Comparison of Grizzly Bear Telemetry Location Data with a Grizzly Bear Habitat Model

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Introduction

In 1998 the Province of Alberta and Jasper National Park worked co-operatively to develop an integrated and regional approach to address ongoing concerns over grizzly bear (*Ursus arctos horribilis*) conservation in the Alberta and Jasper National Park (JNP) portions of the Yellowhead Ecosystem. This effort resulted in a draft document entitled, "A Framework for the Integrated Conservation of Grizzly Bears". This represents a significant co-ordinated effort by two levels of government and stakeholders, and will provide the impetus to effectively address grizzly bear conservation at the landscape level. A grizzly bear research program is currently underway in the Yellowhead region to support this "Framework Document".

The long term goal of this research program is to provide resource managers with the necessary knowledge and planning tools to ensure the long-term conservation of grizzly bears in the Alberta Yellowhead Ecosystem. In addition, this research program plans to develop a set of validated, user friendly, GIS based computer models that will provide predictive capability when resource managers are making land use planning decisions in known grizzly bear range.

Although a number of GIS based grizzly bear cumulative effects models are available (BIOS 1996, Purves and Doering 1998, Weaver et al. 1986), the need remains to obtain detailed data from regional grizzly bear populations to validate and improve these models. The Foothills Model Forest Grizzly Bear Research Project intends to gather this information as one program element (Stenhouse 1999).

In the late 1970's, a 4-year study of grizzly bear ecology in Jasper National Park was completed. Determination of population parameters, movements, behaviour, and food habits were all part of the project's objectives. The results are summarized in *A study of the Grizzly Bear in Jasper National Park 1975 to 1978* (Russell *et al.* 1979).

In the twenty years since the original study was completed there have been many advances in both technology and resource management tools. Personal computers, which today provide numerous common tools for biologists, were only just being developed in the 70's. Remote sensing of habitat data and Geographic Information Systems (GIS) to analyse and correlate this data with grizzly bear movements were not available. Habitat classification has been completed in JNP (Holland and Coen 1982) and computer models developed to allow managers some predictive abilities (Kansas and Riddell 1995, Purves and Doering 1998).

The telemetry data collected by Russell *et al.* (1979) was not collected in a manner consistent with a detailed habitat use analysis, nor was it intended to be used for such. However, we felt that re-examination of the Russell data with some of these new tools was a useful exercise to augment the initiation of the Foothills Model Forest Grizzly Bear Research Project, and to provide an initial overview of bear location information with habitat availability mapping. The intent of this exercise was to:

- transform the bear movement data from Russell et al. (1979) into a computer compatible format,
- explore how these bear locations relate to the habitat attributes assigned to the habitat polygons in which they occurred,
- provide information on the temporal and spatial distribution of grizzly bears in this portion of the "new" study area to aid in the planning of radio collar deployment and DNA sampling sites,
- recalculate home range sizes and compare these with those originally reported and examine home ranges in pre and post-berry seasons.

Methods

Kansas and Riddell (1995) developed and refined a grizzly bear habitat model based on vegetation, grizzly bear food habits, and standardized Ecological Land Classifications. As input, ecosite polygons within Jasper National Park were assigned an Ecosite Importance Value (EIV) based on bear food availability and abundance. EIVs were determined for each of the 7 months (April to October) when grizzly bears were most active. A similar but separately calculated composite rating representing an annual or composite EIV was also assigned to each ecosite. The determination of EIV ratings is described in detail in *Grizzly Bear Habitat Model for the Four Contiguous Mountain Parks* (Kansas and Riddell 1995). Digital files with polygons and associated Habitat Quality Values (HQV) were provided by JNP. HQVs are numbers directly related to EIV's and range from 0.0 to 10.0 in 0.1 increments. Only vegetated ecosites were considered by Kansas and Riddell (1995). JNP staff categorized the remaining non-vegetated area and assigned these an HQV of 0.0.

The data sources for establishing Ecosite Importance Values were a mix of recent (1990's) and older (1980's) sources (Kansas and Riddell 1995). We are aware that the Habitat Quality Values based on this data could be different than those based on data from during the time of Russell *et al.* (1979). However, the Russell study area was within a remote area of Jasper National Park and we assumed that changes there would primarily be through natural succession.

The only source of bear location data available from the original study was the final report of Russell *el al.*(1979). Data points were digitized from figures in the Russell report using Arcview Version 3.0 and a Calcomp Drawing Board II graphics table. The digitization process is summarized in Appendix A. The collection of telemetry locations occurred through the years 1975 to 1978. Flights were scheduled weekly but weather frequently modified that schedule, consequently location intervals were not consistent. Supplemental opportunistic locations were also obtained during the spring trapping season when the researchers were in the study area daily. The original tabulated telemetry data was not available and individual locations on map figures were identified only as sequential and by month. Some telemetry locations occurred in November and December, months for which there was no monthly HQV. These months were omitted from analysis involving monthly HQVs. Two of the bears whose movements were digitized (F17, M18) were orphaned sibling cubs of the year that were located many times over 3 years but remained very localized during the study. These bears were not included in any analysis or on any figures after Figure 1.

For analysis purposes, the year was divided into 2 segments, pre-berry (den emergence to July 31) and post-berry, after berries had ripened (August 1 to denning). The month of April which represented only 3 locations, was omitted from calculations and comparisons of monthly means. Telemetry locations of bears were frequently not uniformly distributed throughout the year (Appendix A, Table 2) and calculations of home range comparisons between years and berry seasons were restricted to those animals that were more evenly represented. Bear locations were associated with the HQV for the month in which the observation occurred, not the composite, or annual HQV.

To allow sufficient sample sizes for some analysis, HQVs were compressed by rounding down the original HQVs (0.0 to 10.0) into an Habitat Quality Value 10 Point Scale (HQV10) comprising integers ranging from 0 to 9. For some analysis these were further reduced to 4 Habitat Quality Categories (HQC) (Table 1).

For the purpose of grizzly bear management, Jasper National Park has been divided into thirty three bear management units (BMU) based on watershed analysis and average female home range size (Purves and Doering 1998). The units vary in area from 155 km^2 to 490 km^2. BMUs containing bear locations were used as area delimiters to bound the study area and establish the relative availability of each habitat type.

Table 1. Relationship of different Habitat Quality Ratings used in this report.

Habitat Quality Value (HQV)	Habitat Quality Value 10 point scale (HQV10)	Habitat Quality Category 4 point scale (HQC)
0.0 - 0.9	0	1 very low
1.0 - 1.9	1	
2.0 - 2.9	2	2 low
3.0 - 3.9	3	
4.0 - 4.9	4	
5.0 - 5.9	5	3 medium
6.0 - 6.9	6	
7.0 - 7.9	7	
8.0 - 8.9	8	4 high
9.0 - 10.0	9	

Statistical difference in means were compared with ANOVA while the difference between monthly and composite Habitat Quality Values were examined with the paired-sample T-test. Difference in distributions were examined with Chi Square. Significance level for all tests was considered to be p=0.05. Statistical analysis were preformed with SYSTAT (ver. 8.0, SPSS Inc. for Windows 95). Calculations of Minimum Convex Polygon (MCP) home ranges were accomplished with Animal Movement Extension (Hooge and Eichenlaub 1997) for ARCVIEW GIS (ERSI, Inc).

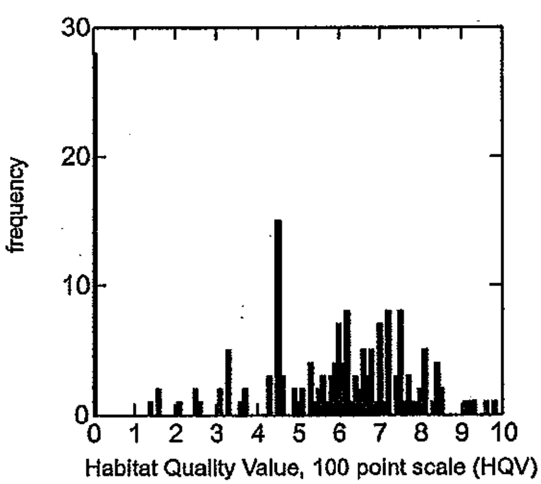
Results and Discussion

Digitization

Locations for eighteen bears, 5 females and 13 males, were digitized from 10 figures in Russell *et al.* (1979). The RMS map error for digitizing the figures ranged from 10 meters to 146 meters with a mean of 60 meters (n=10). Three hundred and sixty one points were digitized

(Fig.1 and Fig. 2), 131 of which belonged to two orphaned siblings F17 and M18. Thirty three of the remaining points fell outside JNP and had no HQV polygon associated with them. These were treated as missing values in analysis involving habitat . Fifty two different values of monthly HQVs (out of a possible 100 greater than 0.0) were represented by 180 locations occurring in 64 different habitat polygons. Fifteen Bear Management Units were represented by at least 1 bear location.

Bears were located in all months from April to December however, the distribution was somewhat skewed with 68% of locations occurring in the pre-berry season and 32% in post-berry. The HQVs ranged from 0.0 to 9.8, with 73% of the locations falling within HQV polygons having values greater than or equal to 5.0 (Fig. 3). Surprisingly, HQVs of "0.0" occurred about twice as frequently as the next most frequent HQV class. The HQVs of "0.0"



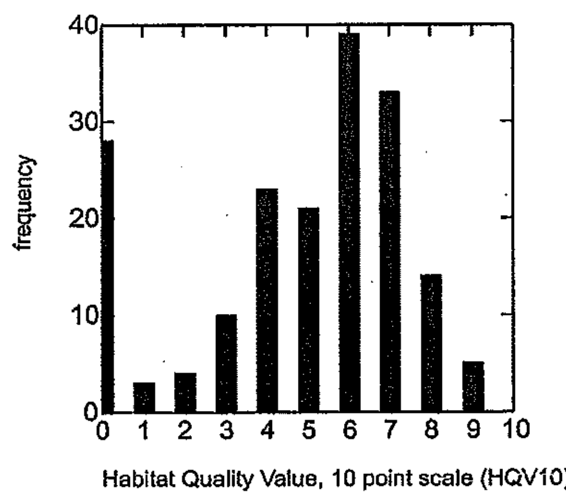


Figure 3. Distribution of bear locations in Habitat Quality Polygons

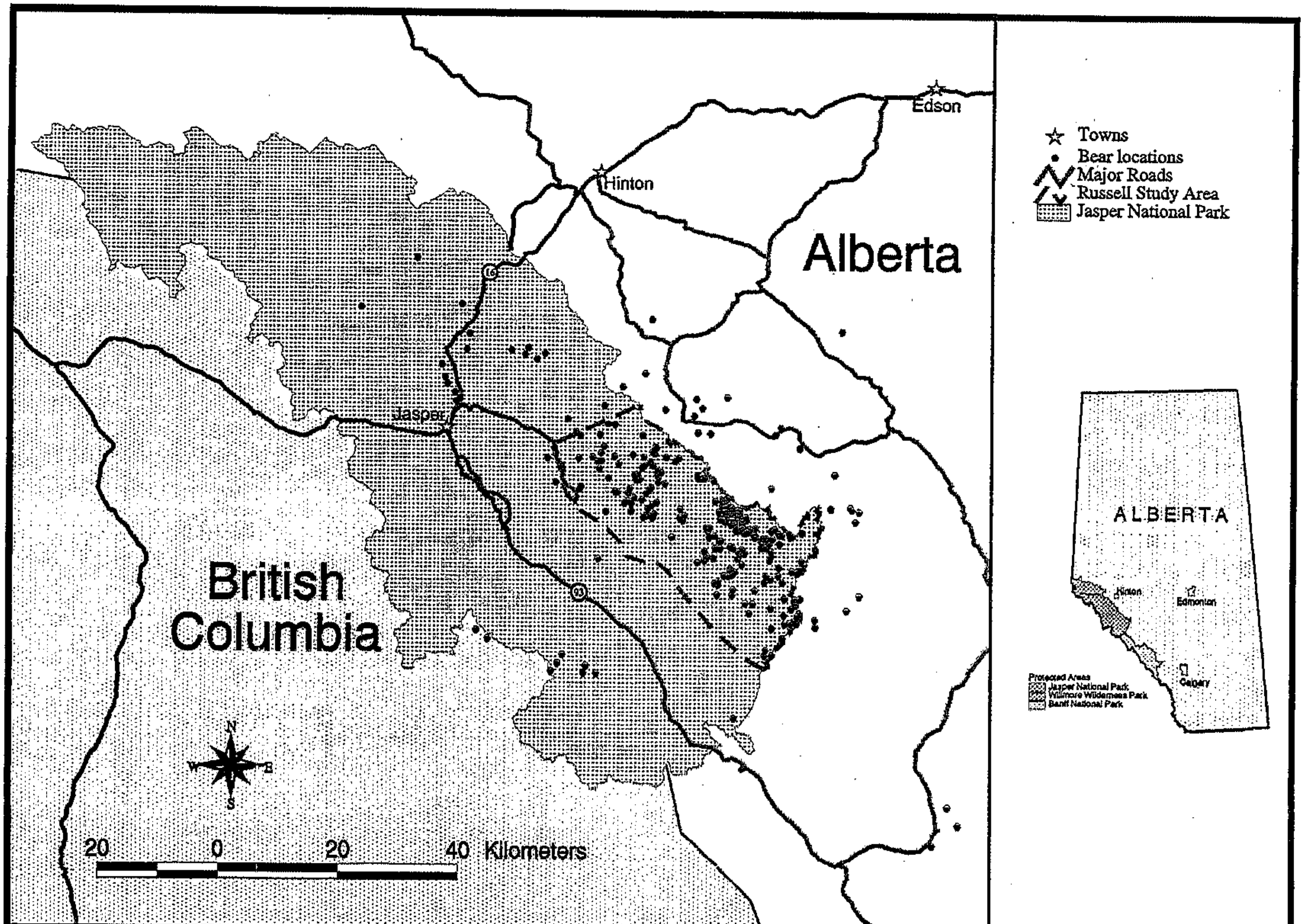


Figure 1. Grizzly bear locations digitized from Russell et al. 1979.

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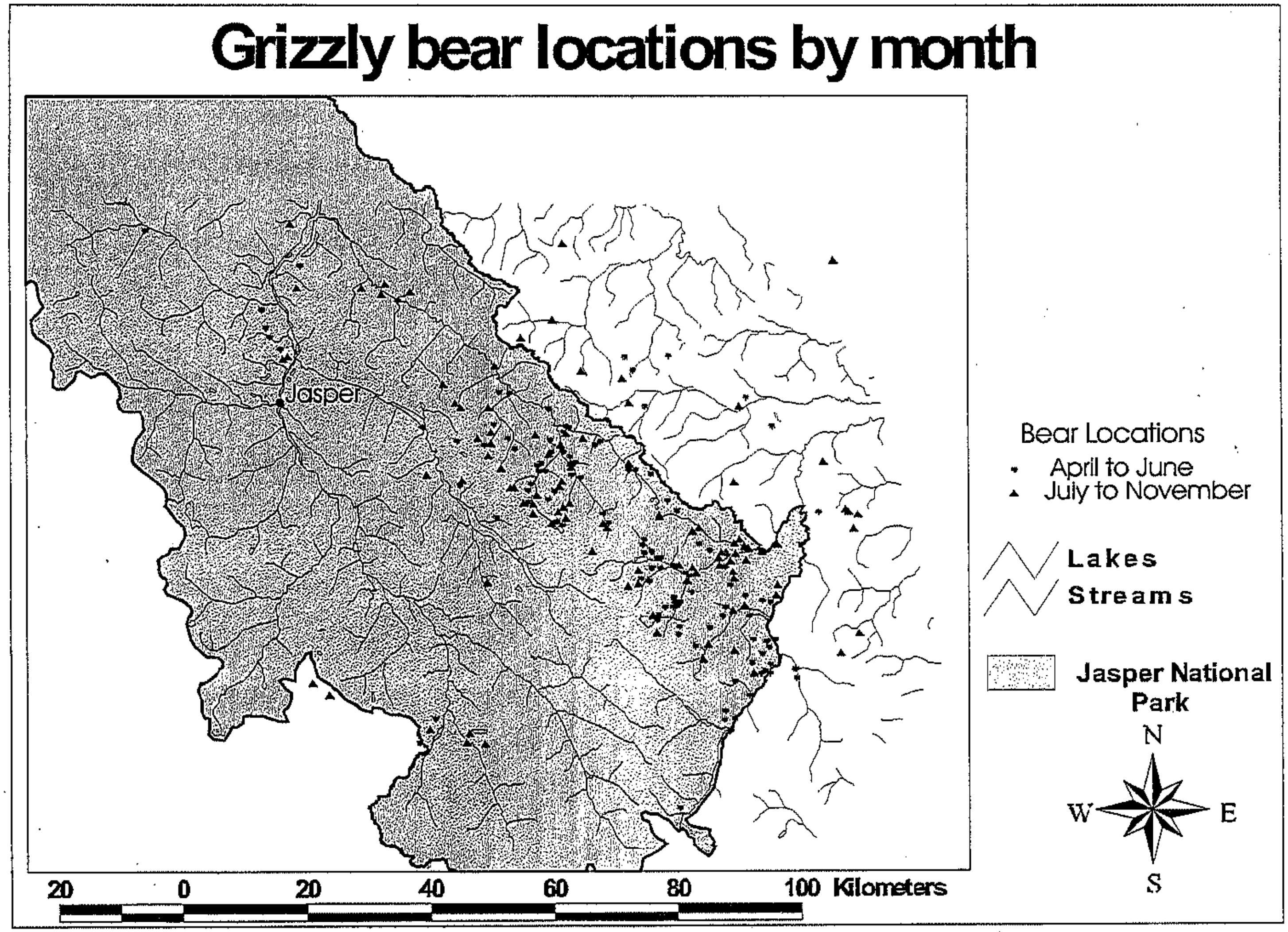

Figure 2. Locations of grizzly bears by month.

that were assigned to un-vegetated areas were determined by a process other than that used by Kansas and Riddell (1995). The latter process was based primarily on vegetative grizzly bear food supply and was not applied to un-vegetated areas. We have included un-vegetated areas in this analysis because if the criteria for habitat evaluation is that of vegetation, presence or absence is a valid category. As a source of plant food for grizzly bears, un-vegetated areas are obviously very poor. However, the fact that bears were frequently located in these areas should invite further investigation. The frequency of bear locations occurring in un-vegetated polygons appeared to change over the course of the year (Fig. 4). The higher proportion of locations occurring in spring may be related to den emergence. Sixty percent of zero class locations occurred below 2300 meters elevation.

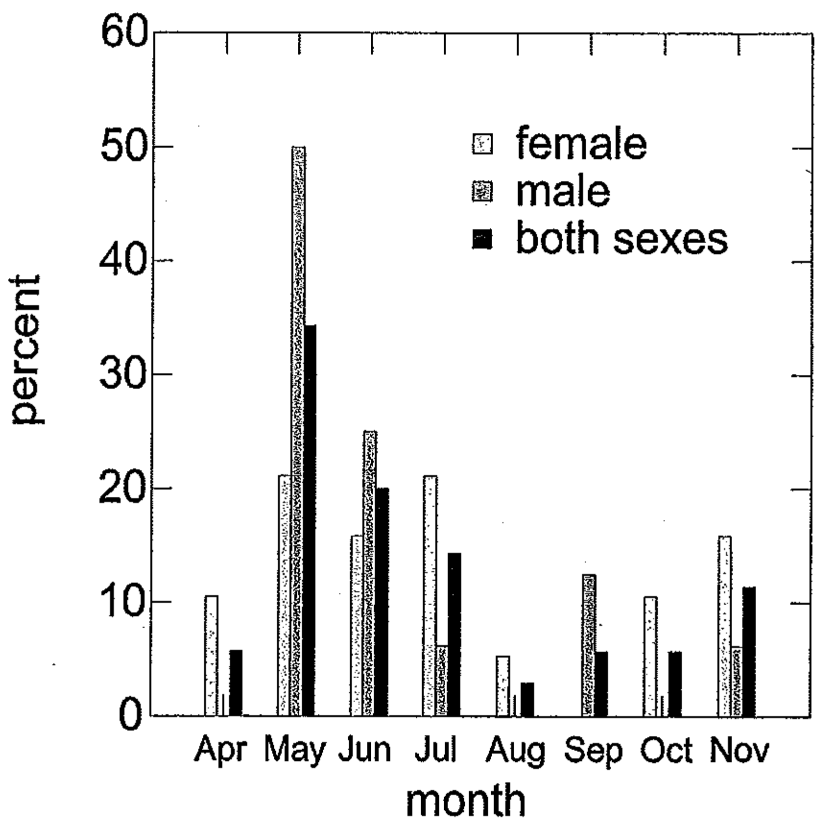

Figure 4 Percent of bear locations occurring in un-vegetated (HQV=0.0) polygons by month

To establish the relative availability of each habitat type in the study area, the area within Bear Management Units containing more than 2 bear locations was determined. The land area covered by polygons of each HQV10 within that area was then calculated and a relative abundance determined. The distribution of telemetry locations (for bears of all sexes) in habitat types was not consistent with the availability of habitat types ($Chi^2 = 80.9$, df = 9, $p<0.05$). This was also the case when sexes were considered separately, supporting the concept of habitat selection or preference.

Buffers

Buffers of 60, 100 and 200 meters in radius were placed around each location to examine the number of habitat polygons associated with each point. The 60 meter buffer was chosen to reflect the mean RMS digitizing error and the 100 meter buffer was chosen based on the digitizing RMS map error 95% confidence interval of 59.6 ± 33.5 meters. As might be expected, the larger the buffer the more habitat polygons that were involved (Fig 5). For this analysis, bear locations within any size buffer involving 2 polygons were considered to be a single polygon if the difference in the two HQVs was less than or equal to 1.0. Bear locations were considered as a single point within a single polygon for all other analysis. For locations with a 100 meter buffer, 68% of the locations were associated with 1 polygon in contrast to 43% with the 200 meter buffer. The 200 meter buffer also had greater proportions of 2 and 3 polygon locations.

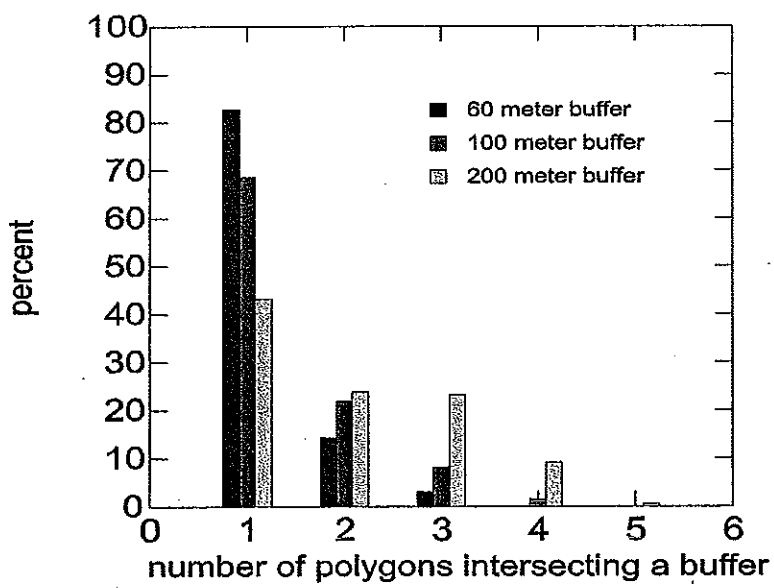

Figure 5. Percent of polygons intersecting radial buffers placed around bear locations.

Distributions

There was no significant difference ($Chi^2 = 5.6$, df = 3, $p = 0.10$) between the distribution of locations of male and female bears occurring in HQCs, ie. overall, males and females occurred in the same proportion in the four Habitat Quality Categories over the 7 months where monthly HQVs were available (Fig. 6). When broken down by sex within berry season, there was no significant difference in the distribution of females and males in HQCs in the pre-berry season.

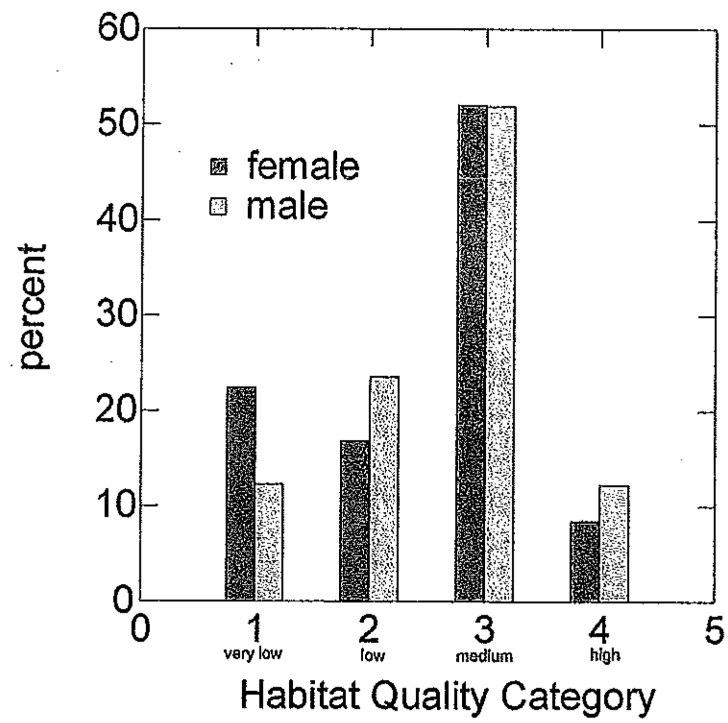

Figure 6. Distribution of males and females in Habitat Quality Categories.

The number of samples in the post-berry season were too small for statistical analysis. When males and females were combined within a berry season, there was a significant difference in the distribution of bear locations between the two seasons, pre-berry and post-berry ($Chi^2 = 34.4$, df = 3, $p<0.001$). Locations in the post-berry season occurred in a higher proportion (Fig. 7) in the higher quality habitat than those locations from the pre-berry season. Although sample sizes were marginal for statistical comparison, this trend was also evident within sex.

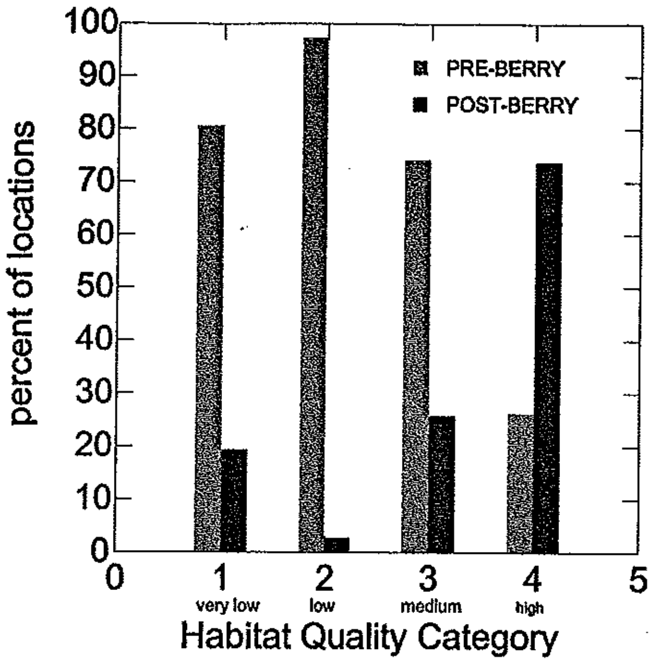

Figure 7. Distribution of locations of bears of both sexes in Habitat Quality Categories during pre and post-berry seasons

The distribution of bear locations by elevation showed a significant difference between sexes ($Chi^2 = 28.02$, df = 11, $p<0.01$). Male bears were found more frequently at lower elevations. Male bears ranged further in elevation (1020 m to 2725 m) than females (1443 to 2611 m). However, the mean elevation of male locations (1832 m, n=145) was significantly (t=4.39, df=205 $p<0.01$) less than that of females (2001 m, n=81). Nine percent of bear locations occurred above 2300 m.

Means

Except for the month of September, the mean monthly HQVs for females was consistently lower than that for males (Fig. 8). However, the difference was not significant (F=3.6, df=(5,165), p=0.10). The sample sizes for the early months of the year were at least twice that of the later months. This, combined with the fact that 2 out of the 9 male samples for September were zero values, may have contributed to the exception in September.

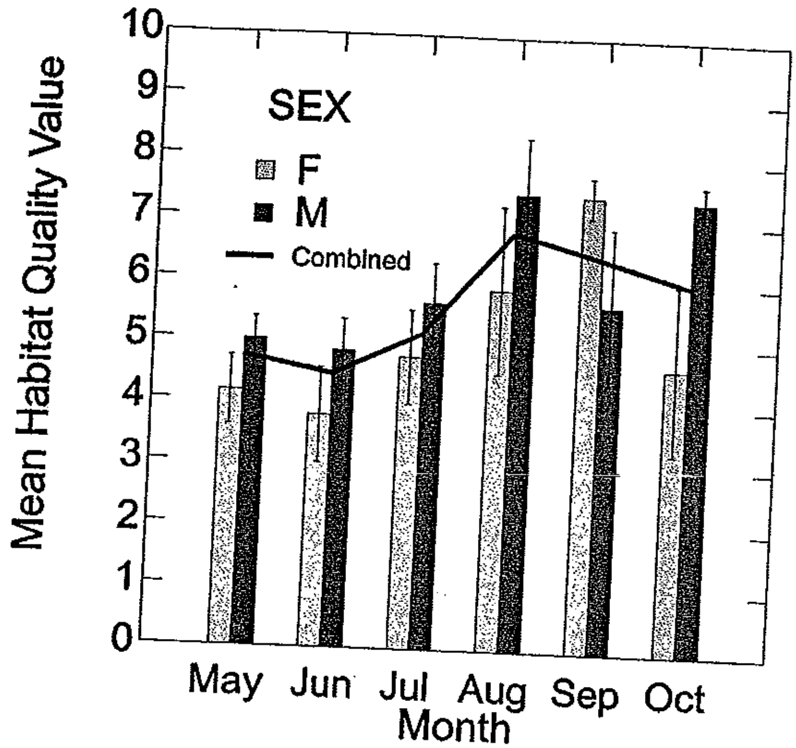

Figure 8. The mean monthly Habitat Quality Value of polygons associated with grizzly bear locations.

Consistent with the frequency distribution of bear locations reflecting increased use of higher habitat quality ecosites in the later months of the year, the mean monthly HQVs also showed an increase as the season progressed. The post-berry mean monthly HQV (6.4) was significantly larger than the pre-berry mean monthly HQV (4.7) ($F=14.9$, $df=1,173$, $p<0.01$). Composite HQVs tended to over-estimate the monthly HQVs of bear locations in the pre-berry season and under-estimate it in the post-berry season (Fig. 9). These differences were significantly different from zero ($t=6.12$, $df=176$, $p<0.01$).

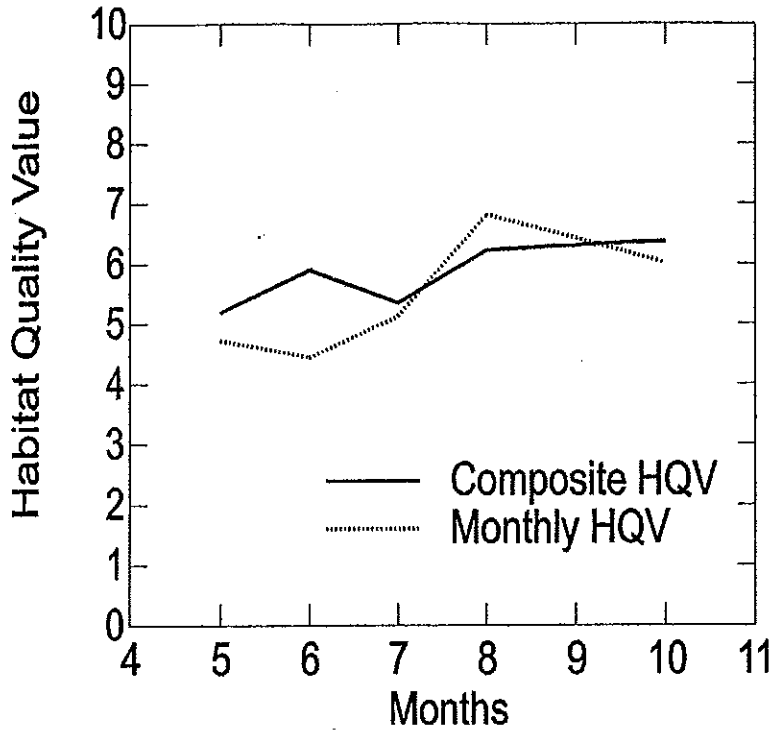

Figure 9. The mean monthly HQV derived from composite and monthly HQV's.

Because the annual HQV for a polygon is an attempt to provide a composite rating for an ecosite, it will not always reflect the actual habitat quality during a given month. An ecosite that is a high quality berry site might get a lower rating in spring but yet a high one in late summer. The composite value could not reflect this. The seasonal shift of habitat use for grizzly bear is well documented (Mattson *et al.* 1987, Mace *et al.* 1997) and use of monthly HQVs to predict bear habitat preference would be desirable where that information was available.

Home Ranges

The MCP home range sizes were estimated by Russell *el al.* (1979) by connecting the outside observation points for each bear marked on topographical maps at scales of 1:50000 to 1:500000 (Table 2). Home range sizes estimated for this report compared well with those results. The occasional discrepancy in the number of data points used in present and past estimates, are likely due to points missed during digitization or points omitted from calculations by the original investigators.

Table 2. Home range areas calculated from digitized data from Russell *el al.* (1979). Numbers in parentheses in the data point column are the number of data points used by Russell.

Bear ID	Home Range Area in km²		Number of data points	Time period in years
	Russell *el al.*	this study		
F1	532	531	31(33)	2
F8	476	461	30(30)	3
F13	154	156	13(12)	2
F19	298	282	7(6)	2
M2	1020	1025	45(50)	2
M3	189	212	7 (6)	2
M7	560	588	10(7)	2
M14	1628	1654	15(15)	2
M15	1212	1185	10(10)	1
M16	1230	1199	7(7)	1
M21	855	930	6(5)	1
M22	420	445	8(8)	1
M23	1233	1242	16(16)	1
M24	869	894	13(9)	1
M25	855	890	9(8)	1

The over all mean MCP home range area for females was 358 km^2 (n=4) and 933 km^2 (n=11) for males. Sample sizes were very limited for examining home range sizes between years. Only 1 bear, M2, had sufficient data points distributed over the active bear months to allow a comparison between years. In 1975, M2's MCP home range was estimated at 576 km^2 (n=20) and increased to 857 km^2 (n=25) in 1976.

A within year, pre and post-berry season MCP home range was calculated for one female (F1) and 2 males (M2 and M23) that had location points distributed relatively evenly over the months April to October in a single year (Figs 10-13). Although the pre-berry MCP home range was substantially larger than the post berry area for these bears (Table 3), the difference in the number of data points in each season may have contributed to the variation. Six other bears (3 females, 3 males) had sufficient data points during just the pre-berry season to allow home range areas to be calculated for that period. The mean pre-berry home range area for all females was 253 km^2 (n=4) and 825 km^2 (n=6) for males. A mean of 283 km^2 (n=3) for males in the post-berry season was also calculated.

Table 3. Grizzly bear minimum convex polygon home range sizes in pre and post-berry seasons

Bear ID and Year	Pre-berry home range area, km^2	Number of data points	Post-berry home range area, km^2	Number of data points
F1 1976	355	13	85	8
M2 1975	381	9	62	11
M2 1976	760	17	395	7
M23 1978	1078	10	394	6
F1 1975	189	10	---	---
F13	129	9	---	---
F8	341	11	---	---
M14	1034	12	---	---
M15	1143	9	---	---
M24	555	10	---	---

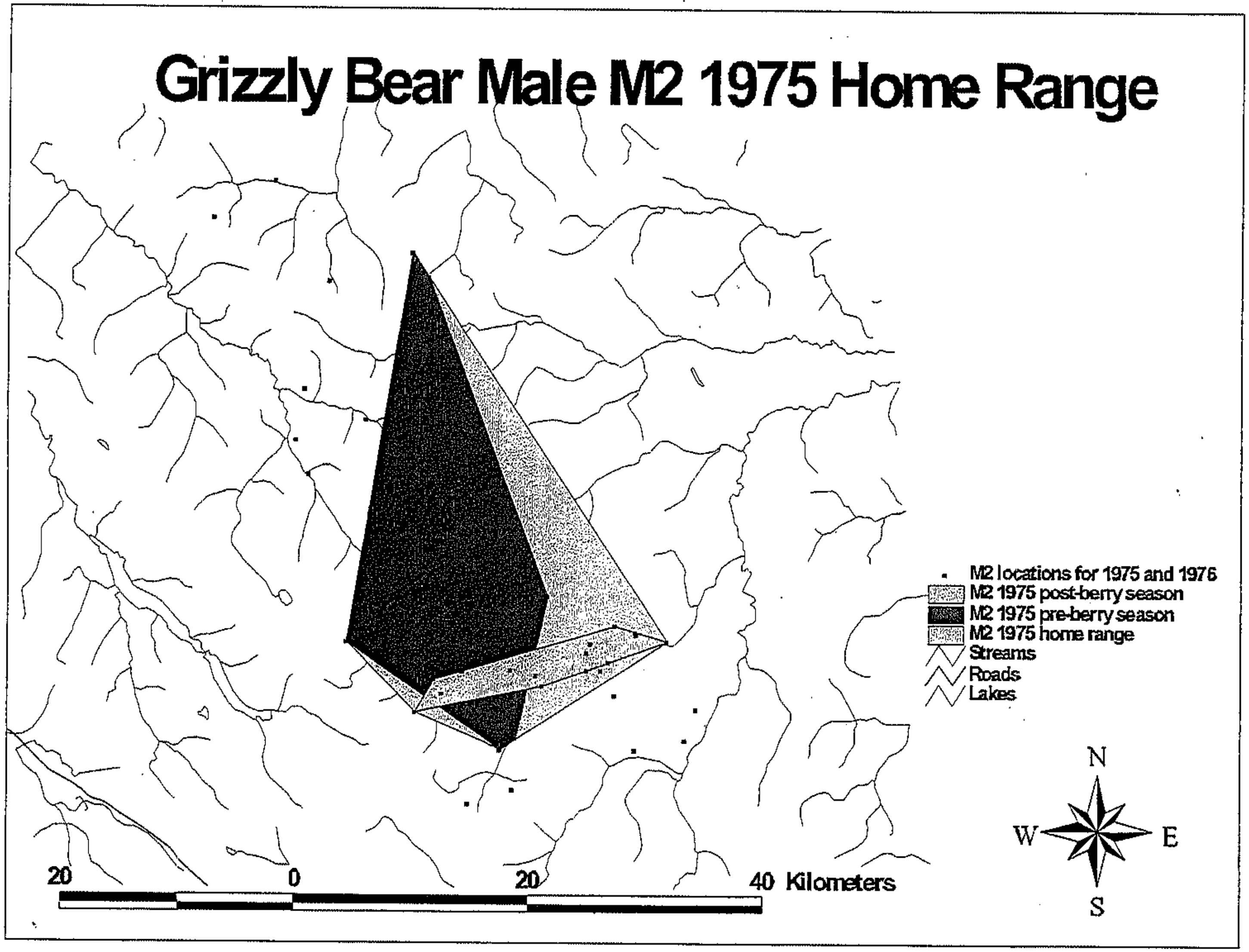

Figure 10. 1975 Minimum Convex Polygon home range for male grizzly M2.

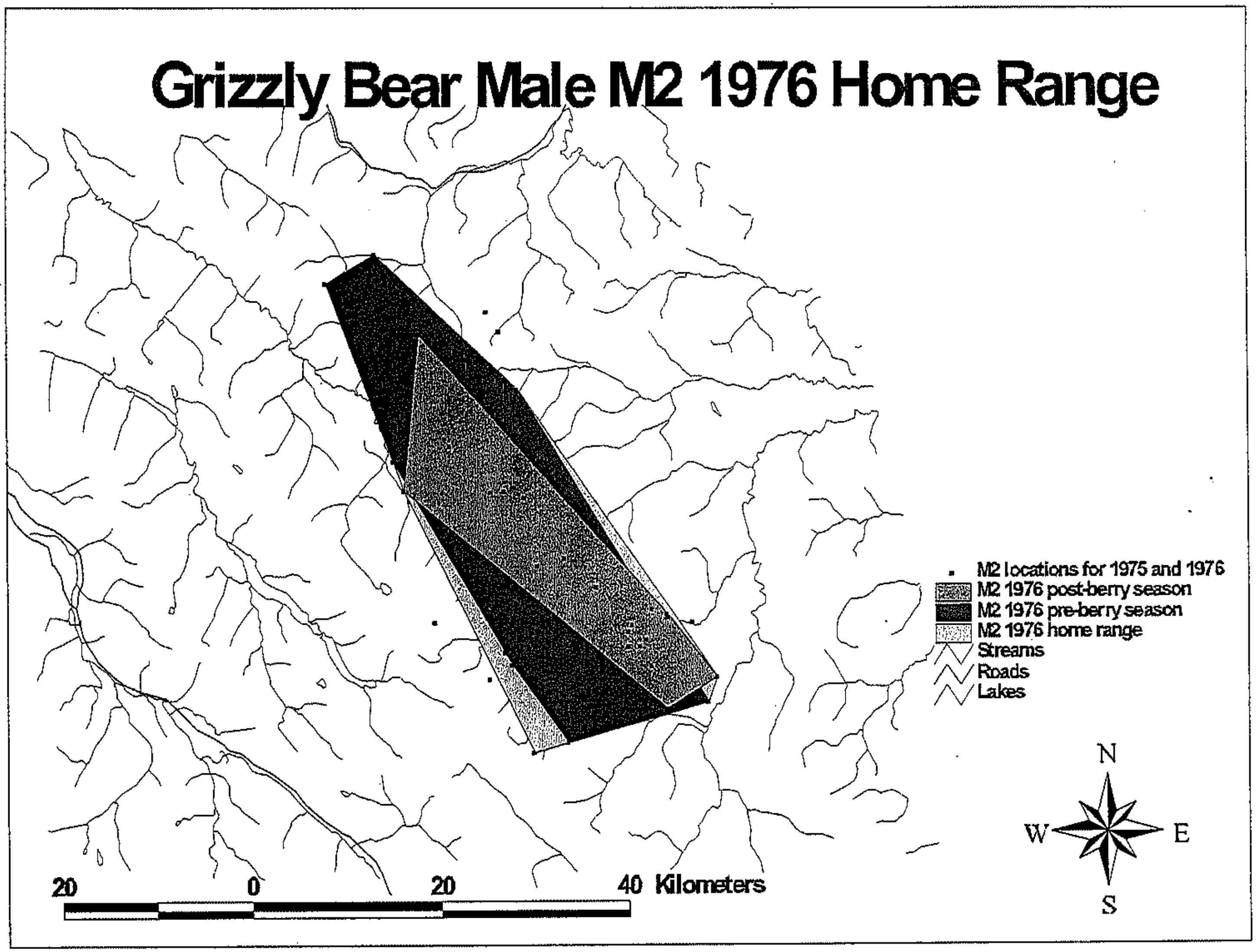

Figure 11. 1976 Minimum Convex Polygon home range for male grizzly M2.

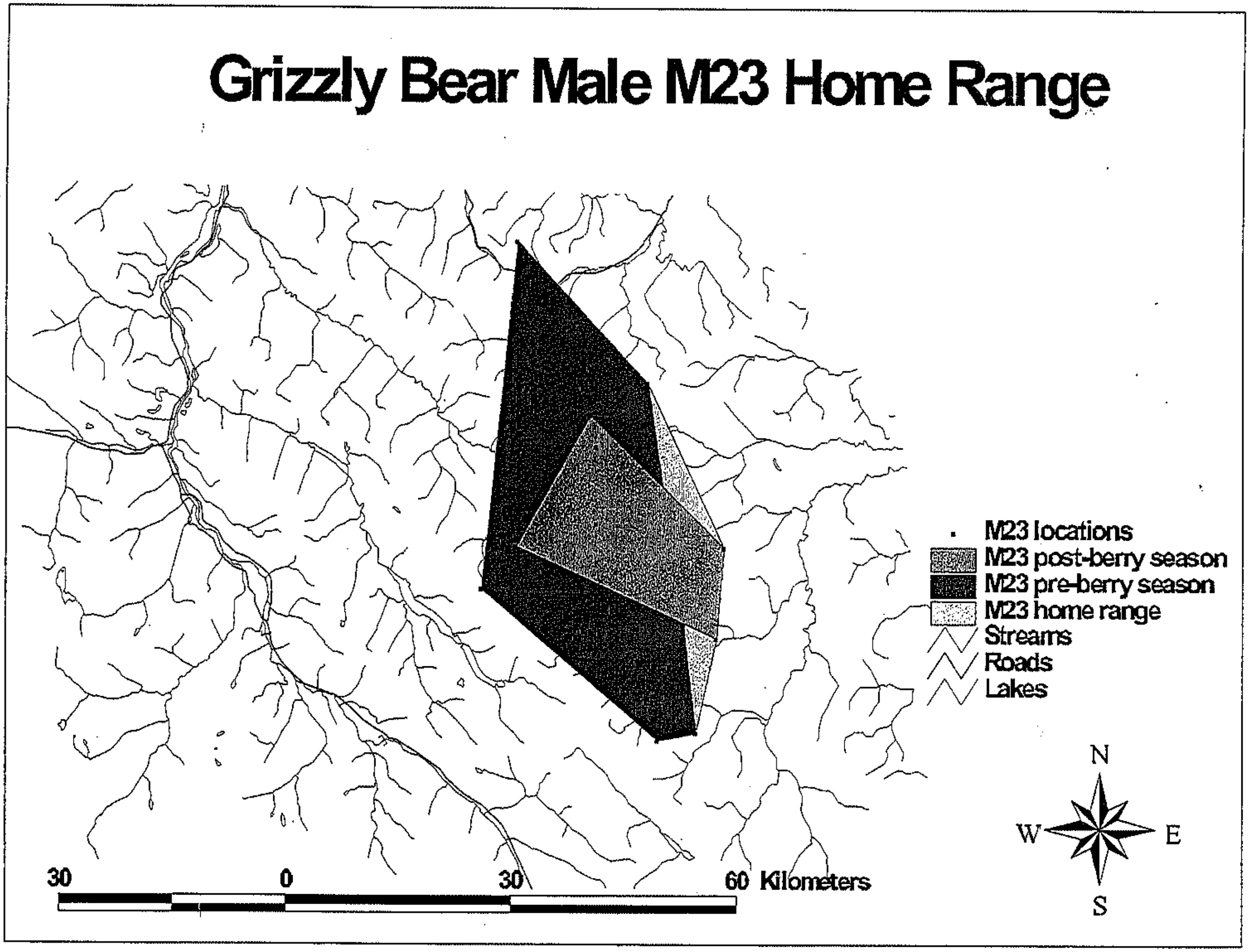

Figure 12. Minimum Convex Polygon home range for male grizzly M23.

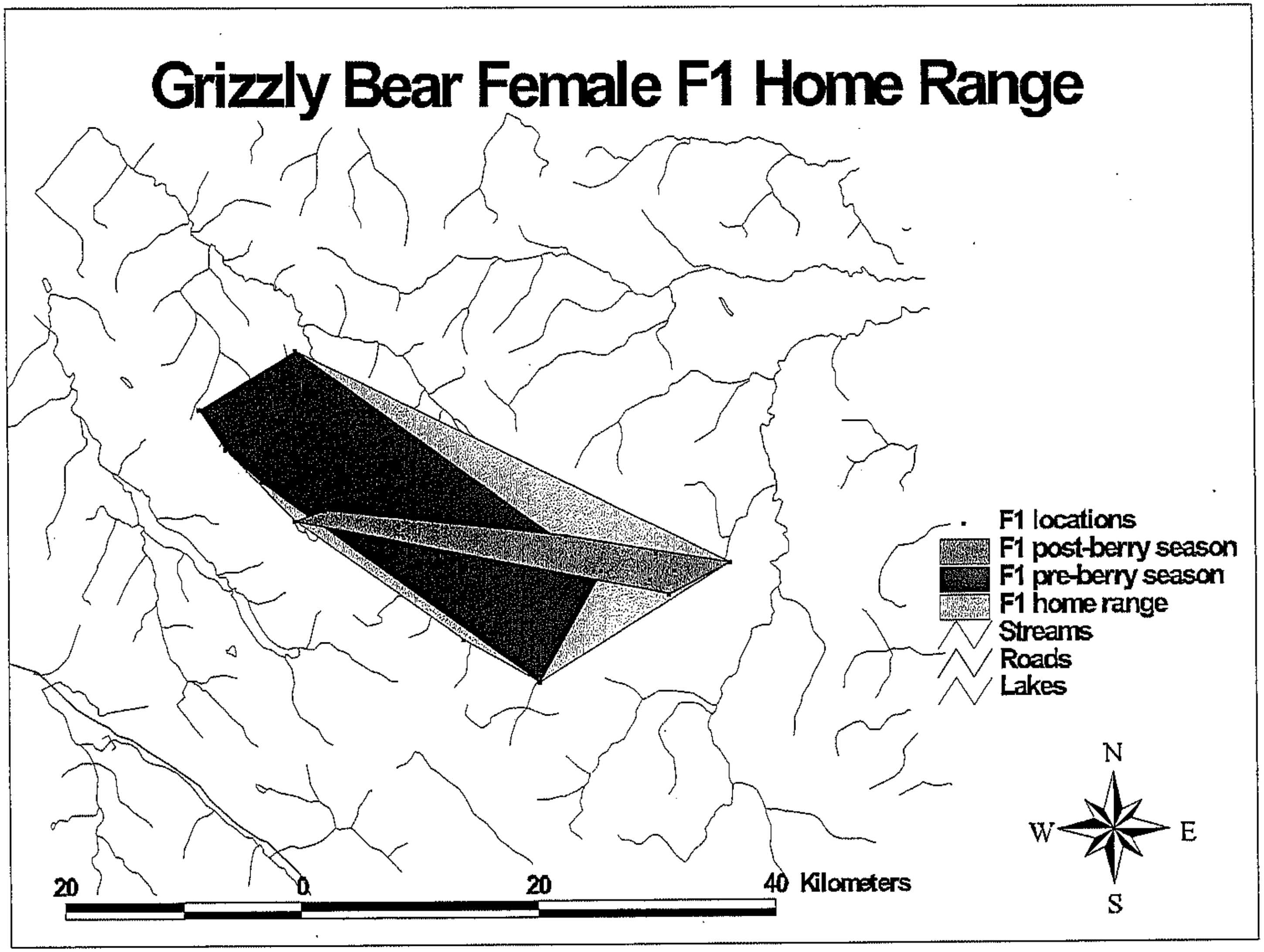

Figure 13. Minimum Convex Polygon home range for female grizzly F1

A minimum number of data points uniformly distributed throughout the year are required to provide a reasonable estimate of home range size with the MCP technique. The area of the MCP home range increase indefinitely as the number of locations increases (Jennrich and Turner 1969) but the area enclosed does tend to approach an asymptote. Only three bears (M2, F1, F8) marginally approached this condition from Russell *el al.*(1979) and 2 to 3 years were required for sufficient data points to accumulate (Fig. 14).

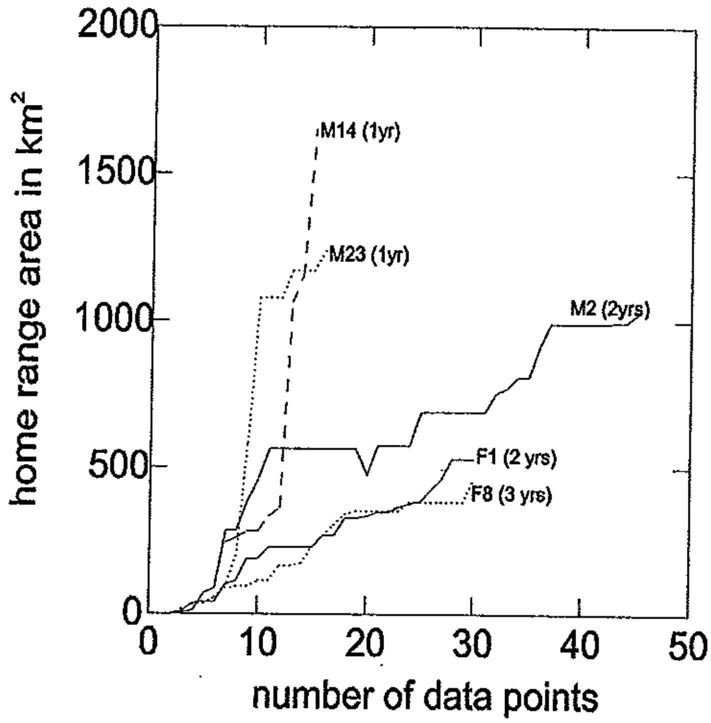

Figure 14. Grizzly bear minimum convex polygon home range sizes as a function of the number of data points collected.

Summary

Grizzly bears were found in higher habitat quality types more frequently than the simple distribution of those habitats would suggest. Additionally, the mean monthly habitat quality value of the habitats chosen increased as the berry season progressed. However, it is not surprising that bears would be choosing higher quality habitat.

The large proportion of occurrences in un-vegetated habitat polygons requires further investigation. Bears may be utilizing some food source other than plants (French *el al.* 1994) or perhaps responding to factors other than vegetation (ie. carrion, escape terrain, mineral licks, conspecific avoidance, etc). The assignment of habitat quality values for these areas may need to be further refined.

Home ranges calculated in this report compared closely with those calculated by hand in Russell *et al.* (1979). This would lend confidence to the reliability of the digitizing process used in this report. The mean female home range size falls within the range of home range areas used to develop BMU (Purves and Doering 1998, Gibeau *et al.* 1996) within JNP. The data indicated larger home ranges in the pre-berry season. Russell *et al.* (1979) refer to this and attributed it to a poorer, more dispersed food supply at that time of the year in combination with increased movements related to breeding activity. However, the discrepancy in the number of data points in the different seasons need to be considered.

This analysis, although limited in scope, supports the habitat potential component of the Cumulative Effects Assessment (CEA) model (Purves and Doering 1998) currently in use in JNP. Further testing and validation of the CEA model components will take place as a primary component of the Foothills Model Forest Grizzly Bear Research Project.

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APPENDIX A

Notes on the digitization of telemetry data from Russell *el al.* 1979 report: *A Study of the Grizzly Bear in Jasper National Park, 1975 to 1978.*

Three hundred and sixty one points were digitized for 18 different bears from 11 different figures (Table 1). Digitization was accomplished with ARCVIEW which created 3 file types: .SHP, .DBF and .SHX for each bear digitized, resulting in a total of 54 files. Data files were named according to the figure number from the report and the bear identification number used by Russell *el al.*; e.g. figure 5 showing movements of male bear number 14, would be named "fig5_m14". The data files are composed of the following 5 fields in addition to the location/coordinate field:

bearid	3 place string field representing individual bears from Russell's report.
month	3 place string field representing the month associated with the location
year	4 place numeric field representing the year of the location
reason	3 place string field representing the reason associated with the location: CAP = capture location TEL = telemetry location SIT = sighting location DEN = den location
loc_no	number associated with the location, indicating sequential locations
comment	comments on location

Miscellaneous notes

1. Orphaned sibling bear cubs of the year, F17 and M18, were always found together except for the one time F17 was captured in a foot snare. These bears were located by sightings until a collar was deployed. These animals were relocated or sighted more frequently than other bears and remained in a much smaller area. Figures 15 and 16 were combined to create data files for each of F17 an M18.

2. Bears F27, F5 and M6 were problem bears that were captured, collared, and moved. Bears F28, M29, and M30 were captured once and did not show up again. These bears were not included in the digitizing.

3. Capture locations based on the coordinates from Appendix 1 and 2 of Russell *el al.* were saved in the ARCVIEW theme file **gbcatp79**. Sex and date of birth from the same Appendices were stored in files **gbears79.xls** and **gbears79.dbf**. These 3 files include the 6 bears mentioned in miscellaneous note 2.

4. Control points for registering the report figures for digitizing were established from points taken from 1:250,000 topographical maps. The RMS map errors ranged from 10 to 146 meters (Table 1).

Appendix A. Table 1. Summary of point digitized from Russell *el al.* 1979.

figure number	bear identification number	number of points	RMS map error in meters
figure 4	M2	45	116
figure 5	M7	10	48
figure 5	M14	15	48
figure 6	M3	7	124
figure 6	M15	10	124
figure 7	M23	16	32
figure 7	M26	3	32
figure 8	M22	8	146
figure 8	M 24	13	146
figure 9	M16	7	80
figure 9	M21	6	80
figure 9	M25	9	80
figure 12	F1	31	11
figure 13	F8	30	10
figure 13	F19	7	10
figure 14	F13	13	21
figure 15/16	F17	66	58/10
figure 15/16	M18	65	58/10

Number of digitized telemetry locations for bears from Russel *et al*, 1979

Bear	Age	Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total	bear total
F1	6	1975	1	3	2	4	0	0	0	0	0	10	
F1		1976	0	7	2	4	2	4	1	1	0	21	31
F13*	13	1976	0	0	0	0	0	0	2	1	0	3	
F13		1977	1	3	3	2	1	0	0	0	0	10	13
F19*	10	1977	0	0	0	0	0	1	3	1	0	5	
F19		1978	0	2	0	0	0	0	0	0	0	2	7
F8	4	1975	0	0	0	0	0	1	3	3	0	7	
F8		1976	0	5	3	3	1	0	0	0	0	12	
F8		1977	0	1	3	4	2	1	0	0	0	11	30
M14	14	1977	0	1	0	0	0	0	0	0	0	1	
M14		1978	0	8	3	1	1	1	0	0	0	14	15
M15	15	1977	0	2	5	2	1	0	0	0	0	10	10
M16	19	1977	0	2	1	3	0	0	1	0	0	7	7
M2	8	1975	1	3	2	3	3	3	2	3	0	20	
M2		1976	0	11	3	3	1	3	2	2	0	25	45
M21	6	1978	0	4	1	0	0	0	0	1	0	6	6
M22	8	1978	0	2	2	1	3	0	0	0	0	8	8
M23	5	1978	0	7	1	2	2	1	2	1	0	16	16
M24	6	1978	0	4	5	1	0	0	0	2	1	13	13
M25	10	1978	0	2	3	2	0	1	1	0	0	9	9
M3	5	1975	0	1	0	1	0	0	0	0	0	2	
M3		1977	0	2	2	1	0	0	0	0	0	5	7
M7	9	1975	0	0	0	0	0	1	3	3	0	7	
M7		1976	0	3	0	0	0	0	0	0	0	3	10
M26	16	1978	0	2	0	1	0	0	0	0	0	3	3
M18	1	1976	0	1	0	5	3	0	0	1	0	10	
	2	1977	0	1	4	9	6	3	4	1	0	28	
	3	1978	3	6	4	4	4	1	3	2	0	27	65
F17	1	1976	0	1	0	5	3	0	0	1	0	10	
	2	1977	0	1	4	9	6	3	4	1	0	28	
	3	1978	3	7	4	4	4	1	3	2	0	28	66
Total			9	92	57	74	43	25	34	26	1	361	361

*F13 with a cub of the year in October 1976
*F19 with a subadult cub in October 1977

Appendix A, Table 2. Summary of grizzly bear telemetry locations digitized from Russell *el al.* 1979