Recreation and Wildlife in SW Alberta
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INTRODUCTION

Monitoring the spatial and temporal patterns of human use in wildland settings is essential to developing adaptive land-use management plans. Interactions between individual recreationists and user groups as well as between people and environment are complex and multi-faceted. Researchers and managers would benefit from non-invasive methods that provide unbiased, accurate and timely data to provide quantitative information on visitor use patterns and the response of the environment.

Human use of linear features results in direct and indirect effects to wildlife. The nature and significance of the effects are a function of the type, timing, intensity, predictability and spatial distribution of the activities. In addition, the responses are highly variable across wildlife species and it is difficult to identify statistically significant causal relationships due to confounding variables. Increasing human use, especially motorized off highway vehicle (OHV) use, can result in loss of habitat connectivity at local and regional scales, habitat fragmentation and habitat alienation [1], [2], [3], [4], [5], resulting in reduced population viability, increased edge effects and loss of genetic variability [1], [6], [7], [8], [9]. These factors can also result in negative effects on wildlife movement patterns and could make important habitat patches and their associated uses such as breeding, denning, feeding and rearing grounds, inaccessible [4], [5], [10], [11]. Disturbance by human use may also alter the availability of prey for the large and meso-carnivores that inhabit the region.

In 2003, the Miistakis Institute undertook a multi-year research project to examine the relationship between human recreation use and wildlife, through the use of remote cameras (mounted on trees and automatically take pictures of any person or animal using the trail). This report provides an overview of the project objectives, methodology and results. On-going analysis will compliment this report that focus on the statistical relationships between wildlife and recreational activity.

Objectives of the study included the following:
- Determine wildlife use and human recreation use in the study area using remote cameras and counters,
- Quantify the spatial and temporal relationships between recreation use and wildlife use,
- Communicate with relevant land managers, recreational and community groups to ensure that the information contributes to regional decision-making.

STUDY AREA

The Livingstone Range is located in the Crown of the Continent, an international ecosystem spanning the shared Rocky Mountain region of British Columbia, Alberta and Montana. The 1200km² area provides a critical linkage between the protected area complexes of Waterton-Glacier and Kananaskis-Banff. The study area encompasses four natural sub-regions defined primarily by elevation including the foothills parkland, montane, subalpine and alpine regions. The diversity of habitats results in high native biodiversity and the original floral and faunal assemblage remains largely intact.
Landscape disturbance associated with recreational and industrial trail use in the Livingstone Range is significant and continues to intensify with regional population growth. The area is entirely comprised of public land and supports a variety of industrial activities including petroleum exploration and development, forestry, and mining which have resulted in a proliferation of access roads and trails. In addition, the landscape provides a wide range of opportunities for “unmanaged” recreational activities such as OHV use, equestrian use, fishing, hunting, camping and hiking. Much of this activity is concentrated along critical riparian zones and in sensitive montane, subalpine and alpine environments. In recent years, OHV recreational use has been increasing significantly in the province of Alberta with sales of off-highway recreational vehicles increasing over 120% in the past 7 years.

Map 1: Study Area
METHODS - REMOTE CAMERAS
The use of digital infrared cameras is becoming a common technique for examining the spatial and temporal responses of wildlife to recreational disturbances [12], [13], [14]. Remote sensing cameras provide effective, accurate, appropriate and non-biased data [14], [15], [16], [17]. In order to examine the spatial and temporal relationships between wildlife and human activity we developed a sampling method that employs remote cameras on known human trails and wildlife trails.

Cameras were deployed from the middle of May to September in each of 2004, 2005, 2006 and 2007. The study area was stratified into 8 sampling units to ensure representational coverage. Within each of the 8 sampling areas, a series of random locations was generated from a spatial algorithm within a GIS. Each randomly generated sample focal area consisted of a camera on each human (OHV) trail and 2 cameras on adjacent wildlife trails (see Figure 1). Human use trails were defined as a trail that could be accessed by off-highway vehicles (motorbike, ATV or truck) and showed evidence of recent off-highway vehicle use. Wildlife use trails were defined as a trail that showed evidence (scat, tracks, visual sighting) that wildlife used the trail. From each randomly generated point, a perpendicular line was drawn on a map to the nearest human trail. At this point a digital infrared camera was attached to a suitable tree to photograph all people and wildlife passing the point (day and night). A 500m transect perpendicular to the direction of the human trail was established from each of these camera points. Along this transect a wildlife trail was identified within 0-250m and another within 250-500m. Remote cameras were placed on each of these identified wildlife trails. Sites were sampled for 2 weeks and then the cameras were moved to a new location using the same process described above.

In addition, 3 control sample sites were established using the same sampling design as the regular sample sites. The control sites were established in areas with similar conditions to the regular sites, but with no motorized recreation use and in some cases no human use at all.
The technology available for remote cameras has changed dramatically over the past decade. Infrared sensors have long been used for counting human and wildlife use on trails and sometimes these were coupled with cameras. However, this technology was often cumbersome, difficult to power and unreliable. The development of more effective units was largely driven by the hunting industry and today there are dozens of commercially available remote cameras that are suitable for use in monitoring human recreation and wildlife. We tested three types of remote sensing cameras over the four seasons of field research. The three types included GameVue, Deercams (www.deercam.com) and Reconyx (www.reconyx.com). All three types require a combination of both movement and a change in heat for the sensor to be triggered and an image to be captured. Both the GameVue and Reconyx cameras are digital cameras with infrared flashes that allow them to capture images at night with only minor visual disturbance. The Deercam camera employs a standard 35mm ‘point-and-shoot’ camera attached to sensors with a conventional flash that allows for nighttime images at the expense of an obvious visual disturbance. All of the units are encased in rugged, weather-proof housings and can easily be attached to trees or posts.
The GameVue cameras had built-in digital memory with a capacity of 60 images. The Reconyx cameras use a compact flash cards and are capable of holding up to 5000 images on a 256 Mb card. The Deercam cameras run standard 400 ISO 24 or 36 exposure 35mm film.

DeerCam cameras were used on wildlife trails only and were used on 28% of the total sample sites. GameVu cameras were used on human use trails only and were used on 8% of the sample sites. Reconyx cameras were used on both human use trails and wildlife trails and were used at 64% of the sample sites. The following describes when each type of camera was deployed. For the purposes of analysis all data collected by the three different type of cameras was analyzed together.

<table>
<thead>
<tr>
<th>Camera Type</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeerCam</td>
<td>113</td>
<td>197</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GameVu</td>
<td>59</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reconyx</td>
<td>0</td>
<td>76</td>
<td>336</td>
<td>282</td>
</tr>
<tr>
<td>TOTAL</td>
<td>172</td>
<td>297</td>
<td>336</td>
<td>282</td>
</tr>
</tbody>
</table>

The replacement of GameVue and Deercam cameras with Reconyx cameras reflects the greater reliability, image quality and battery life of the Reconyx cameras.

During each two-week sampling period cameras were checked to ensure they were operating correctly. GameVue and Deercam cameras were checked every 4-5 days or two times during each two-week period. Reconyx cameras were able to run the entire 2-week period without being checked. Cameras were attached to suitable trees with a minimum 6-inch diameter (to prevent false image triggers due to wind shaking the tree). Cameras were mounted at approximately chest height and were tilted slightly down, at a 45-degree angle to the trail, to maximize the amount of time a subject could be detected. Cameras were set to take a picture every three seconds if the sensor was triggered. Date, time and temperature were recorded on each image.

All images were reviewed with the following information collected from each:
- Observer
- Date/Time of Recording
- Sample Site
- Date
- Time
- Event – all images were classified as either a human event or a wildlife event
- Species
- Gender of Wildlife Species - if possible
- Adult with Young
- Age of Wildlife Species
- Number of individuals
- Direction of travel
- Activity of Wildlife Species
- Animal Aware of Camera
- On/Off Trail
Only ‘unique events’ were included in all subsequent analysis. A unique event included the following consideration:

- If a human or wildlife was captured in a series of frames continuously, without a break, this was considered one unique event.
- If a human or wildlife entered and exited a frame a series of times and it could be determined it was the same individual and it was not longer than five minutes, then this was considered a unique event. If the entering and exiting of the frame continued past five minutes then it was entered again as a new unique event.
- If a human or wildlife appeared in a frame, then left a frame for more than five minutes and reappeared, this was entered as two unique events.
- Wildlife and human events were entered for the largest number of subjects in a single image of the group.

For some of the subsequent analyses relative use activity indices are used. This standardization was calculated by taking the number of images (of wildlife or humans) divided by the number of hours the camera was functioning for each of the sample sites.

**METHODS - HUMAN USE**

Human use levels were mapped along the road and trail network (see Wildlife Relative Use Section) by associating the "Motorized" index values at "OHV" sample points with the nearest mapped segment of the road and trail network. If more than one sample point was associated with a given segment of the network, the index values were averaged. Mapped levels of use include "No Observed Use" (sample points where "Motorized" = 0), "Low Use" ("Motorized" values between 0.001 & 0.024), "Medium Use" ("Motorized" values between 0.025 & 0.085), and "High Use" ("Motorized" values between 0.086 & 1.77). Excluding points with no observed use, breakpoints between high, medium and low use were determined by dividing the data into three quantiles. Segments of the network that were not sampled are also mapped, including major collector roads in the Livingstone area.

Wildlife Use was mapped for each species (see Wildlife Relative Use Section) and aggregate of species at actual sampling locations, and was classified into four categories: "Zero Observations"; "Low Use"; "Medium Use"; and "High Use". Breakpoints between high, medium, and low use were determined by excluding "Zero Observations" points and employing the "Natural Breaks" classification method in ESRI ArcMap; "Natural" breaks is a statistical classification method that groups data so as to minimize the difference within groups and maximize the difference between groups.
RESULTS

Four field seasons have resulted in 1087, 14 day sampling periods including over 424,000 hours of camera operation (see Figure 2 for location of all sampling sites). Cameras were deployed an average of 380 hours per sample site yielding 17,045 images of motorized human use and large mammals.

Figure 2 – Location of sampling sites May 2004 – Sept 2007.
Results include 6572 unique wildlife events, including 484 large carnivore detections. Over 10,000 unique human events were documented.

<table>
<thead>
<tr>
<th></th>
<th>Sampling Periods</th>
<th>Human Events</th>
<th>Wildlife Events</th>
<th>Sampling Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>172</td>
<td>950</td>
<td>596</td>
<td>51539</td>
</tr>
<tr>
<td>2005</td>
<td>297</td>
<td>3207</td>
<td>1405</td>
<td>102272</td>
</tr>
<tr>
<td>2006</td>
<td>336</td>
<td>3802</td>
<td>2455</td>
<td>143402</td>
</tr>
<tr>
<td>2007</td>
<td>282</td>
<td>2514</td>
<td>2116</td>
<td>127584</td>
</tr>
<tr>
<td>TOTALS</td>
<td>1087</td>
<td>10473</td>
<td>6572</td>
<td>424797</td>
</tr>
</tbody>
</table>

Wildlife events include carnivores and ungulates and only large mammals were included (many small species including squirrel, hare etc. were documented but are not included as part of the results). Large mammals include grizzly bear, black bear, cougar, wolf, bobcat, badger, lynx, wolverine, coyote, moose, elk, mule deer, white-tailed deer and big horn sheep. Mule-deer and undetermined deer species were the most frequently detected large mammal (50.2%), followed by elk (13.3%), coyote (12.1%), moose (8.7%), and white-tailed deer (7.5%). Of the large carnivore detections, grizzly bear were most common (35.3%) followed by black bear (18.6%), undetermined bear (14.0%), wolf (10.3%), lynx (9.3%), cougar (6.8%) and bobcat (5.4%).

Figure 3: Total number of unique events for each ungulate species. Deer sp. And ungulate sp. refers to images that were unidentifiable by species.
Figure 4: Total number of unique events for all carnivore species.

Figure 5: Breakdown of human use at all sample sites

Cameras detected 10,473 human events on recreational trails with 9083 (86.7%) of these events included motorized use followed by hikers 764 (7.3%), equestrian use 474 (4.5%) and cyclists 149 (1.5%). There were also 2472 visits by researchers to camera stations. These events were not included in the total number of human events.
Table 1: Summary statistics for all species for n=1067 sample sites.

<table>
<thead>
<tr>
<th>Species (all large mammals)</th>
<th>Total Unique occurrences</th>
<th>Percent of all unique large mammal events</th>
<th>Percent of all unique human events</th>
<th>Mean per Site (unique occurrences/number of sample sites)</th>
<th>Mean occurrences per sites</th>
<th>Max number of occurrences per site</th>
<th>Min number of occurrences per site</th>
<th>Number of observed sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coyote</td>
<td>716</td>
<td>12.52</td>
<td>0.690</td>
<td>2.63</td>
<td>33</td>
<td>0</td>
<td>257</td>
<td></td>
</tr>
<tr>
<td>Gray Wolf</td>
<td>38</td>
<td>0.66</td>
<td>0.037</td>
<td>1.46</td>
<td>4</td>
<td>0</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Black Bear</td>
<td>75</td>
<td>1.31</td>
<td>0.072</td>
<td>1.27</td>
<td>3</td>
<td>0</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Grizzly Bear</td>
<td>163</td>
<td>2.85</td>
<td>0.157</td>
<td>1.46</td>
<td>6</td>
<td>0</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Bear Sp.</td>
<td>56</td>
<td>0.98</td>
<td>0.054</td>
<td>1.27</td>
<td>4</td>
<td>0</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Cougar</td>
<td>21</td>
<td>0.37</td>
<td>0.020</td>
<td>1.05</td>
<td>2</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Canada Lynx</td>
<td>41</td>
<td>0.72</td>
<td>0.039</td>
<td>1.46</td>
<td>9</td>
<td>0</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Bobcat</td>
<td>20</td>
<td>0.35</td>
<td>0.019</td>
<td>1.11</td>
<td>3</td>
<td>0</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Elk</td>
<td>759</td>
<td>13.27</td>
<td>0.731</td>
<td>2.45</td>
<td>18</td>
<td>0</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td>Moose</td>
<td>507</td>
<td>8.86</td>
<td>0.488</td>
<td>1.93</td>
<td>10</td>
<td>0</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>Mule Deer</td>
<td>1804</td>
<td>31.54</td>
<td>1.738</td>
<td>3.22</td>
<td>22</td>
<td>0</td>
<td>560</td>
<td></td>
</tr>
<tr>
<td>White-tailed Deer</td>
<td>350</td>
<td>6.12</td>
<td>0.337</td>
<td>1.99</td>
<td>17</td>
<td>0</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>Deer Sp.</td>
<td>1137</td>
<td>19.88</td>
<td>1.095</td>
<td>2.44</td>
<td>25</td>
<td>0</td>
<td>466</td>
<td></td>
</tr>
<tr>
<td>Ungulate Sp.</td>
<td>23</td>
<td>0.4</td>
<td>0.022</td>
<td>1.28</td>
<td>3</td>
<td>0</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>10</td>
<td>0.17</td>
<td>0.010</td>
<td>1.43</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Hiker</td>
<td>541</td>
<td>5.34</td>
<td>0.521</td>
<td>3.49</td>
<td>45</td>
<td>0</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>Cyclist</td>
<td>118</td>
<td>1.16</td>
<td>0.114</td>
<td>3.37</td>
<td>29</td>
<td>0</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Hunter</td>
<td>3</td>
<td>0.03</td>
<td>0.003</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ATV/Quad</td>
<td>4854</td>
<td>47.92</td>
<td>4.676</td>
<td>17.52</td>
<td>128</td>
<td>0</td>
<td>277</td>
<td></td>
</tr>
<tr>
<td>Motorbike</td>
<td>1404</td>
<td>13.86</td>
<td>1.353</td>
<td>7.59</td>
<td>56</td>
<td>0</td>
<td>185</td>
<td></td>
</tr>
<tr>
<td>Truck - Commercial</td>
<td>392</td>
<td>3.87</td>
<td>0.378</td>
<td>24.5</td>
<td>164</td>
<td>0</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Truck - Other</td>
<td>2403</td>
<td>23.72</td>
<td>2.315</td>
<td>16.57</td>
<td>516</td>
<td>0</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>Horse and Rider</td>
<td>414</td>
<td>4.09</td>
<td>0.399</td>
<td>3.98</td>
<td>21</td>
<td>0</td>
<td>104</td>
<td></td>
</tr>
</tbody>
</table>

The maximum large mammal event at one sample site was 33, the minimum 0. The maximum large carnivore event at one sample site was 9, the minimum 0. The maximum human use occurrence at a sample site was 516 (truck). Grizzly bears were detected the most at sample sites with grizzly bears being detected at 10% percent of the sample sites, followed by black bears at 5.5% of sample sites, 4.1% for bear sp, 2.6% for lynx, 2.4% for wolf, 1.9% for cougar and 1.7% for bobcat. Mule deer were detected at the highest percentage of sample site ((52.4%), followed by deer sp (43.7%), elk ((29.1%), moose (24.6%), and white-tailed deer (16.5%), ungulate sp. (1.7%) and big horn sheep (0.6%).
Figure 6: Temporal pattern of use for human use motorized activity, large mammals combined and large carnivores combined.

Figure 7: Daily pattern of use for human use motorized activity, large mammals combined and large carnivores combined.
Human motorized use on recreation trails peaked between the hours of 1100 and 1700 while both large mammals combined and carnivore activity peaked on recreation and wildlife trails between 0500 and 0900 and also between 1900 and 2300 with the least amount of activity between 1100 and 1800. Human motorized activity was greatest on recreation trails on Saturdays and Sundays while there was no difference between the daily use of recreation and wildlife trails for all large mammals and large carnivores.

The following scatter plots demonstrate the relationship between motorized relative activity indices and wildlife. All plots demonstrate an inverse relationship between relative motorized activity and wildlife use.

Figure 8: The relationship between motorized human use and moose (n=1067).
Figure 9: The relationship between motorized human use and elk (n=1067).

Figure 10: The relationship between motorized human use and deer (n=1067).
Figure 11: The relationship between motorized human use and lynx (n=1067).

Figure 12: The relationship between motorized human use and grizzly bear (n=1067).
Figure 13: The relationship between motorized human use and bobcat (n=1067).

Figure 14: The relationship between motorized human use and wolf (n=1067).
Figure 15: The relationship between motorized human use and cougar (n=1067).

Figure 16: The relationship between motorized human use and black bear (n=1067).
WILDLIFE RELATIVE USE

GRIZZLY BEAR

Grizzly Bear were detected 163 times at 112 different sampling sites from 2004 to 2007. The following maps (the study area has been divided into 3 regions for ease of visually displaying results) depict relative use (high, medium and low) based on relative use indices. Each map also depicts relative human use.
Black Bear were detected 75 times at 59 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Cougar were detected 21 times at 20 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Bobcat were detected 20 times at 18 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Lynx were detected 41 times at 28 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Wolf were detected 38 times at 26 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Elk were detected 759 times at 310 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Moose were detected 507 times at 263 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
Deer (including white-tailed deer, mule deer and deer sp.) were detected 3291 times at X1202 different sampling sites from 2004 to 2007. The following maps depict relative use (high, medium and low) based on relative use indices.
LESSON LEARNED

The use of remote cameras for monitoring the flows of people and wildlife has proven to be very effective in our context. The camera technology has improved significantly since we initiated our research in 2004. In particular, the advancement of infrared illumination, digital image capture and memory capacity have all resulted in substantial improvement to commercially available cameras. In addition, the newer units draw a relatively small amount of power and can be operated for a month or more on a single set of batteries. The Reconyx cameras performed very well in our field conditions and we recommend their use. However, there are many suitable units now available commercially.

The selection of cameras depends on the type of data required, but some considerations for model selection include: size of infrared illuminator, field of detection, size and flexibility of digital memory, image quality/resolution, speed of camera to detect a target and acquire an image, and quality of the camera housing. The newest models now include an option for colour images during daylight and black-and-white during dark. Although we did not test any, there are now units available to capture digital video. Remote cameras have emerged as a highly effective means of non-invasive monitoring.

Although the use of cameras does not result in a significant direct disturbance to wildlife or visitors, their deployment raises ethical issues and has the potential affects the quality of visitor experience. Visitors need to be informed that their activities may be monitored by camera. In addition, the anonymity of visitors should be protected and identifiable images of users should be managed carefully. We recommend the development of strict policies for the use and storage of images that is clearly communicated to users. Cameras may capture illegal human behaviour and researchers/managers need to make a priori decisions about how such data will be used. Vandalism and theft of cameras may be an issue in remote settings. Communication with visitors about how and why the cameras are being used is essential to managing loss and damage.

The use of remote cameras for monitoring has the potential to result in a huge volume of data. Depending on the levels of use and the sensitivity of the cameras (e.g., false triggers caused by vegetation movement in wind), each unit may capture thousands of images per week. The process of downloading, viewing, classifying, storing and managing images is currently tedious and labour intensive. Effective use of cameras in a monitoring program requires an adequate budget to perform these tasks and analyze the data. The potential for automated classification of images using change detection software and artificial intelligence is in its infancy, but has the potential to greatly improve the efficiency of managing camera data. The authors are currently exploring automated methods to help in the process of image classification.

The use of remote cameras requires carefully methodological consideration to the spatial and temporal distribution of sampling. Quantitative comparison of results between areas or between different time periods requires the acquisition of viable sample sizes over adequate periods of time. We recommend that researchers work closely with statisticians to ensure that the sampling design is providing the type of data that is needed.
REFERENCES


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