was when the canopy was in excess of 2m. It was then difficult to visualise the cover at 2m. The canopy cover percentage diagrams were useful.
7. The vertical projection was conceptually easy. In practice it became difficult when there were multiple layers e.g. forbs, cohorts of short, young trees and cohorts of mature trees.
8. The photos were useful, but it was difficult in some vegetation types to relate the photos to the sites being evaluated. In some cases there were no suitable photos.
9. The "gut feel" evaluations could become useful once operators become more experienced.
10. The approach of using classes rather than estimating exact quantities could be useful, but has its disadvantages. The danger is that it becomes easy to drift into the next class. This may in fact enhance variation between operators. As an example, operator 1 may estimate cover of 32% while operator 2 estimates 28%. There is only 4% difference, but they fall into different classes.
11. Knowledge of rhino feeding habits will probably be an advantage, but may lead to increased subjectivity.
12. Sampling procedure is probably one of the major factors that will determine the overall accuracy of the technique.

ADEQUACY OF THE APPROACH

I like the concept of rapid assessment estimation techniques for management decision-making and believe firmly that trained individuals can estimate quantities accurately in a reasonably repeatable manner. I have used the comparative yield techniques (Haydock & Shaw 1975) and the dry-weight-rank techniques (t'Mannetje & Haydock 1963) extensively for grassland evaluations and have found the results to be satisfactorily reliable for research purposes (Kirkman 2002). In a comparison between four independent operators using the comparative yield technique and a disc meter with harvested quadrats providing an absolute measure, the four operators gave exceptionally consistent results, which were very similar to the disc meter. In relating the comparative yield estimates to the harvested quadrats, the four independent operators each had greater R^2 values than the disc meter (unpublished data).

I believe that technically the approach could work well. The success of the technique will hinge on several factors, including:

- Sampling strategy
- Operator enthusiasm and motivation
- Using the results for management decision making
- Collecting comparable data from a wide range of reserves and relating the data to climate, black rhino numbers, other browser numbers etc.

Positive aspects

- The assessors have to get out and assess on foot across all vegetation types. This alone is a positive contribution to black rhino management.
- An inaccurate measure is better than no measure.
- The accuracy will improve with practice
- The survey assists with finding rhino feeding areas and observing what is being eaten.
- The technique is rapid. It is therefore possible to cover large areas in a short time.
- For management purposes this is preferable to more accurate, smaller samples.

Negative aspects

- It is a subjective technique.
- There will be variation between assessors.
- There may be variation per assessor over time or between different vegetation types.
- It may be difficult to relate to actual carrying capacity.
- It is impossible to assess accuracy.
- The overlap between black rhino browse with other animal's browse is difficult to take account of.

RECOMMENDED IMPROVEMENTS

- The photos could be improved. It may be preferable in the longer term to develop a set of photos for each reserve, as photos from totally different vegetation types may confuse the operators.
- The manual could be separated into two parts. Part 1 could cover the background and theory. Part 2 could be a brief recipe style field guide. This may make it easier to refer to the manual in the field for guidance on a specific aspect.
- The procedure for selecting sample sites is probably more important than the actual assessment procedure. Some clear guidelines will need to be developed regarding this. It would be useful in practice to base the sampling procedure on aerial photos. If GIS capacity is available then it should be used for determine areas of various vegetation types before sampling. The sampling sites can then be selected accordingly.
- If sampling is to be repeated then it would be useful to specify that sites are recorded on a GPS for re-sampling in the following cycle. This implies that selection of sampling sites will only be done once before the first survey. It is worth putting some effort into the selection process.
- Some clarity on the time of year would be useful with clear reasoning. This may vary between reserves.

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EVALUATION OF THE PROCEDURE FOR VISUAL ASSESSMENT OF BROWSE AVAILABILITY FOR BLACK RHINO

BRUCE R. PAGE

PREAMBLE

I had no familiarity with the technique prior to being contracted to participate in the field trial to evaluate the procedure. I became familiar with the technique by (i) reading the manual, (ii) a short briefing prior to the 2-day field session, and (iii) by asking questions during the first few hours of the field session. My comments are based on this experience and prior experience regarding similar assessments and field techniques published in the literature and used in a range of ecological assessments.

ADEQUACY OF APPROACH

1. My evaluation is that the procedure is both a scientifically valid and efficient approach for determining a reasonably accurate estimate of the carrying capacity of a given area for black rhinoceros.

2. The between observer variability appeared to me to be quite low, and well short of the level that would influence the estimate of carrying capacity significantly. Information provided about the effect of over and underestimating the BA in all vegetation types by one assessment class indicates that the "error in the estimate" was about 0.04 animals when carrying capacity was about 0.04 and about 0.2 when carrying capacity was about 0.4. Based on nothing more than gut-feel and the very limited data available on inter-seasonal variability in carrying capacity of other browsers, the range in carrying capacity between wetter and drier years over a decade or so in any particular locality, is more or less the same as the variation obtained in the estimates obtained from the simulated "observer error". The between observer variation that I observed during the field trial, appeared to be nowhere near the level that would consistently place estimates in a class above or below the correct one. In my opinion anyone with even a relatively low level of education (high school year 5) should be able to apply the technique by using the manual. Anyone with a diploma or more in wildlife management should have no problem at all.

3. Based on what I have observed, the method appears to be sufficiently sensitive to detect habitat changes that affect carrying capacity in successive years in the same locality, and also detect differences in carrying capacity between localities.

4. The sampling intensity in terms of both the number of samples and the sampling unit sizes, is likely to affect estimates more than between observer differences, and should be given more attention (see below).

5. I found discrepancies when comparing estimates obtained using the photographs and the visual estimate of cover. The use of the photographs as a guide only is supported.

6. The addition of browse over 2m for trees that can be pushed over is problematic. My impression is that this is not a significant factor in determining carrying capacity, and it is a potential source of huge errors. I suggest that either this is omitted completely, or only included when there are very clear signs that trees in a sample plot have been pushed over. The additional volume should then be added only for these trees.

EASE OF APPLICATION OF THE ASSESSMENT METHOD

1. The technique is easily applied, but as with all field based assessments requires a certain level of discipline to obtain the required sample sizes. In areas with a high degree of spatial heterogeneity sampling would need to be more intensive.

2. If anything the technique is a little too easily applied, and particularly at the end of the day when people are tired, it becomes easy to simply make quick estimates. Assessors should be warned about being rigorous and working in short spells for longer, rather than attempting to cover everything in as short a time as possible.

3. The manual is mostly clear, but requires some additional information (see below).

4. One aspect that I found affected the ease of application was the use of different size sample plots (see comments below).

RECOMMENDED IMPROVEMENTS

1. In my experience people with little or no experience in matching measured cover to estimated cover almost always overestimate cover. I recommend including in the manual, a paragraph or two on estimating cover.

2. I recommend that the sampling method is standardized as much as possible in terms of the sampling unit employed as well as the number of samples per stratum (different topographic positions in each vegetation type) sampled. Different people use different methods to estimate cover. For this reason I suggest standardizing on the technique. The accuracies of cover estimates are very dependent on the size of the sample plot. I recommend using a standard size. Some people find circular plots easier to work in and others square plots. If both are to be employed (I recommend only square plots) I suggest including a section on the use of both in the manual. In most areas a square 10m x 10 m square plot in very dense thicket is visible, 20 m x 20 m in most woodlands is visible and 30 m x 30 m in most open areas. (Or, alternatively a circle of radius 10, 20 or 30 m).

3. Depending on what type of sampling unit is employed, it should be explained in the manual, with illustrations that (for example) in a 20m x 20 m square, a single tree (or individuals combined) that cover an area of 2m x 2m covers 1% of the area, 4m x 4m 4 % and so on, for each of the suggested sizes. Similarly the % cover for wedges of different angles should be illustrated. (The advantage of using a circular plot is that all angles of the same dimension cover the same percentage of the area irrespective of the size of the plot. However, I think that it is much more difficult to imagine moving all trees (or forbs) in a plot to a wedge than to a square).

4. I found that the manual did not explain how to measure the height of available browse clearly enough. The importance of estimating the average height of the bottom of the canopy, and how to do it should be explained.

5. I think that some guideline, even a rough idea, about the level of sampling required, in vegetation with different characteristics should be provided.

6. The data sheets are quite straightforward, but for people who have never used them before the manual should include an example and some instructions.