DISTRIBUTION AND HABITAT USE OF WHITE RHINOCEROSES AT WELGEVONDEN GAME RESERVE, SOUTH AFRICA

A Capstone Experience Manuscript

Presented by

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ABSTRACT

Increasingly, private game reserves are playing a critical role in rhino conservation in South Africa, where the majority of the southern white rhinoceros (Ceratotherium simum simum) population exists. The white rhino population on Welgevonden Private Game Reserve in South Africa increased from 51 to 79 rhinos between 1998 and 2011. Information on the habitats used by rhinos can be used to develop more effective management programs for rhinos on the reserve. This study determines the distribution of rhinos using data from aerial surveys conducted annually from 1998-2011. Kernel density maps were developed using ArcMap10 for four 3-4 year intervals to assess how rhino distribution on the reserve may have changed over time. Habitat use versus availability by rhinos is analyzed from 2010 and 2011 surveys using chi-square analysis to assess how habitat types (n=8) are used in relation to their abundance on the reserve. Old Farmlands and Plains were the habitats used in a higher proportion than they were available on the reserve in 2010-11, whereas Hill Slope and Crest Summit were used in a lower proportion than they were available. Kernel density maps indicate that rhino density has been consistently high in the central and southern portions of the reserve, where much of the Old Farmlands and Plains habitat types occur. Active management of these habitat types is important for maintaining Welgevonden's rhino population.

INTRODUCTION

The black rhino (*Diceros bicornis*) and the white rhino (*Ceratotherium simum*) have existed for tens of thousands of years across Africa. There are four subspecies of black rhino (eastern, western, south-western, south-central) and two subspecies of white rhino (northern and southern). By 1985, the southern white rhino (*Ceratotherium simum simum*) was reduced to a population of only 20 individuals due to excessive hunting for sport and meat. Conservation strategies rescued the population, and by 1997, there were over 8,400 southern white rhinos in the wild with nearly 8,000 of those occurring in South Africa (Emslie, 1999). While the white rhino is now listed as a species of least concern, their population is in danger across Africa. The rhino's horn can be sold on the black market for tens of thousands of dollars. In 2011, more than one white rhino per day was killed by poachers. Changes in habitats also caused declines in some rhino populations (Reid, *et al.*, 2007). Although smaller reserves are better able to prevent rhino poaching, their relatively smaller size challenges reserve managers to provide optimal habitats to suppport viable rhino populations (Emslie, 1999). The large numbers of rhinos and high dependency on intensive conservation efforts makes the small reserve management for white rhinos in South Africa critical for the survival and persistence of the species.

During summer 2011, I was a student with Operation Wallacea at the Welgevonden Private Game Reserve, South Africa. Using data collected during the annual helicopter surveys, the objectives of my research were to: 1) assess the numbers and distribution of white rhinos between 1998-2011, and 2) identify the habitats used by rhinos using data from the annual helicopter surveys conducted on the reserve from 2010-2011.

METHODS

Study Site

Located in the Waterberg Biosphere northeast of Johannesburg, Welgevonden is a private, fenced game reserve, totalling 37,500 ha. Twenty different vegetation types (Appendices 1 & 2) occur on the reserve within eight habitat types: Riparian, Valley Bottom, Saddle, Plains, Old Farmlands, Crest Summit, Hill Slope, and Plateau (Fig. 1). The old farmlands provide some of the most nutrient-rich vegetation on the reserve. Three rivers occur on the reserve and all flow into the Limpopo River.

Aerial surveys

Helicopter surveys are conducted yearly during the dry season in either August or September to census all wildlife on the reserve. Over three days, the same observers are used to census the entire reserve. The pilot and data recorder sit in the front two seats with the two observers in the back seat, each looking out each side of the door-less helicopter. The reserve is divided into three sections, and east/west transects are flown with 200 m observation strips on either side of the helicopter.

The observers report species and number to the data recorder, who records each observation on a laptop computer. Using a GPS unit, the location of each observation is automatically calculated from the helicopter's coordinates and altitude. When cover or animal behavior (e.g. kudu, *Tragelaphus strepsiceros*) limits visibility or when a large herd (e.g. impala, *Aepyceros melampus*) is encountered, the helicopter typically circles around an area to obtain a more accurate count of animals. No aerial census was conducted in 2000 due to cost. It is assumed that helicopter surveys provide total counts of all species surveyed on the reserve.

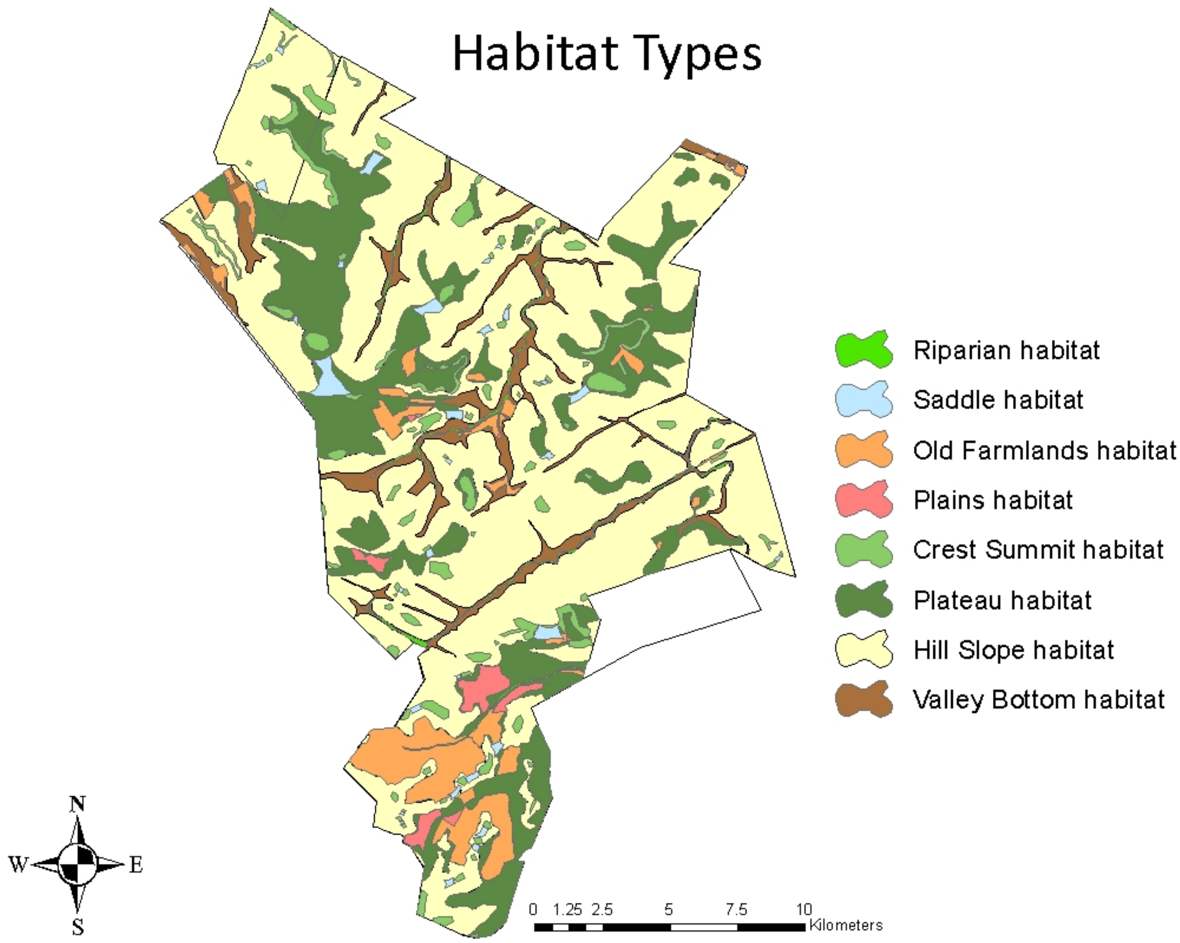

Figure 1: Habitat Types at Welgevonden Game Reserve, South Africa

Kernel Density Estimations

ArcMap10 was used to plot all white rhinoceros observations from 1998 to 2011. Data were aggregated into four 3-to-4-year intervals (1998-2002, 2002-2005, 2006-2008, and 2009-2011). The Kernel Density tool in ArcMap10 was used to calculate rhino density for each of these multi-year intervals. All points represented one individual, and therefore were given equal weights. A 1,500 m search radius was used with an output unit in square kilometers. An output cell size of 50 m was used to create a smooth surface. The scaled density was then rounded to the nearest 0.5 rhino.

Habitat Use versus Availability

I used ArcMap10 to compare rhino habitat use versus availability for the eight habitat types: Riparian, Valley Bottom, Saddle, Plains, Old Farmlands, Crest Summit, Hill Slope, and Plateau (Fig. 1). Only rhino observations from aerial surveys in 2010 and 2011 were used for this analysis because habitat maps were based upon vegetation surveys conducted in 2010. The northwest and southeast corners of the reserve were added to the reserve more recently than vegetation types were mapped, thus these areas were excluded from the analysis. Consequently, two rhino sightings in 2010 were also omitted from the analysis because they occurred within the northwest corner of the reserve.

I used a chi-square analysis to evaluate if rhinos used habitats in proportion to their availability. Rhino habitat use was calculated by percent of sightings within each habitat for 2010 and 2011. Rhino habitat availability was calculated as the proportion of the reserve that each habitat covered. Numbers of rhino occurrences per habitat were obtained by using the intersect tool in ArcMap10 by year and habitat. My null hypothesis was there is no difference between percent of habitat available and percent of rhino observations within a habitat.

A Bonferroni correction was used to calculate standard error and a 95% confidence interval for observed use. The Bonferroni correction was used to scale the level of significance of confidence intervals when estimating multiple parameters. It reads: $z_{(1-\boldsymbol{\alpha}/2k)}$ where $\boldsymbol{\alpha}$ is the level of significance and $\boldsymbol{k}$ is the number of parameters being simultaneously estimated. For a 95% confidence interval with four habitat types, $\boldsymbol{\alpha} = 0.05$ and $\boldsymbol{k} = 4$. Standard error is then calculated by $\sqrt{[p_i(1 - p_i)/n]}$ where p_i is the proportion of rhinos in the ith habitat type and n is the number of observed rhinos. p_i (+/-) the Bonferroni correction multiplied by the standard error calculates the upper and lower limits (respectively) of a confidence interval (calculations follow

Neu, *et al.,* 1974). If proportion of expected results falls within the limits of the confidence interval for that habitat, there is no statistical difference between expected and observed use. If the proportion of expected results falls outside the confidence interval, there is a statistical difference. The program R was used to perform these calculations and create the resulting graphs.

Riparian, Plains, Saddle, and Crest Summit habitat types were too small in area to expect five rhino observations for either year. Furthermore, a minimum of five sightings is needed to use the Bonferroni correction (Neu, *et al.,* 1974). Valley Bottom and Saddle (2010 only), Riparian, Plains, and Crest Summit had fewer than five sightings. Thus, Old Farmlands and Plains, Hill Slope and Crest Summit, and Valley Bottom and Saddle were combined, and Riparian was omitted from analysis because it comprised < 1% of the reserve and had zero rhino sightings (Fig. 2).

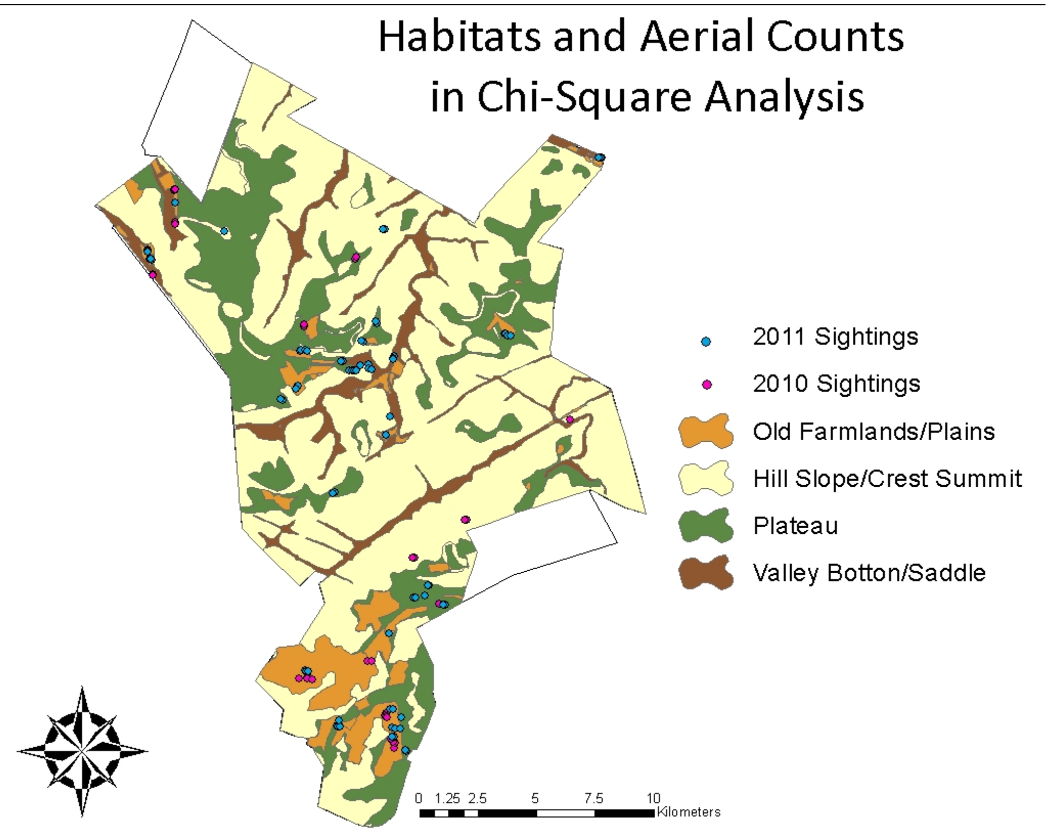

Figure 2: Combined habitat types for chi-square analysis, with sightings form 2010 and 2011 plotted.

RESULTS

Population trends

White rhino numbers on the reserve varied from a low of 42 in 2005 to a high of 79 in 2011 (Fig. 3). The highest change occurred between 2010 and 2011, when the population increased from 60 to 71 individuals. The average annual growth rate (PC = [((Vpresent - Vpast)/ Vpast) x 100] / N) of the rhino population from 1998 to 2011 at Welgevonden was 4.22%.

Kernel Density

Overall, rhino distribution was generally consistent on the reserve from 1998 to 2011 (Fig. 4). Population density was consistently high in the central and southern regions of the reserve, and in the northern part of the reserve from 2006 – 2008. Rhinos occurred most frequently in the Old Farmlands/Plains and Plateau habitat types. .

Habitat Use versus Availability

For both 2010 and 2011, rhinos used Old Farm Lands/Plains habitat more than expected and Hill Slope/Crest Summit habitat was used less than expected (Table 2, Fig. 5). Valley Bottom/Saddle and Plateau habitats were used in proportion to their availability.

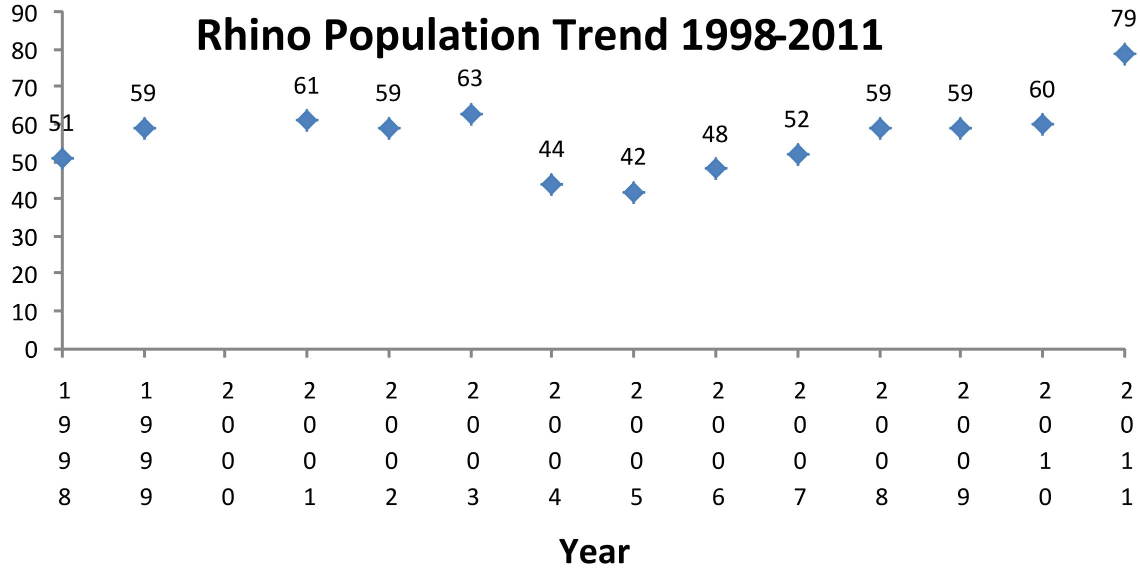

Figure 3: White rhino aerial counts from 1998-2011. A trend line shows an average annual increase (4.22%) in population size.

2010

habitat	area (sq.km)	rhinos	expected %	observed %	lci	uci
Valley Bottom/Saddle	2,825.6	6	8.24	10.34	0.35	20.34
Plateau	7,415.9	8	21.64	13.79	2.47	25.11
Old Farm Lands/Plains	2,566.9	30	7.49	51.72	35.32	68.13
Hill Slope/Crest Summit	21,465.6	14	62.63	24.14	10.09	38.19

2011

habitat	area (sq.km)	rhinos	expected %	observed %	lci	uci
Valley Bottom/Saddle	2,825.6	12	8.24	15.58	5.25	25.92
Plateau	7,415.9	22	21.64	28.57	15.70	41.44
Old Farm Lands/Plains	2,566.9	32	7.49	41.56	27.52	55.60
Hill Slope/Crest Summit	21,465.6	11	62.63	14.29	4.32	24.26

Table 2: Results from chi-square test. Expected % is the proportion of habitat area on the reserve, observed % is proportion of rhino sightings observed in that habitat. lci and uci represent lower and upper limits of a 95% confidence interval.

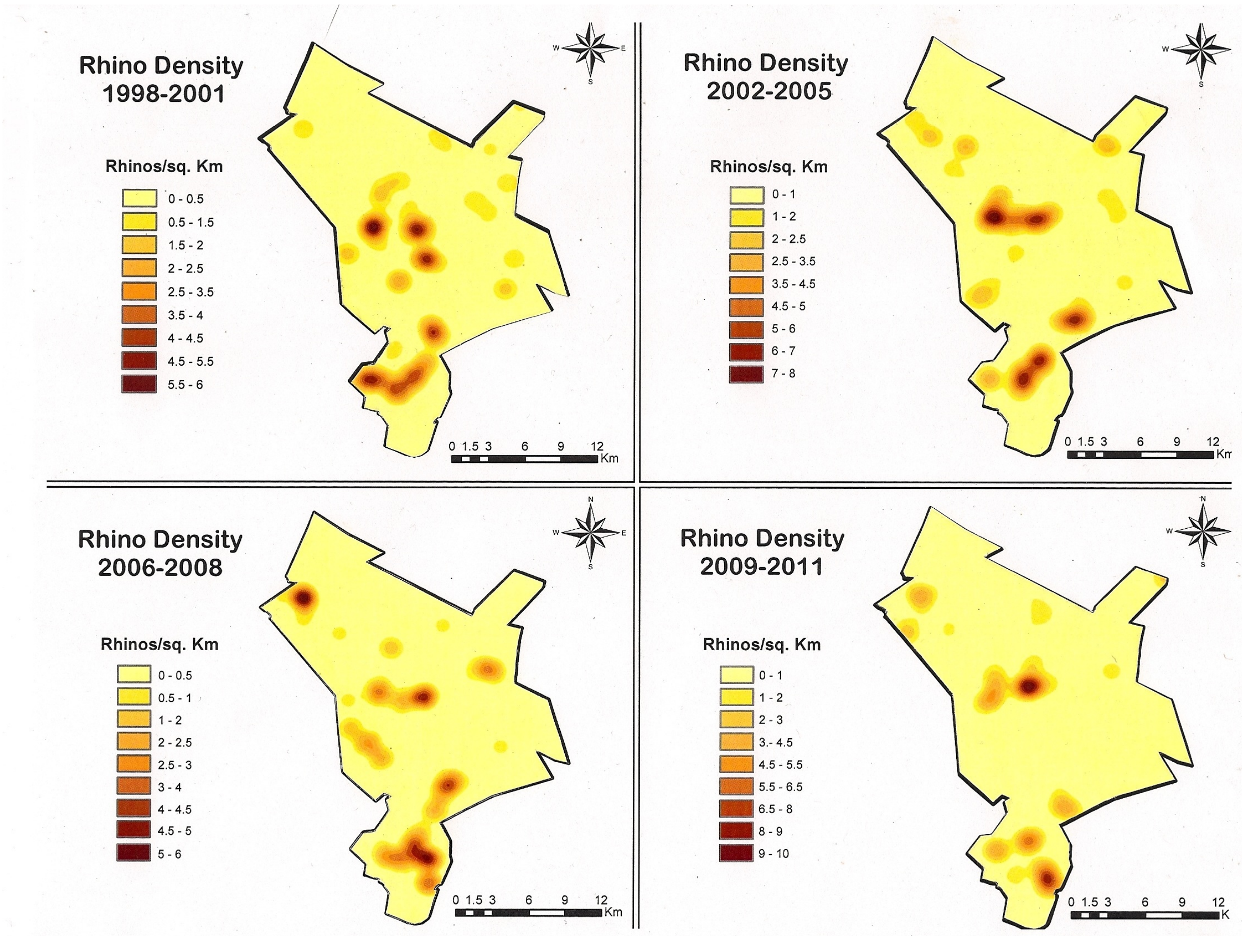

Figure 4: Kernel densities show the trend of distribution throughout the reserve over a course of 13 years. Highest densities are consistent in the southern and central areas of the reserve.

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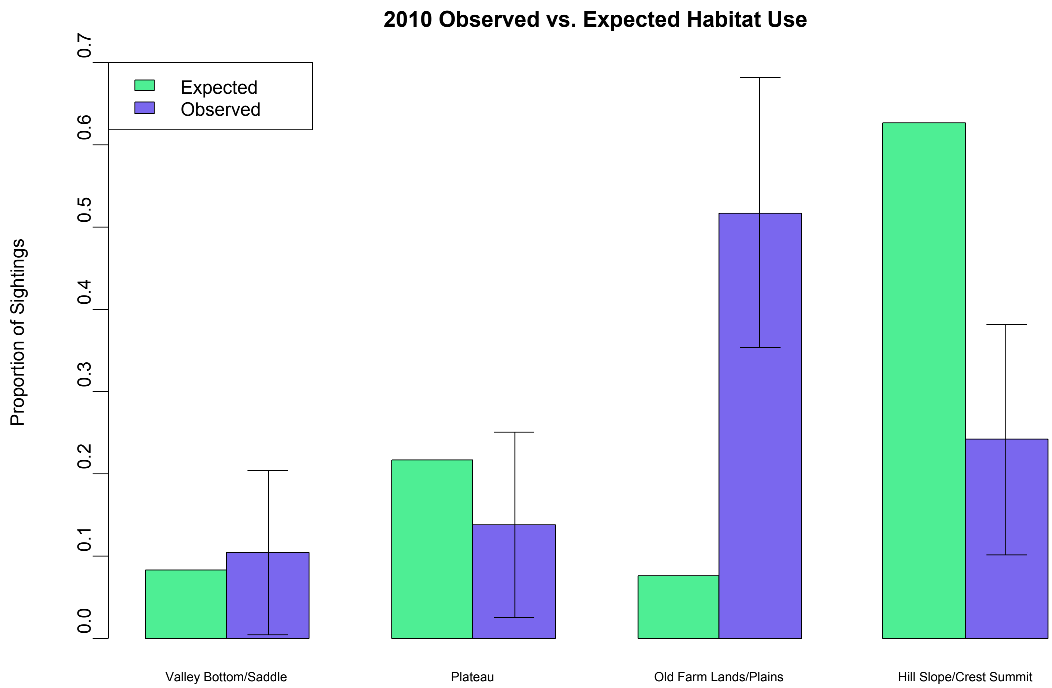

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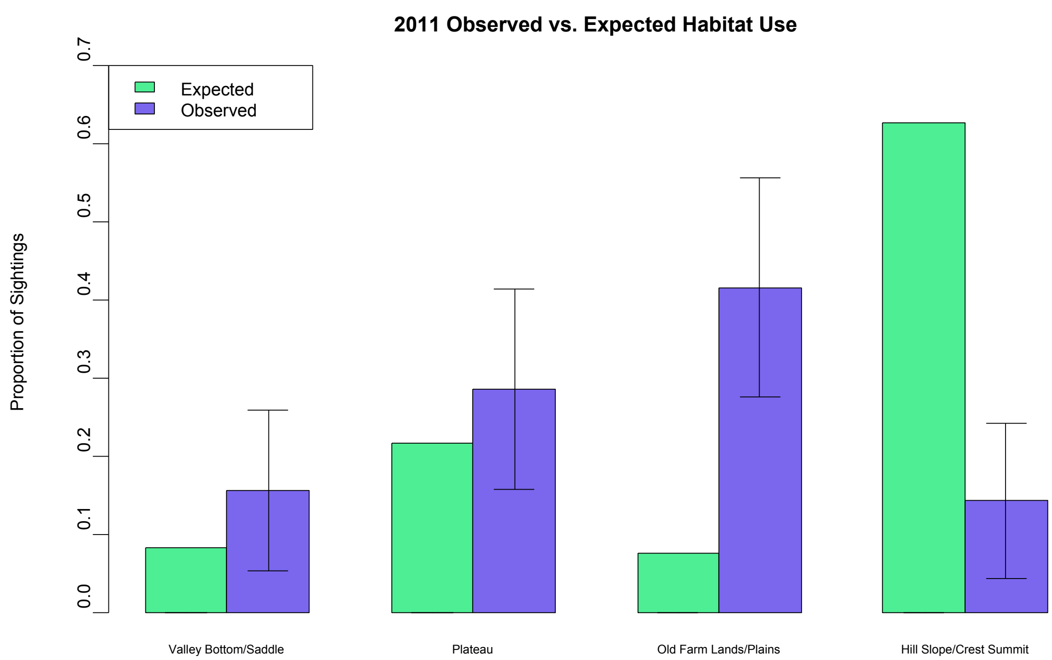

Figure 5: Rhino habitat use versus availability at the Welgevonden Reserve in 2010 (a) and 2011 (b). Error bars represent 95% confidence interval in observed results.

DISCUSSION

Population Growth

The white rhino population at Welgevonden increased from 1998 to 2011 (Fig. 4), similar to that reported for Kruger National Park (Nicholls, *et al*., 1996). This increase at the reserve was facilitated by the intensive anti-poaching efforts at the reserve where poachers on the reserve killed only one rhino in recent years. The poachers were caught before they could acquire the horn but unfortunately the animal was killed. The spike in population growth (31.7%) between 2010 and 2011 may be due to a larger number of females reaching sexual maturity (age of first calving is approximately six years old) or high number of females at a new calving period (every two to three years) in 2010, but information on these population dynamics before 2011 is lacking for rhinos on the reserve.

Although positive population growth on a small reserve may reflect good protection against poaching, there may be trade-offs. Rachlow, et al. (1998) reported that a higher density of white rhinos in Matobo National Park, Zimbabwe was correlated with in increasing age at first breeding and decreasing body condition. They also reported decreasing rhino home range and territory sizes with increasing density, suggesting density dependent effects on the rhino population. Determining the carrying capacity of rhino at the Welgevonden Reserve may help managers keep the population at a healthy size for the reserve and avoid density dependent effects.

Habitat Use

Considering the white rhino is exclusively a grazer, the high use of Old Farmlands/Plains habitat by rhino on the reserve is not unexpected. However, the Old Farmlands habitat is unique at Welgevonden because the reserve is a collaboration of privately owned land, much of which was farmland before owners came together to create a wildlife reserve. The Old Farmlands habitat on the current reserve was previously cultivated and contains grass species rich in nutrients. Plains and Old Farmlands are dominated by grasses and often adjacent on the reserve with Plains being partially open woodland. Similarly, Pienaar, et al. (1992) indicated that white rhino in Kruger selected granitoid plains habitat in a higher proportion than it was available.

White rhino selection of Old Farmlands/Plains habitat is important to consider for ecosystem management. As large grazers, white rhino have an important impact on the biotic and abiotic factors of the reserve. One study suggests that white rhino grazing alone maintains short grass swords and hence alters habitat for other grazers and changes the fire regime (Waldram, et al., 2008). Having a high density of white rhino using Old Farmlands/Plains habitat may provide important habitats for other grazers, such as impala (*Aepyceros melampus*) and blue wildebeest (*Connochaetustaurinus*), who prefer shorter grass. It is also important for creating patches of short grass that act as natural fire-breaks.

Hill Slope/Crest Summit habitat was used less than expected by rhinos. These habitats are comprised mostly of rocky and woodland areas that contain fewer grasses. Yet, these woodland habitats may provide shade for rhinos and habitats for less dominant males that are forced into less suitable habitats by dominant males.

The Plateau and Valley Bottom/Saddle habitats were selected in proportion to their availability. These habitats are woodlands dominated by *Burkea africana*. These habitat types tend to occur in cooler low lands or near riparian areas, where access to water and shade may be preferred on hot days.

CONCLUSION

Small wildlife reserves in South Africa play a major role in protecting rhinoceros populations from poaching and other human threats. With an average annual growth rate of 4.22%, the rhino population at the Welgevonden Reserve is thriving. Old Farmlands/Plains habitat was selected significantly more frequently by white rhino in 2010 and 2011 than expected based on the small proportion this habitat occurring on the reserve. The densities of white rhino were consistently higher in the southern and central areas of the reserve from 1998 to 2011, where Old Farmlands and Plains frequently occur. The availability of this habitat type is critical for maintaining and expanding the rhino population on the Welgevonden Reserve.

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LITERATURE CITED

du Toit, R. (2001) *Rationale for Ongoing Radio-Collaring of Black Rhinos- A Response to Alibhai and Jewell.* Oryx 35(4):289-290.

Emslie, R. and M. Brooks (1999) *African Rhino. Status Survey and Conservation Action Plain.* IUCN/SSC African Rhino Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. ix- 92.

Neu, C.W., R.C. Byers and J.M. Peek. (1974) *A Technique for Analysis of Utilization-Availability Data.* Journal of Wildlife Management 38(3):541-545.

Nicholls, A.O., P.C. Viljoen, M.H. Knight and A.S. van Jaarsveld. (1996) *Evaluating Population Persistence of Censused and Unmanaged Herbivore Populations from the Kruger National Park, South Africa.* Biological Conservation 76:57-67.

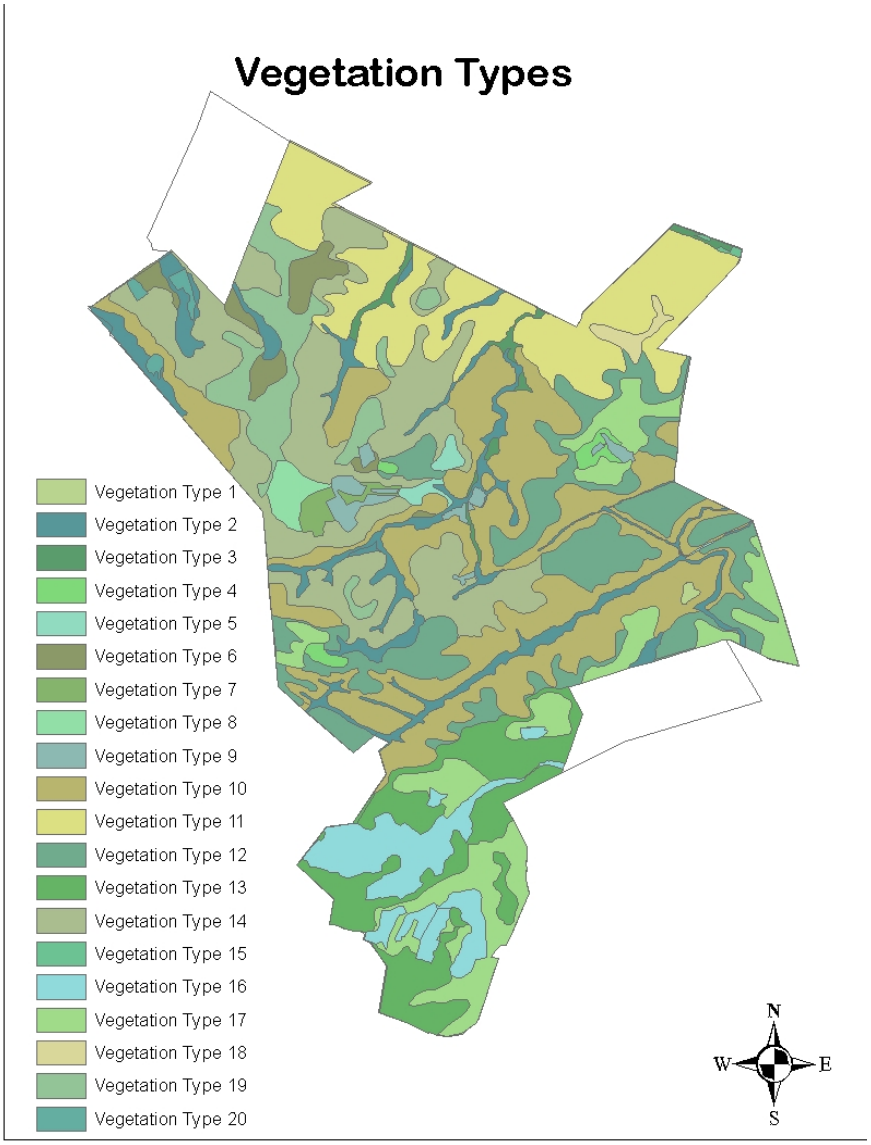
Pienaar, D.J., J. Du, P. Bothma and G.K. Theron. (1992) *Landscape Preference of the White Rhinoceros in the Southern Kruger National Park.* Koedoe 35(1):1-7.

Rachlow, J. and J. Berger. (1998) *Reproduction and Population Density: Trade-offs for the Conservation of Rhinos in situ.* Animal Conservation 1:101-106.

Rachlow, J., J.G. Kie and J. Berger. (1999) *Territoriality and Spatial Patterns of White Rhinoceros in Matobo National Park, Zimbabwe.* African Journal of Ecology 37:295-304.

Reid, C., .R Slotow, O. Howison and D. Balfour. (2007) *Habitat Changes Reduce the Carrying Capacity of Hluhluwe-Umfolozi Park, South Africa, for Critically Endangered Black Rhinoceros Diceros bicornis.* Oryx 41(2):247-254.

Waldram, M.S., W.J. Bond and W.D. Stock. (2008) *Ecological Engineering by Mega-Grazer: White Rhino Impacts on a South African Savanna.* Ecosystems 11:101-112.



Appendix 1: Map of Vegetation Types at Welgevonden Game Reserve, South Africa

Vegetation 1	Burkea africana/ Setaria pallide-fusca open woodland Terminalia sericea subcom.
Vegetation 2	Burkea africana/ Chrysopogon serrulatus/ Schizachirium sanguineum open woodland Te
Vegetation 3	Burkea africana/ Setaria pallide-fusca open woodland Faurea Saligna subcom.
Vegetation 4	Burkea africana/ Trachypogon spicatus/ Diheteropogon amplectans open woodland Terr
Vegetation 5	Burkea africana/ Trachypogon spicatus/ Schizagirium sanguineum open woodland Faure
Vegetation 6	Burkea africana/ Trachypogon spicatus/ Schizagirium sanguineum open woodland Term
Vegetation 7	Burkea africana/ central grassland open woodland Faurea Saligna subcom.
Vegetation 8	Burkea africana/ central grassland open woodland Terminalia sericea subcom.
Vegetation 9	Central Grasslands
Vegetation 10	Mixed Burkea africana/ Chrysopogon serrulatus/ Melinis repens woodland Diplorynchu
Vegetation 11	Mixed Burkea africana/ Chrysopogon serrulatus/ Schizachirium sanguineum woodland
Vegetation 12	Mixed Burkea africana/ Trachypogon spicatus/ Diheteropogon amplectans woodland Di
Vegetation 13	Mixed Burkea africana/ Trachypogon spicatus/ Diheteropogon amplectans woodland En
Vegetation 14	Mixed Burkea africana/ Trachypogon spicatus/ Schizachirium sanguineum woodland Di
Vegetation 15	Northern Grasslands
Vegetation 16	Southern Grasslands
Vegetation 17	Trachypogon spicatus/ Diheteropogon amplectans Rocky plateau open woodland
Vegetation 18	Trachypogon spicatus/ Melinis repens Rocky plateau open woodland
Vegetation 19	Trachypogon spicatus/ Schizachirium sanguineum Rocky plateau open woodland
Vegetation 20	Western Grasslands

Appendix 2: Vegetation types on Welgevonden Private Game Reserve