Creation and Analysis of

Habitat Capability Ratings within the

Muskwa-Kechika Management Area (MKMA)

BGIS 492

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Contents

Executive Summary:

The goal of this project was to accurately represent ungulate (stone sheep, elk, moose) critical winter habitat in the Muskwa-Kechika Management Area (MKM-A). This was achieved by analyzing previously created GIS models, calculating statistics, analyzing telemetry data, and much discussion with the biologist who set the parameters of the GIS models. The goal was achieved. The rest of this paper will focus on processes involved in achieving the stated goal.

Target Audience:

This paper is being written for persons with basic Geographic Information Systems (GIS) knowledge, and for persons who do not have an understanding of what role GIS plays within the British Columbia government.

The topic of the paper:

This paper will focus on the analysis and revision of Habitat Capability Ratings (HCR) for ungulates in the M-KMA. The M-KMA is located in north east British Columbia and is 6.4 million hectares in size. HCR are used to safeguard essential habitat within the M-KMA. HCR may restrict natural resource extraction in the M-KMA, specifically oil and gas extraction. Industries' environmental impact is regulated based on the HCR. The impact is quantified by percent disturbance of sensitive habitat, within defined areas in the M-KMA.

Background on the M-KMA:

The Muskwa-Kechika Management Area Act (the M-KMA Act) establishes the requirement for Pre-tenure planning for oil and gas exploration and development in the M-KMA prior to the disposition of petroleum and natural gas rights.

(Muskwa-Kechika Advisory Board, 2005)*http://www.muskwa-kechika.com/*

Pre-tenure plans are intended to:

- Encourage and guide environmentally-responsible development of oil and gas resources by providing results-oriented management direction that ensures oil and gas activities are consistent with the M-KMA Act;
- Provide a sustainable resource management framework to address social well-being, environmental conservation and economic prosperity, and
- Identify roles and responsibilities for ongoing monitoring of progress towards achieving the results anticipated by the pre-tenure plan

In early 2000, as part of the Pre-tenure planning process, HCR were created. The HCR focused on ungulate winter range within 4 Regional Management Zones (RMZ) within the M-KMA. The four RMZ's are: Besa Prophet, Halfway Graham, Muskwa South and Upper Sikanni. Specifically, the study focused on moose, stone sheep, and elk. Using a GIS, models where created to generate HCR specific to each ungulate within each RMZ. The HCR depict polygons which are ranked from one to six, six being the least suitable habitat and one being the most suitable habitat.

In an effort to increase the accuracy of the HCR, mammals within the M-KMA (between 2001 and 2005) were collared with Global Positioning Systems (to obtain telemetry data). Stone sheep, moose, caribou, elk, wolf and grizzly bears were collared. The collars placed on the mammals where programmed to transmit latitude and longitude coordinate points three times a day at the same times each day.

Main issues to be addressed in this paper:

The three main issues within this project are: (1) past (initial) analysis, (2) analysis of telemetry data overlaid on the HCR created in 2000, (3) re-creation of the HCR with adjustments resulting from review of the initial and final analyses

The importance and the implications of the main issues:

HCR are a part of the pre-tenure planning process. The HCR restrict oil and gas development by limiting development based on percent of "area disturbed" within RMZ's in the M-KMA. In an effort to effectively represent and protect the habitat of the mammals within the M-KMA, the project of re-creating HCR was undertaken.

Key assumptions pertinent to analysis:

The key assumptions pertinent to the analysis and creation of HCR are: (1) the telemetry data is an accurate representation of the ungulates habitat and (2) the digital elevation models are precise and accurate.

Key data used:

The key data used was:

- Telemetry data: Telemetry data is defined as: transmit (radio signals, data) automatically and at a distance, as between a ground station and an artificial satellite, space probe, or the like, esp. in order to record information, or operate guidance apparatus.

  http://dictionary.reference.com/browse/telemetry

- Digital elevation models (DEM) were used where supplied by the British Columbia government at a resolution of 25 meters.

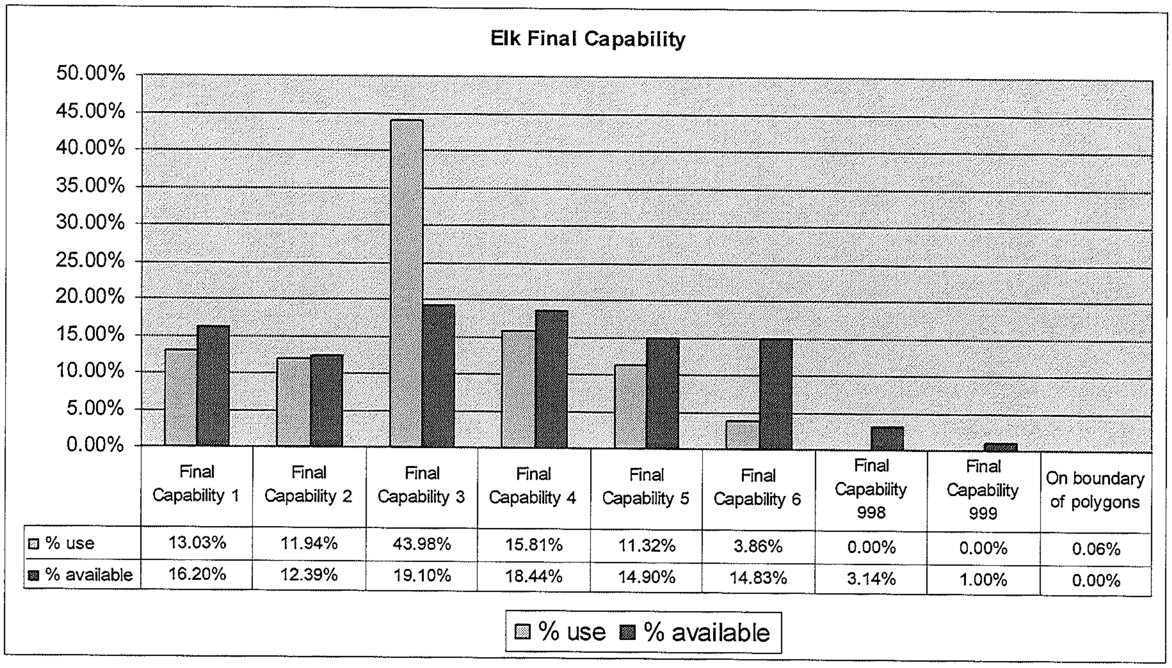
Phase of the project:

This project had three phases; (1) initial analysis, of telemetry data when overlaid on the HCR's created in 2000, (2) re-creation of HCR's with the model adjustment identified in the conclusions of the initial analysis, and (3) the final analysis and conclusions of the newly created HCR's.

Initial analysis:

The first step in the project was analyzing the previously created HCR with the telemetry data. The goal of the initial analysis was to identify the deficiencies and strengths of each model (Stone Sheep, Elk and Moose). This was achieved by: Calculating number of points (telemetry data) that fell within each polygon within each HCR, which was ranked from 1 to 6, and calculating the percent use of each polygon, and comparing that to the percent of area for each polygon. The telemetry data was broken down into: Winter range data (November through March) and data with 3D precision or higher. Graphs were created per month, overall, and a graph that contained all months, overall and percent of area. Below are some of the graphs that where generated.

<u>Conclusions on initial analysis from the biologist (**Rod Backmeyer**)</u>



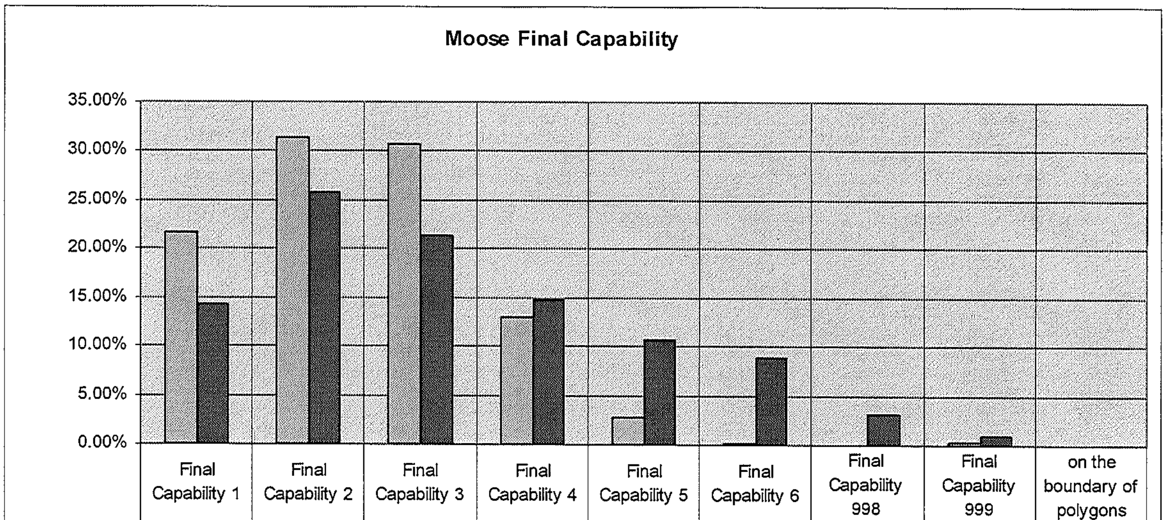
	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	Final Capability 998	Final Capability 999	On boundary of polygons
% use	13.03%	11.94%	43.98%	15.81%	11.32%	3.86%	0.00%	0.00%	0.06%
% available	16.20%	12.39%	19.10%	18.44%	14.90%	14.83%	3.14%	1.00%	0.00%

Graph indicates a relatively poor model with only 25% of use falling into class 1 and 2 habitat capability and 44% use falling into class 3 habitat capability. 69% of locations in winter, range classes 1-3. There should be a much higher selection of classes 1 and 2 with less use of classes 3 and 4.

Evaluations of the assumptions used in the model indicated that both the slope and elevation selection criteria were inaccurate.

UNBC studies indicated that elk selected moderate to moderately steep slopes and avoided flat areas and lower slopes. This study also showed that elk preferred higher elevations than originally expected, with their winter use ranging from approximately 1700 metres in early winter to 1500 metres in late winter.

Adjustments to the assumptions used for slope and elevation will result in a more accurate model of the use in all habitat classes.



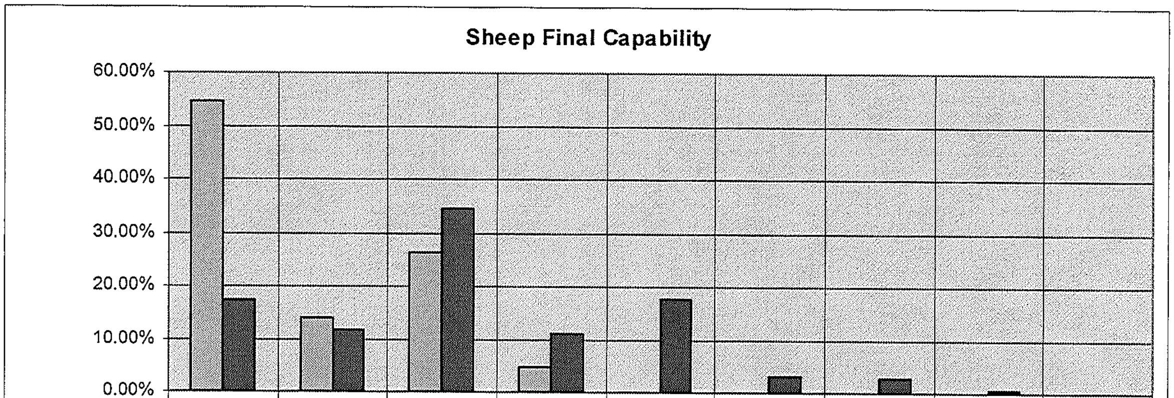
	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	Final Capability 998	Final Capability 999	on the boundary of polygons
% use	21.65%	31.31%	30.68%	13.00%	2.82%	0.09%	0.00%	0.39%	0.06%
% available	14.35%	25.79%	21.36%	14.77%	10.73%	8.88%	3.14%	1.00%	0.00%

This graph indicates a relatively good model on a broad scale with 53% of locations falling in class 1 and 2 capability habitats and 31% of locations falling into class 3 habitats. 84% of locations in broad winter, range classes 1-3. A very accurate model should result in higher use of classes 1 and 2 as compared to class 3.

Evaluation of the assumptions used in the model indicate that moose showed no selection or avoidance for aspect and showed minimal preference for slope, with the exception of avoidance of very steep slopes. This lack of selection is likely related to snow conditions during the one year of telemetry data. In years where snow conditions do not restrict animal movement, habitat selection is likely driven by forage availability and predator avoidance

Moose appear to select for elevations ranging from 1200 to 1400 meters and 1500 to 1800 meters. This selection may be related to forage production in the low elevation wetlands (1200-1400 m.) and shrub dominated sub alpine basins (1500-1800 m.). More analysis is needed to test this theory.

Adjustment to the elevation assumptions and vegetation assumptions may result in a more accurate model of classes 1 and 2.



	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	Final Capability 998	Final Capability 999	on the boundary of polygons
% of use	54.57%	14.08%	26.32%	4.83%	0.12%	0.00%	0.00%	0.01%	0.06%
% of available	17.58%	11.80%	34.76%	11.24%	17.83%	3.20%	3.00%	0.60%	0.00%

% of use ■ % of available

This graph indicates a good model on a broad scale with 69% of locations falling into class 1 and 2 capability habitats and 26% of locations falling into class 3. 95% of locations in broad winter, range classes 1-3.

Evaluations of the assumptions used in the model indicate that most assumptions are reasonably accurate. There was a slightly higher use of cool aspect in early winter than originally expected with a shift to selection of more southerly aspects in late winter.

Review of the telemetry data indicates that the assumption that sheep-use is restricted to within 500 meters of escape terrain (slopes >70%) in winter is very conservative. The data shows that all locations are within 200 meters of escape terrain. An adjustment to the model will be applied and the significance of the change evaluated. Adjusting the distance to escape terrain from 500 m to 200 m is not a huge revision because much of the sheep habitat shows a vast majority of escape terrain being separated by less than 400 meters of non-escape terrain. Therefore, the majority of the change will be a reduction of the buffer around the perimeter of large blocks of sheep winter range. The exact significance of this adjustment will be determined in further assessments prior to any final recommendations for model adjustments.

Re-creation of HCR

The re-creation of the HCR's for Elk, Moose, and Stone Sheep were based upon the rankings of three elements (four elements for the sheep model). The elements are: Slope, elevation, aspect, and distance from escape terrain (for sheep only)

The HCR's where created by breaking down the individual elements; aspect, slope, and elevation into ranges. Within each range a model adjustment was given. Below is an example of the model adjustments and ranges:

Sheep Aspect

Aspect in degrees	Model adjustment
Flat	2
0-134	2
135-150	1
151-284	0
285-360	1

Within ArcGIS, spatial layers were created. These layers where specific to each model and each element within each model. Below is an example of an attribute table:

Sheep Model – Slope

Slp_range = slope range

Slp_adj = slope adjustment

OBJECTID	GRIDCODE	Slp_range	Slp_adj	Shape_Length	Shape_Area
1	1	-0 to 39	4	792.2993208	30193.37137
2	1	-0 to 39	4	792.2993208	30193.37137
3	2	40 to 59	3	792.2993208	30193.37137
4	3	> 60 to	2	792.2993208	30193.37137
5	3	> 60 to	2	792.2993208	30193.37137
6	3	> 60 to	2	792.2993208	30193.37137
7	3	> 60 to	2	792.2993208	30193.37137
8	3	> 60 to	2	792.2993208	30193.37137
9	3	> 60 to	2	792.2993208	30193.37137
10	3	> 60 to	2	792.2993208	30193.37137
11	3	> 60 to	2	792.2996702	30193.40013
12	3	> 60 to	2	792.2994955	30193.38575

13	3	> 60 to	2	792.2994955	30193.38575

Once each layer is classified and contains the model adjustment within the attribute table, the three or four layers are merged together using the union tool. This creates one layer with a single attribute table. The final step is summing the model adjustments within the attribute table.

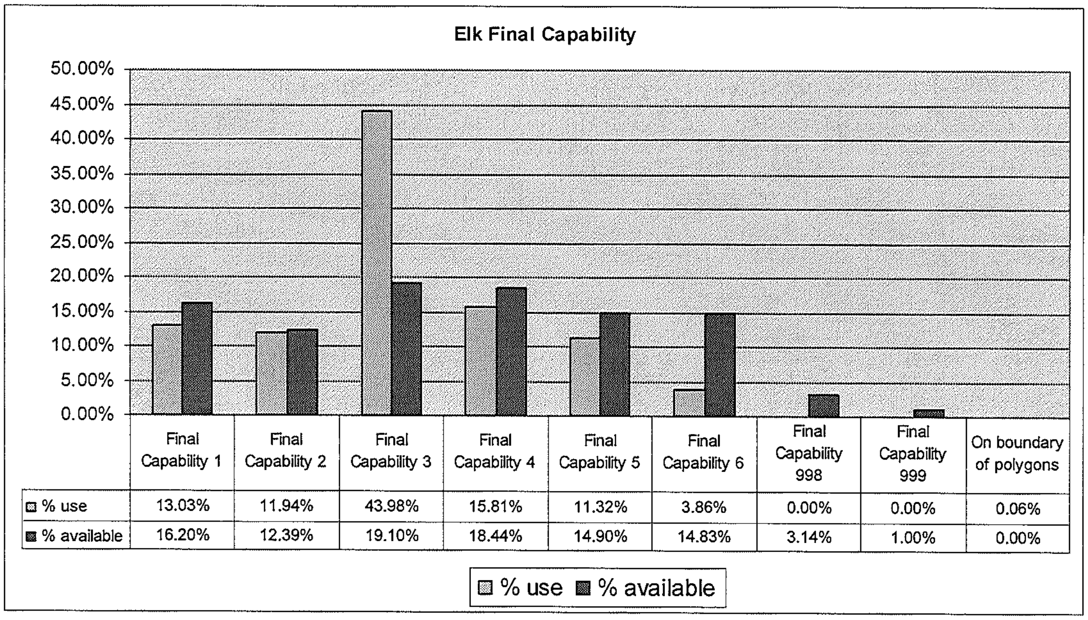
The final polygon rankings were summed using the following rules and algorithms:

1. The final polygon ranking could not be greater than six or less than one
2. The column names that where summed are: Slp_adj, Asp_adj, elv_adj (all models) and esp_adj (sheep model only)
3. The algorithm used to sum the columns was: 1 + Slp_adj + Asp_adj + elv_adj = sum_adj then, using the 'select by attribute' tool all values that where greater than 6 where converted to the value of 6.

Final Analysis and Conclusions

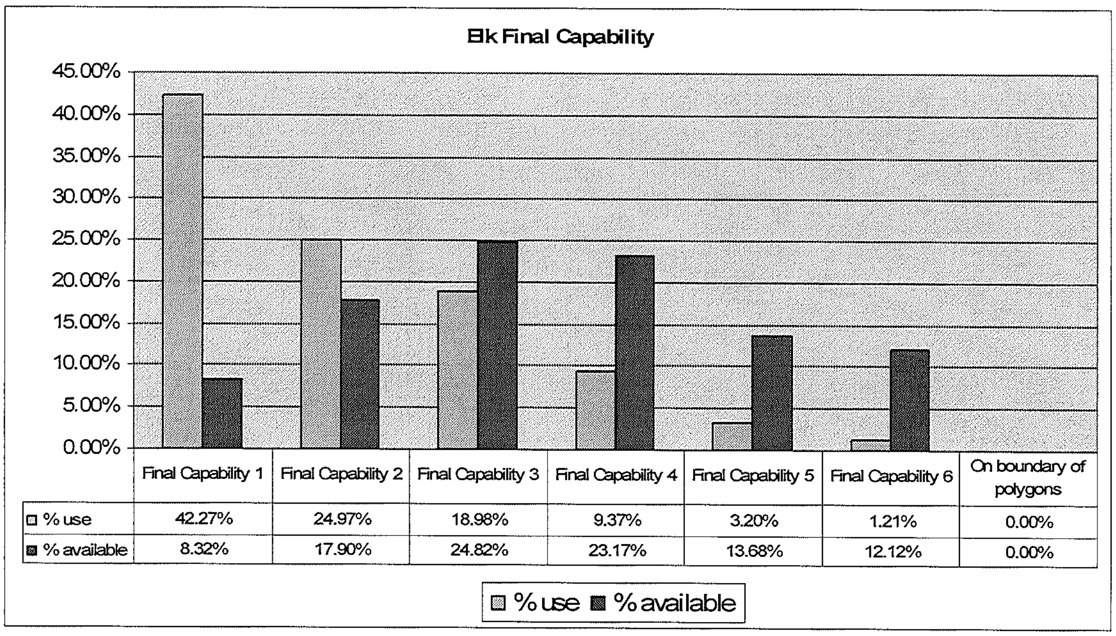
Once each model was created, statistics were calculated. The end goal was to compare the percent- use of the old model with the percent-use of new models created. The same process used in the initial analysis was used to calculate the statistics. Below are graphs comparing the old HCR's to the new HCR's

Original HCR



	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	Final Capability 998	Final Capability 999	On boundary of polygons
% use	13.03%	11.94%	43.98%	15.81%	11.32%	3.86%	0.00%	0.00%	0.06%
% available	16.20%	12.39%	19.10%	18.44%	14.90%	14.83%	3.14%	1.00%	0.00%

Revised HCR

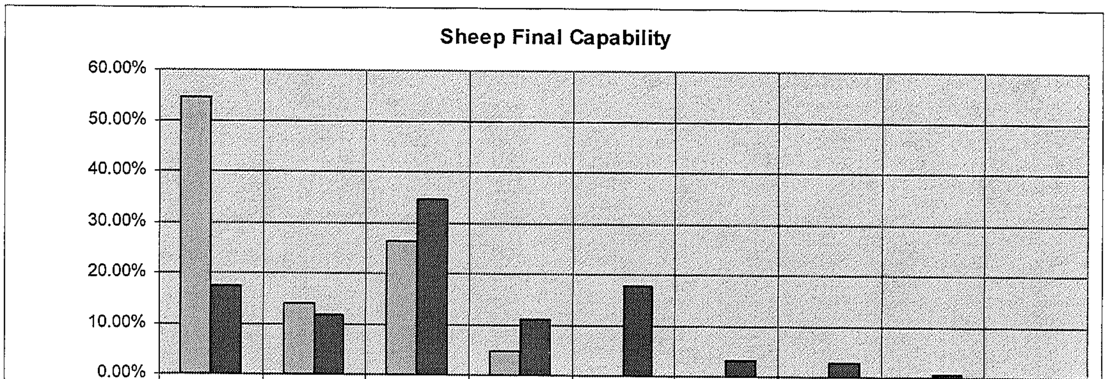


	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	On boundary of polygons
% use	42.27%	24.97%	18.98%	9.37%	3.20%	1.21%	0.00%
% available	8.32%	17.90%	24.82%	23.17%	13.68%	12.12%	0.00%

Original model – 15% of use in winter habitat classes 1 & 2 (29% of area)

Revised model – 67% of use in winter habitat classes 1 & 2 (26% of area)

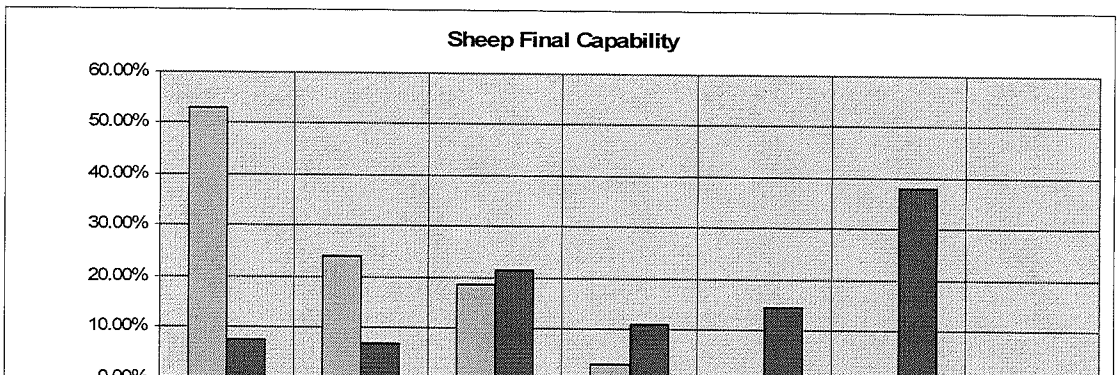
Original HCR



	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	Final Capability 998	Final Capability 999	on the boundary of polygons
% of use	54.57%	14.08%	26.32%	4.83%	0.12%	0.00%	0.00%	0.01%	0.06%
% of available	17.58%	11.80%	34.76%	11.24%	17.83%	3.20%	3.00%	0.60%	0.00%

% of use % of available

Revised HCR



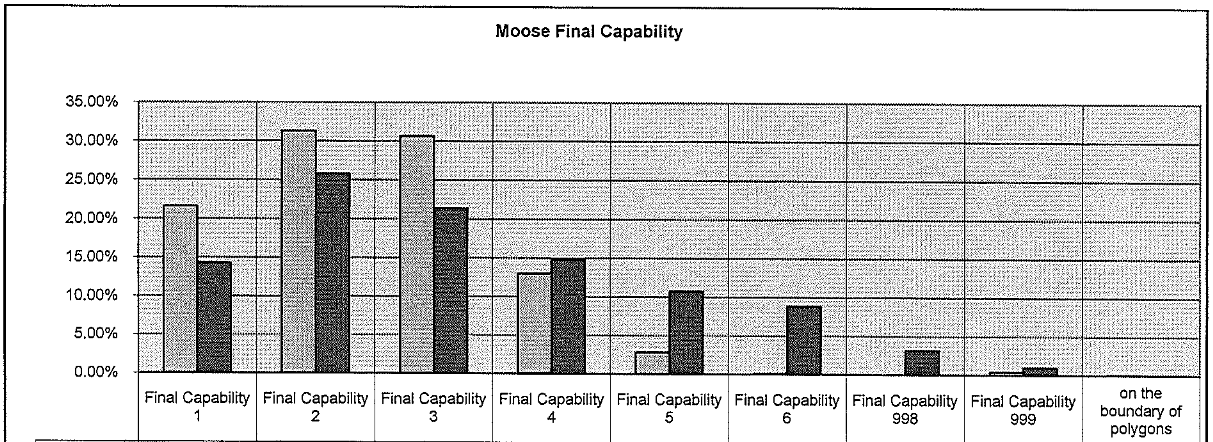
	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	on the boundary of polygons
% of use	52.91%	24.04%	18.73%	3.23%	0.71%	0.37%	0.00%
% of available	7.51%	7.09%	21.60%	11.11%	14.50%	38.19%	0.00%

% of use % of available

Original model – 69% of use in winter habitat classes 1 & 2 (29% of area)

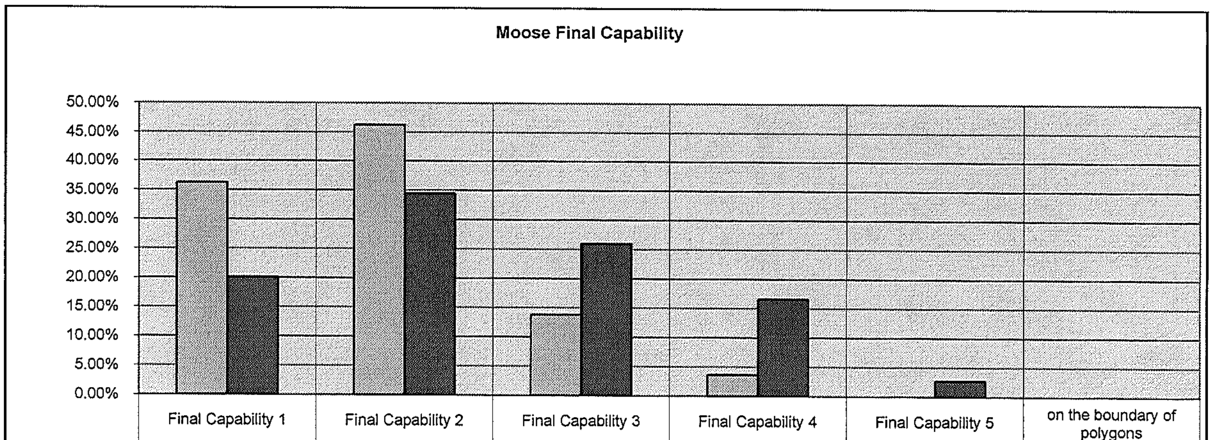
Revised model – 77% of use in winter habitat classes 1 & 2 (15% of area)

Original HCR



	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	Final Capability 6	Final Capability 998	Final Capability 999	on the boundary of polygons
% use	21.65%	31.31%	30.68%	13.00%	2.82%	0.09%	0.00%	0.39%	0.06%
% available	14.35%	25.79%	21.36%	14.77%	10.73%	8.88%	3.14%	1.00%	0.00%

Revised HCR



	Final Capability 1	Final Capability 2	Final Capability 3	Final Capability 4	Final Capability 5	on the boundary of polygons
% use	36.24%	46.26%	13.81%	3.69%	0.00%	0.00%
% available	20.13%	34.53%	25.96%	16.62%	2.75%	0.00%

Original model – 53% of use in winter habitat classes 1 & 2 (40% of area)

Revised model – 82% of use in winter habitat classes 1 & 2 (55% of area)

The biologist believed the new models provided a more accurate assessment of habitat requirements for ungulates in the region. No further GIS analysis where required upon completion of the three models.

Conclusions

- The telemetry data was essential, as it provided real data for assessment and refinement of each model.
- The use of model builder in ArcGIS proved to be extremely useful.
- The most challenging part of the process was bridging the gap between what a GIS could do and communicating that to the biologists who had minimal experience with GIS
- The goal of accurately representing ungulates (stone sheep, elk, and moose) critical winter habitat in the M-KMA, was achieved.

Appendix

Statistical comparison of old and new HCR Sheep

Old HCR - Aspect

Aspect in degrees	% of plan area	% of telemetry points	Model adjustment
Flat	3.3	0.3	0
0-104	34.3	11.5	2
105-134	7.3	3.5	1
135-254	29.2	65.6	0
255-284	9.0	9.0	1
285-360	16.2	8.8	2

New HCR Aspect

Aspect in degrees	% of plan area	% of telemetry points	Model adjustment
Flat	3.3	0.3	2
0-134	41.6	15.0	2
135-150	3.2	3.5	1
151-284	34.6	67.5	0
285-360	12.4	12.4	1

Old HCR Elevation

Biogeoclimatic zone	% of plan area	% of telemetry points	Model adjustment
BWBSmw2 (900-1000 m.)	4.2	0.0	1
SWBmk	49.8	1.6	0

(900-1600 m.)			
SWBmks (1500-1800 m.)	30.6	63.9	0
AT (>1750 m.)	15.4	34.5	0

New HCR Elevation

Elevation in metres	% of plan area	% of telemetry points	Model adjustment
<1500 m.	54.0	5.4	2
1501-1600 m.	10.2	10.2	1
1601-2000 m.	29.6	80.4	0
2001-2100 m.	2.5	3.9	1
>2100 m.	3.7	0.0	2

Adjustments of Stone's Sheep Winter Range Model Assumptions (Jan. 16/08)
Slope and Escape Terrain Considerations.

Step 1 - Size of Escape Terrain

Determine all areas with >70% slope and dissolve all polygons with a size equal to or less than four (25 m. X 25 m.) pixels.

Step 2 - Distance to Escape Terrain

Old HCR = Distance to escape terrain for all areas not within 500 metres of >70% slopes decrease class by 2

Old HCR – Slope

Slope in %	% of plan area	% of telemetry points	Model adjustment
0-45	58.1	20.0	2
46-70	28.4	36.3	2

>70	13.5	43.7	0

New HCR = for all areas not within 200 meters of the resultant polygons of >70% slope adjusts by table:

Slope in %	% of plan area	% of telemetry points	Model adjustment
0-39	51.3	15.1	4
40-59	23.0	22.5	3
>60	25.7	62.4	2

Statistical comparison of old and new HCR Elk

Old HCR - Aspect

Aspect in degrees	% of plan area	% of telemetry points	Model adjustment
Flat	3.3	0.1	0
0-104	34.7	12.1	1
105-134	7.4	10.5	0
135-254	29.2	70.8	-1
255-284	9.0	5.2	0
285-360	16.2	1.3	1

New HCR – Aspect

Aspect in degrees	% of plan area	% of telemetry points	Model adjustment
Flat	3.3	0.1	2
0-59	18.5	2.1	2
60-104	16.3	9.9	1
105-254	36.3	81.2	0
255-284	9.4	5.3	1

285-360	16..2	1.3	2

Old HCR - Elevation

Biogeoclimatic zone	% of plan area	% of telemetry points	Model adjustment
BWBSmw2 (900-1000 m.)	4.2	0.0	0
SWBmk (900-1600 m.)	49.8	22.0	0
SWBmks (1500-1800 m.)	30.6	65.5	1
AT (>1750 m.)	15.4	12.5	2

New HCR - Elevation

Elevation in metres	% of plan area	% of telemetry points	Model adjustment
<1400 m.	42.5	13.0	1
1400-1800 m.	47.3	84.9	0
>1800 m.	10.2	2.1	2

Old HCR - slope

Slope in %	% of plan area	% of telemetry points	Model adjustment
0-45	58.1	47.5	0
46-70	28.4	40.4	1

>70	13.5	12.1	2

New HCR - slope

Slope in %	% of plan area	% of telemetry points	Model adjustment
0-19	24.5	7.3	2
20-29	14.0	12.0	1
30-69	47.0	68.7	0
70-79	8.0	8.7	1
>79	6.5	3.3	2

Statistical comparison of old and new HCR Moose

Old HCR - Aspect

Aspect in degrees	% of plan area	% of telemetry points	Model adjustment
Flat	3.3	5.0	0
0-104	34.7	34.2	1
105-134	7.4	8.6	0
135-254	29.2	21.1	0
255-284	9.0	13.3	0
285-360	16.2	17.8	1

New HCR - Aspect

Aspect in degrees	% of plan area	% of telemetry points	Model adjustment

Flat	3.3	5.0	0
0-104	34.7	34.2	1
105-134	7.4	8.6	0
135-254	29.2	21.1	0
255-284	9.0	13.3	0
285-360	16.2	17.8	1

Old HCR - Elevation

Biogeoclimatic zone	% of plan area	% of telemetry points	Model adjustment
BWBSmw2 (900-1000 m.)	4.2	0.0	0
SWBmk (900-1600 m.)	49.8	46.7	0
SWBmks 1500-1800 m.)	30.6	52.2	1
AT (>1750 m.)	15.4	0.7	2

New HCR - Elevation

Elevation in metres	% of plan area	% of telemetry points	Model adjustment
<1200 m.	18.5	2.0	2
1200-1400	24.0	34.6	0
1401-1500	11.5	12.1	1
1501-1800	29.5	49.1	0

>1800	16.5	2.2	2

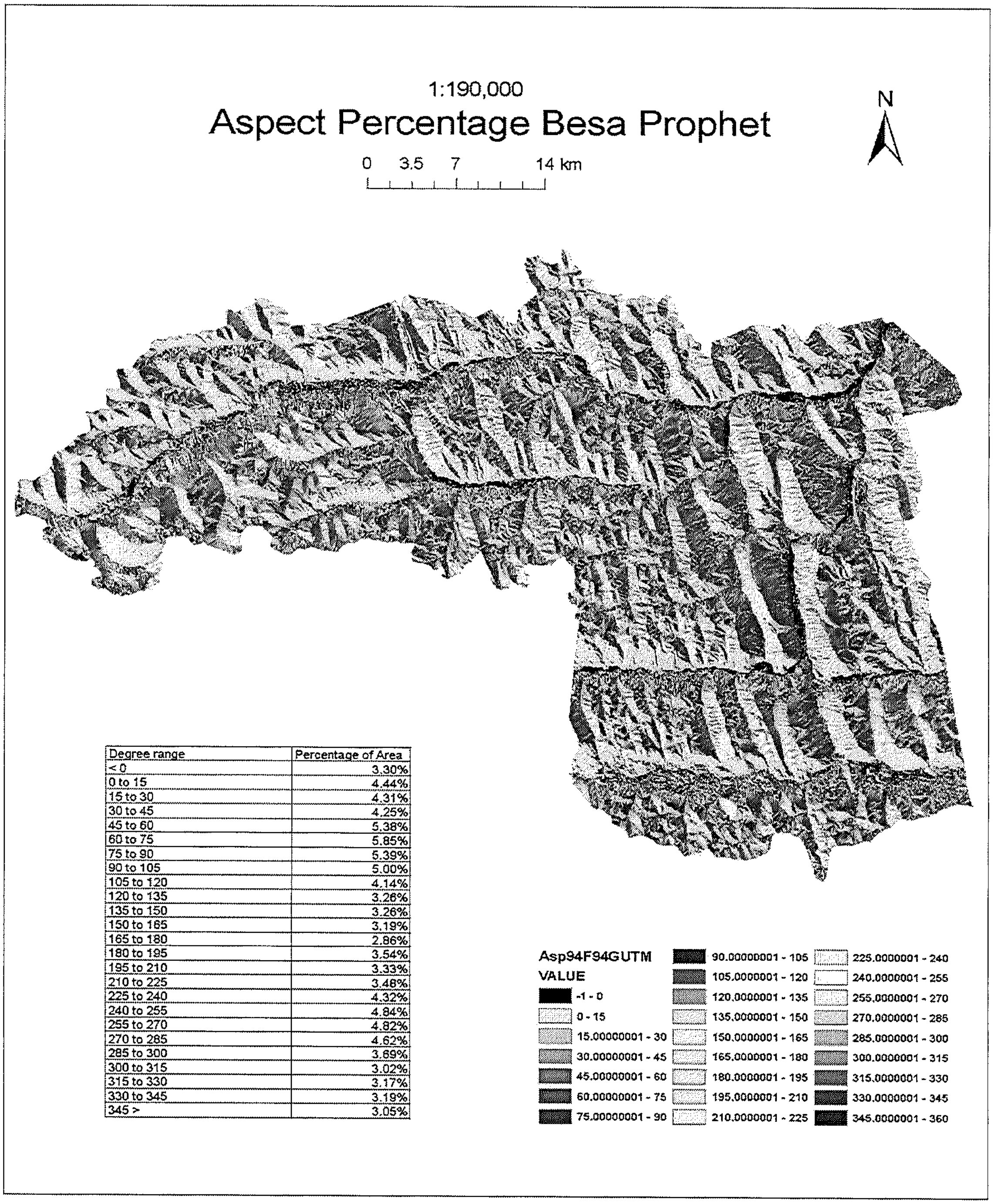
Old HCR - Slope

Slope in %	% of plan area	% of telemetry points	Model adjustment
0-45	58.1	69.3	0
46-70	28.4	24.4	1
>70	13.5	6.3	2

New HCR - Slope

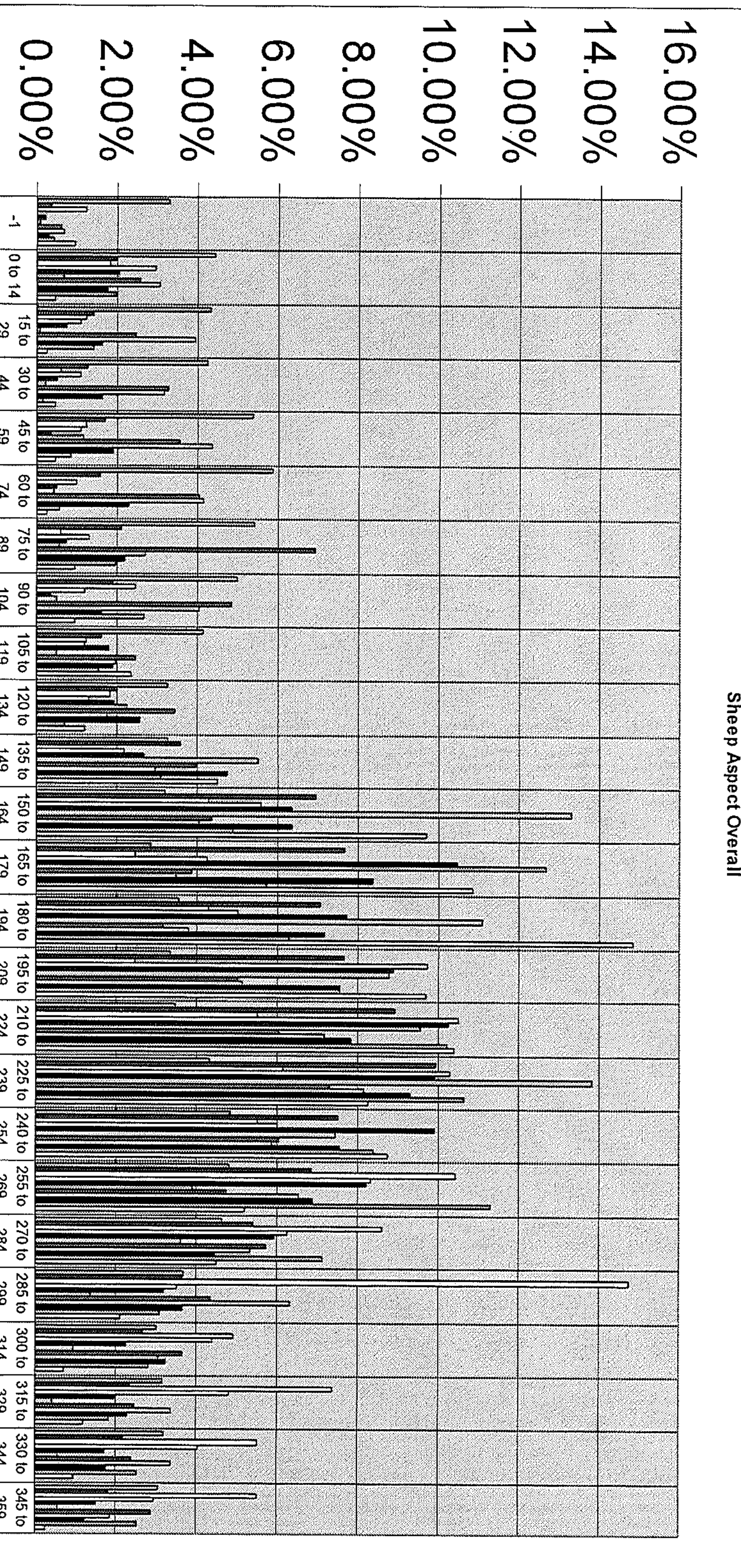
Slope in %	% of plan area	% of telemetry points	Model adjustment
0-60	74.3	86.3	0
>60	25.7	13.7	1

Aspect break down Besa Prophet



Degree range	Percentage of Area
< 0	3.30%
0 to 15	4.44%
15 to 30	4.31%
30 to 45	4.25%
45 to 60	5.38%
60 to 75	5.85%
75 to 90	5.39%
90 to 105	5.00%
105 to 120	4.14%
120 to 135	3.26%
135 to 150	3.26%
150 to 165	3.19%
165 to 180	2.86%
180 to 195	3.54%
195 to 210	3.33%
210 to 225	3.48%
225 to 240	4.32%
240 to 255	4.84%
255 to 270	4.82%
270 to 285	4.62%
285 to 300	3.69%
300 to 315	3.02%
315 to 330	3.17%
330 to 345	3.19%
345 >	3.05%

Overall Comparison of sheep winter use



	-1	0 to 14	15 to 29	30 to 44	45 to 59	60 to 74	75 to 89	90 to 104	105 to 119	120 to 134	135 to 149	150 to 164	165 to 179	180 to 194	195 to 209	210 to 224	225 to 239	240 to 254	255 to 269	270 to 284	285 to 299	300 to 314	315 to 329	330 to 344	345 to 359
% of total Area	3.30%	4.44%	4.31%	4.25%	5.38%	5.85%	5.39%	5.00%	4.14%	3.26%	3.26%	3.19%	2.86%	3.54%	3.33%	3.48%	4.32%	4.84%	4.82%	4.62%	3.69%	3.02%	3.17%	3.19%	3.05%
% of moose points	0.35%	1.96%	1.40%	1.27%	1.69%	1.59%	2.09%	1.91%	1.60%	1.99%	3.59%	6.96%	7.65%	7.07%	7.66%	8.90%	9.94%	7.49%	6.83%	5.40%	3.64%	2.66%	2.35%	2.18%	1.81%
2001-12	1.23%	1.84%	1.23%	0.61%	1.23%	0.00%	0.61%	2.45%	1.23%	1.84%	0.00%	4.29%	2.45%	4.29%	2.45%	5.52%	6.13%	5.52%	10.43%	8.59%	14.72%	4.91%	7.36%	5.52%	5.52%
2002-01	0.00%	2.95%	1.09%	1.09%	1.09%	0.98%	1.31%	1.20%	1.20%	1.31%	2.19%	5.57%	4.26%	5.03%	9.73%	10.49%	10.27%	6.01%	8.31%	6.23%	3.50%	4.37%	4.81%	4.04%	2.95%
2002-02	0.20%	2.05%	0.75%	0.48%	0.34%	0.48%	0.75%	0.34%	1.78%	1.91%	2.66%	6.35%	10.45%	7.72%	8.88%	10.25%	9.90%	9.90%	8.20%	5.94%	3.21%	2.25%	1.98%	1.71%	1.50%
2002-03	0.07%	0.65%	0.07%	0.22%	1.16%	0.43%	0.58%	0.51%	0.51%	2.24%	5.50%	13.31%	12.66%	11.07%	8.76%	9.55%	13.82%	7.45%	3.91%	3.62%	1.37%	0.94%	0.43%	0.58%	0.58%
2002-11	0.59%	2.57%	2.47%	3.26%	3.55%	4.05%	6.91%	4.84%	2.47%	3.46%	3.95%	4.34%	3.85%	3.16%	5.03%	6.02%	7.31%	6.02%	4.74%	5.73%	4.34%	3.65%	2.47%	2.37%	2.86%
2002-12	0.65%	3.04%	3.91%	3.15%	4.35%	4.13%	2.72%	4.02%	1.96%	1.74%	2.93%	4.02%	3.48%	3.80%	5.11%	7.17%	8.15%	5.87%	6.52%	5.33%	6.30%	3.04%	3.37%	3.37%	1.85%
2003-01	0.27%	1.75%	1.62%	1.62%	1.89%	2.29%	2.16%	1.62%	1.89%	2.56%	4.72%	6.34%	8.37%	7.15%	7.56%	7.83%	9.31%	7.56%	6.88%	4.45%	3.64%	3.24%	2.29%	1.75%	1.21%
2003-02	0.42%	1.96%	1.40%	0.14%	0.84%	0.56%	1.96%	2.65%	1.54%	0.70%	3.07%	4.89%	5.73%	6.28%	7.54%	10.20%	10.61%	8.38%	11.31%	7.12%	3.07%	2.79%	1.82%	2.51%	2.51%
2003-03	0.94%	0.47%	0.24%	0.47%	0.47%	0.24%	0.94%	0.94%	2.36%	1.18%	4.48%	9.67%	10.85%	14.86%	9.67%	10.38%	8.25%	8.73%	5.19%	4.48%	2.12%	0.71%	1.18%	0.94%	0.24%

% of total Area ■ % of moose points □ 2001-12 □ 2002-01 ■ 2002-02 □ 2002-03 ■ 2002-11 □ 2002-12 ■ 2003-01 □ 2003-02 □ 2003-03

ArcGIS model builder Stone Sheep