Spatial analysis of home range, core area and habitat selection of red deer (*Cervus elaphus*) on an extensively managed high-country station

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ABSTRACT

The aim of this research was to determine the behavior and habitat selection of red deer (*Cervus elaphus*) hinds during the calving period, on an extensively managed rangeland in the high-country of New Zealand's South Island. The research was developed using ArcView and *eCognition* software, GPS collars on five red deer hinds, an aerial photograph and topographic data. The results showed that three out of the five study deer escaped the original study paddock into adjacent extensive paddocks. The deer did not use the entire study paddocks they were in, but instead formed distinct home ranges (total area of movement) and core areas (areas of intensive use, 45% of deer locations). These home ranges were highly variable in size from 225 ha. To 36 ha.. Core areas ranged from 102 ha. To 36 ha.. The variation in size of home ranges and core areas was directly related to the size of the paddock, and indirectly to social constraints within the paddock. The results suggest that deer within these extensive paddocks are under strong density-dependent effects during the calving season that may be forcing some hinds (probably less-dominant hinds) to the marginal edges of the pasture, where they may eventually escape. Habitat selection indicated, that while red deer often selected the naturalized pasture grass areas (high in metabolized energy), tussock grassland, when present in the home range, was also highly selected for. The selection of tussock grasslands was probably a result of tussock habitat providing both good cover/security during the calving season, and the presence of reasonably good forage in the inter-tussock area.

***Keywords and phrases*: **red deer (*Cervus elaphus*), extensive pastures, production, density-dependent, habitat selection, home range, core areas, tussock grassland

1.0 INTRODUCTION

Increasing numbers of red deer (*Cervus elaphus*) farms in New Zealand are moving from low-country intensive pastures to high-country extensive properties. This move has been driven by competing land use in the low-lands, and by a growing opinion that red deer, not highly evolved as a domestic stock, may do better under extensive systems that mimic a more natural environment. There has been some preliminary evidence that red deer hinds under extensive systems have better reproductive performance (increased weaning rates of 7-10%), which is probably a result of reduced stress due to the presence of adequate calving habitat and lower stock densities (Asher & Adams, 1985).

This research used global positioning system (GPS) collars attached to five red deer hinds during the calving season to understand resource utilization on an extensively managed rangeland at Haycock's Station, near Te Anau, on New Zealand's South Island. A detailed map of topography and vegetation was developed with a 20 meter contour topographic dataset, and a color aerial photograph, using ArcView and *eCognition* software.

The data downloaded from the five GPS collars was analyzed for home range (total spread of GPS locations), and core area (45% of locations) for each of the study deer. The GPS locations for each of the deer were also analyzed for habitat selection using the vegetation map. After downloading the data, it was found that three out of the five study deer had escaped into adjacent paddocks and, therefore, the study site was expanded to include these paddocks. The results indicated that red deer at Haycock's Station, despite the large rangeland, experience strong density-dependent effects during the calving period, which is probably an effect of dominant hinds pushing sub-dominant hinds out of preferred feeding and calving sites. The affects of social constrains, driven by the density of deer in the paddock, and the biological need for deer to seek isolation and suitable habitat for calving, was probably the primary cause of deer escaping. The habitat selection of red deer revealed that, while pasture grass habitats were often selected, tussock grassland when present in the deer home range was always highly selected for. Therefore tussock grasslands seem to be highly valued by red deer during the calving season.

The implication for this study, are that even under extensively managed farm systems red deer, during calving, experience considerable social constraints that may relegate sub-dominant hinds to more marginal pastures, and driving them to try and escape. The presence of tussock grasslands seemed to be highly valued by red deer, and it may be beneficial for production and welfare of hinds and their calves, to maintain healthy tussock habitats.

2.0 LOCATION

Haycock's Station is located approximately 30 kilometer east of Te Anau on the South Island of New Zealand. The original study paddock that was selected at Haycock's Station was Rough Gully paddock, which is approximately 250ha. Rough Gully is a complex water catchment, ranging in elevation from 398-703 meters, with a diverse mosaic of naturalized pasture grass environments, tussock grassland (predominantly *Chionochloa rubra*), and some mature matagouri (*Discaria toumatou*) shrub lands. The paddock is stocked every summer with about 920 pregnant red deer hind (stocking rate of 3.7 hinds/ha). Because three out of the five study deer escaped Rough Gully and entered the adjacent extensive paddocks of Beehive Gully and Big Basin, the study site was extended to include all three paddocks.

3.0 MATERIALS AND METHODS

Five female red deer were randomly selected from Haycock's Station and fitted with GPS collars (Blue Sky Telemetry Inc. Edinburgh Scotland). The collars were put on October 15th, before the hinds were released with the rest of the herd, into Rough Gully paddock. The collars were set to record hourly location starting November 1st at 8am. All hinds including the five study hinds were pregnant. These hinds have consistently been put in Rough Gully and adjacent extensively managed paddocks for the past 4-5 years. They are released into these extensive paddocks during early spring (October) for the calving period and pulled out after the rut in late autumn (March-April). The study deer were identified by collar numbers: 130, 122, 121, 117 and 116. Deer 121 who escaped in the middle of the study period to Big Basin paddock was split into two events, 121.1 and 121.2, representing before she escaped and after she escaped. This was only done for 121 because there was considerable data obtained both before and after escaping that warranted a separate analysis.

Collars were recovered during the autumn round-up of the herd, and all data from the collars was downloaded into ArcView 9.1. Because of the way the signal was recorded GPS locations were unfortunately not able to be differentially corrected, however tests showed that at a stationary location with average satellite coverage locations were accurate to about 5m±1m. All locations for each of the study deer were overlayed with a map of topography, and vegetation. All features on the map were either differentially corrected or georeferanced to within 1m accuracy. The vegetation map was ground truthed and found to be approximately 87% accurate with boundaries ±4m accuracy.

Home ranges and the analysis of core areas (areas of intensive use) within home ranges were derived from the hourly GPS locations of each of the deer during the study period. Minimum convex polygons (MCP) were used to generate the home ranges of each deer, while a fixed-kernel density estimations (FKER) algorithm was used for core areas. The minimum convex polygon method uses all the locations obtained from an individual animal forming an area defined by the outermost locations. Core areas, or areas of intensive use, were defined using FKER contour line that included 45% of the locations for each deer. The development of a core area definition was derived from analyzing the percent of deer locations to the percent of their range, and identifying a point where the percent of locations began to erode in comparison with area (Clutton-Brock, Guinnness & Albon, 1982). The 45% core area was an average for all the study deer.

The MCP and FKER were developed from the ArcMap 9.1 platform using Hawth's tools functions "create minimum convex polygons" and "fixed kernel density estimator." The home range and core area polygons generated from these functions were then clipped by the fence line feature using ArcTools "clip," which eliminated any area outside of the respective study paddock (Figure 1).
Habitat selection was analyzed using ArcMap 9.1, and overlaying the GPS locations from each of the study deer with the vegetation map. The number of GPS locations within each of the five habitat types (exposed ground, pasture grass brown, pasture grass green, tussock grasslands, and shrubs) were counted using the ArcView extension Hawth's Tools, "count points in polygons." A chi-squared goodness of fit was used to analyze the actual to expected locations for a deer in each habitat type to determine if any of the study deer were using a particular habitat type more than would normally be expected (Neu, 1974). The extent of available habitat was determined by the home range of each deer. Initially it was thought that the entire paddock would be the best definition for available habitat, but the realization that most deer did not use the entire paddock, and that this was likely due to social constraints, made defining home ranges a more realistic and telling of the habitats available to each deer.

4.0 RESULTS

The home ranges and core areas for each of the study deer were significantly different in size (Figures 1 & 2). Only two hinds remained in the original study paddock (122 and 117), and both of these deer had considerably larger home ranges and core areas, and spent less time on the fence line. The three deer (130, 121 and 116) with the smallest home ranges spent considerably more time on the fence line, and eventually escaped the study paddock. The deer that remained in the study paddock selected ranges with diverse topographic relief, streams, and healthy green pasture grass habitats. The deer with smaller home ranges were often relegated to ridgelines along which the paddock fence line ran, that were of limited topographic relief, smaller streams, and more brown pasture grass environments, which probably are more marginal environments.

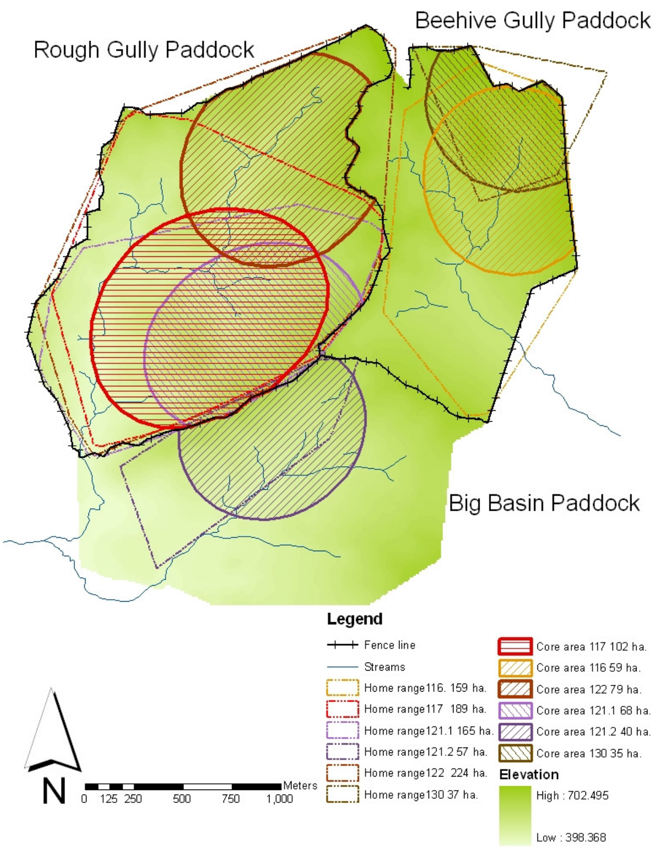


Figure 1: Map of the study paddocks at Haycock's Station showing the core areas and home ranges for each of the study deer

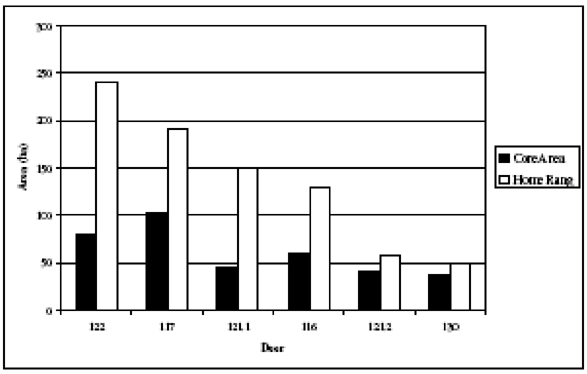


Figure 2: Total area for each deer's home range and core area

Habitat selection for the study deer was analyzed based on the available habitat within their respective home ranges, and therefore the availability of different habitat types and extent of those habitat types, varied for each deer (Figure 3). In Figure 3 it can be seen that for all the deer, except 130 and 116, who resided in Beehive Gully paddock, green pasture grass was the most prominent habitat type followed by

brown pasture grass, shrubs and then tussock. For all deer, the selection of certain habitats within their home range was highly significant (Chi-Sq $p<.05$).
The Chi-squared analysis for each of the study deer (130, 122, 121.1, 121.2, 117 and 116) are shown in Figure 4, and reveals that for all deer without tussock grassland in their home range, green or brown pasture grass was selected the most. However, for all the deer, except 117, with tussock grassland in their home range, tussock was selected far more than was expected. Deer 117 is thought to be an exception, because there was one day during the study period when she was disturbed by research in the paddock and she expanded her home range to include a large patch of tussock. However, besides this one day, deer 117 would be considered as having no tussock in her home range.

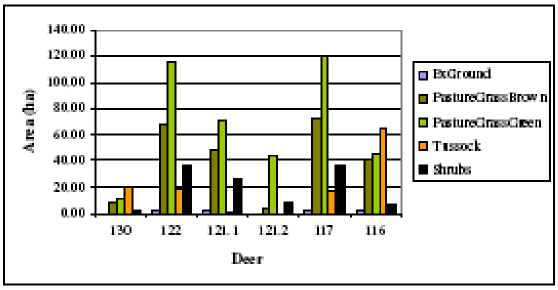
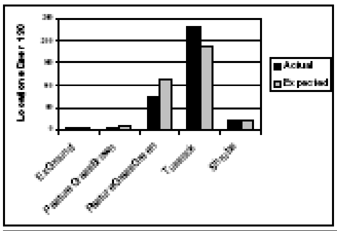
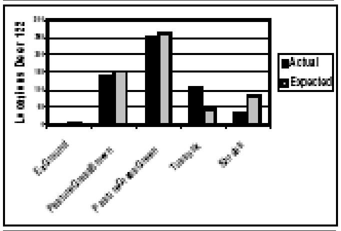


Figure 3: Total area of different habitat types within each deer's home range

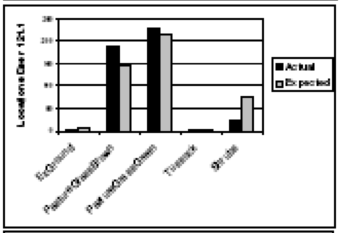
Deer 130	Observed	Expected	Residual	Sig
ExposedGround	2	2	0	p<0.001
PastureGrassBrown	4	7	-3	
PastureGrassGreen	74	112	-38	
TussockGrassland	232	189	42	
Shrubs	21	22	-1	



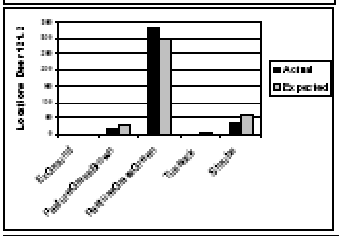
Deer 122	Observed	Expected	Residual	Sig
ExposedGround	3	6	-3	p<0.001
PastureGrassBrown	141	152	-12	
PastureGrassGreen	255	260	-6	
TussockGrassland	110	42	68	
Shrubs	34	82	-48	



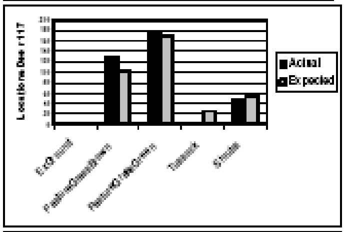
Deer 121.1	Observed	Expected	Residual	Sig
ExposedGround	2	5	-3	p<0.001
PastureGrassBrown	191	145	46	
PastureGrassGreen	228	214	14	
TussockGrassland	2	3	-1	
Shrubs	23	79	-56	



Deer 121.2	Observed	Expected	Residual	Sig
ExposedGround	1	1	0	p=0.003
PastureGrassBrown	18	28	-10	
PastureGrassGreen	331	300	-31	
Shrubs	39	60	-21	



Deer 117	Observed	Expected	Residual	Sig
ExposedGround	2	4	-2	p<0.001
PastureGrassBrown	129	103	26	
PastureGrassGreen	177	171	7	
TussockGrassland	1	26	-25	
Shrubs	47	52	-5	



Deer 116	Observed	Expected	Residual	Sig
PastureGrassBrown	33	299	-266	p<0.001
PastureGrassGreen	506	338	167	
TussockGrassland	531	477	54	
Shrubs	93	49	44	

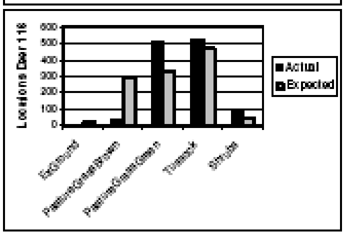


Figure 4: Tables and charts from the chi-squared analysis of habitat selection at Haycock's Station

5.0 DISCUSSION

The spatial distribution of red deer within the study paddocks at Haycock's Station provides meaningful insight in to the overall relations of individuals to their environment and between conspecifics within that environment. The home range and core areas for the study deer at Haycock's showed marked differential spatial behavior between study deer that is directly related to the size of the study paddock, and indirectly to social constraints within the paddocks.

Red deer are highly social animals, and in the wild will form groups of two to three individuals up to loose herds of 50-150 (Clutton-Brock *et al.*, 1982). However they are not highly gregarious like many other domesticated herbivores, and seem to prefer group sizes of around 20-40 animals. At Haycock's Station, it was observed during the study period, many close-nit groups of ≈20 hinds were commonly seen together, and often in the afternoon larger more spread out herds of over 100 would congregate on the sunny ridge lines. In the wild, hinds will form herds based on matrilineal groups, with an age structured hierarchy (Milne, 1987). However, under farmed situations these groups are formed more by a deer's live-weight, and not by lineage (Milne, 1987).

During calving red deer are well known to seek isolation from their herd, and to selects sites for parturition with good cover where they can hide their calf safely out of view from potential predators (Ciuti *et al.*, 2006; Clutton-Brock, Guinness & Albon, 1983; Hester *et al.*, 1999; Lent, 1974; Pollard & Drewry, 2002). This need to find isolation from the herd and suitable habitat is evident even in intensive pastoral systems, and the failure to find suitable environments almost certainly contributes to stress and perinatal mortality (Cowie *et al.*, 1985; Pollard *et al.*, 2002).

It has been observed in more intensively farmed situations, aggressive social encounters between dominant and less dominant individuals increased with decreasing size of the paddock (Hall, 1983; Milne, 1987; Van Mourik, 1985). Because of increasing harassment, sub-dominant females have been observed to move to the outskirts of the herd to avoid attacks (Milne, 1987). It seems likely, that for some of the study deer, these type of social constraints have resulted in their marginalized home ranges and core areas, and contributed to their need to escape.

This research suggests that red deer under extensive farm situations with a stocking rate of 3.7 hinds/ha have highly variable home range and core areas that are directly linked to the size of the paddock and indirectly to social constraints placed on the deer within the paddock. These social constraints, particularly during calving, can lead to some individuals, probably less dominant females, being relegated to the fringes of the paddock, and can lead to increased use of fence lines and escaping. The biological desire to find suitable habitat and isolation from the herd for calving is strong, and clearly even the extensive paddocks at Haycock's, are limiting these biological needs.

Habitat selection is the primary interaction that herbivores have with the natural environment, providing food, shelter, and security. Indications from this research show that while pasture grass habitats were highly selected, most likely for their high forage value, tussock grasslands were also highly selected when available. Tussock grasslands provide considerably less forage value, but their high tussock growth form (up to 1m), and there brown-red color, do provide reasonable cover and camouflage for deer to either bed down in, or to graze in relative obscurity. It is also noted, from field observations, that in many areas the inter-tussock vegetation could be quite lush, with large clovers and pasture grass specie, which may be a result of more moist soil and reduced evapotranspiration created by the shade from the tussock canopy (Holdsworth & Mark, 1990). Therefore tussock grasslands may be highly valued by red deer as a habitat with good cover, and relative grazing value.

6.0 CONCLUSION

The implications from this research are important for farm managers who want to understand the effects different stocking rates are having on their herds, and the possibility that at higher stocking rates sub-dominant deer may be relegated to marginal pastures and driven by the desire to escape. However, it also raises the question, that if hinds at Haycock's are under considerable stress during calving due to densities in the paddock, what effect are intensive paddocks (stocking rate of over 10 hinds/ha) having on the stress of hinds during calving.

Habitat selection is important when considering valued habitats of deer during calving that could be important for reducing stress on deer, which in-turn could lead to higher weaning rates and better production and welfare for deer. However, it is also important because tussock grasslands are of considerable conservation value in New Zealand, and the effects that large red deer herd densities are having on the tussock grasslands needs to be monitored.

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REFERENCES

Asher, G.W. & Adams, L.J. (1985) Reproduction in farmed red and fallow deer in northern New Zealand. *Biology of Deer Production, Royal Society Bulletin*, 217-224.

Ciuti, S., P., B., Vassale, S., & Apollonio, M. (2006) Influance of fawning on the spatial behaviour and habitat selection of female fallow deer (*Damma damma*) during late pregnancy and early lactation. *Journal of Zoology*, 97-107.

Clutton-Brock, T.H., Guinness, F.E., & Albon, S.D. (1983) The costs of reproduction to red deer hinds. *Journal of Animal Ecology*, **52**, 367-383.

Clutton-Brock, T.H., Guinnness, F.E., & Albon, S.D. (1982) *Red Deer: Behavior and ecology of two sexes* The University of Chago Press, Chigo.

Cowie, G.M., Moore, G.H., Fisher, M.W., & Taylor, M.J. (1985) Calving behaviour of farmed red deer. *Proceedings of a Deer Course for Veternarians*, 143-154.

Hall, M.J. (1983) Social organization in an enclosed group of red deer (*Cervus elaphus L.*) on Rhum. I. The dominance hierarchy of femailes and their offspring. *Zeitschrift fur Tierpsychologic*, 250-262.

Hester, A.J., Gordon, I.J., Baillie, G.J., & Tappin, E. (1999) Foraging behaviour of sheerp and red deer within natural heather/grass mosaics. *Journal of Applied Ecology*, 133-146.

Holdsworth, D.K. & Mark, A.F. (1990) Water and nutrient input: output budgets: effects of plant cover at seven sites in upland snow tussock grasslands of eastern and central Otago, New Zealand. *Journal of Royal Societu of New Zealand*, **20**, 1-24.

Lent, P.C. (1974) *Mother-Infant Relationship in Ungulates* Union Conservation Nature Publishing, Morges, Switzerland.

Milne, J.D. (1987) *Comparison of Behavioral Interactions of Red Deer Hinds and Their Pure or Hybrid Offspring*, University of Otago, Dunedin.

Neu, C.W., Byers, C. R., Peek, J. M. (1974) A technique foe analysis of utilization-availability data. *Journal of Wildlife Management*, **Vol. 38**, 541-545.

Pollard, J.C. & Drewry, J. (2002) Calving environments for farmed red deer: a review of current knowledge and a pilot study on soil quality. In New Zealand Veteranary Assoceation Deer Branch No.19/97, pp. 104.

Van Mourik, S. (1985) Expression and relevance of dominance in farmed rusa deer (*Cervus russa timonensis*). *Applied Animal Behaviour Science*, 275-287.