THE IMPACT OF HUMAN ACTIVITIES ON HABITAT EFFECTIVENESS FOR GRIZZLY BEARS IN JASPER NATIONAL PARK

by

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ABSTRACT

Grizzly bear (*Ursus arctos horribilis*) populations are subject to increasing human encroachment into their habitats. Data were gathered on levels of human activity over seven months (April - October 1997) to link with data on habitat suitability for grizzly bears in the Maligne Valley of Jasper National Park, Alberta, Canada. We used electronic trail counters, direct counting by observers, and self-counting methods to quantify and compare human use in linear (e.g. trails), point (e.g. campgrounds), and dispersed (e.g. water bodies) landscape features. The data were then combined with habitat data in a Geographic Information System to determine habitat effectiveness to support bears (the capability of an area to support bears, as influenced by human activities, in relation to the area's inherent ability without human use) and the availability of security areas (useable bear habitat that is >9 km^2 and >500 m from human activity). To minimize the dilution of the effects of human activities on grizzly bear habitat due to large area size, we divided the Maligne Valley into three bear management units.

Weekly averages of the amount of human use rose markedly during the first week of July and declined after the first weekend of September. Increasing recreational activity in habitats with high or very high value for grizzly bears resulted in a decrease in the habitat effectiveness values. The three bear management units in July and August and one bear management unit in September did not meet Parks Canada's threshold for protected areas of having >80% habitat effectiveness levels. One bear management unit in August failed to meet the recommended >60% threshold value for secure / usable. The use of the grizzly bear habitat effectiveness model and security area analysis offers a predictive tool for more detailed planning of current and proposed developments in areas containing bear habitat.

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INTRODUCTION

Parks Canada's *Guiding Principles and Operational Policies* (1994) mandates that national park ecosystems be given the maximum degree of protection to ensure the perpetuation of natural environments essentially unaltered by human activity, and that Parks Canada establish goals and strategies to ensure the protection of ecosystems in and around national parks. As human use levels rise, park research is becoming increasingly focused on the interactions of human influences on the ecosystem. Jasper National Park now receives approximately three million visitors per year (Wright et al. 1995), many of whom are drawn up the Maligne Valley to the scenic attractions of Maligne Canyon and Medicine and Maligne Lakes. Current visitation estimates indicate a 50% increase in people coming to the park since the *Jasper National Park Management Plan* was written in 1988 (Environment Canada 1988).

With this increase in visitation, park managers are looking for more refined approaches to ensure the maintenance of the park's ecological integrity within their management plans (Parks Canada 1994). Ecosystem management initiatives (Nepstad and Nilsen 1993) and the Carnivore Conservation Strategy (Hummel and Pettigrew 1992, Paquet and Hackman 1995) have been the catalysts for addressing landscape ecology issues and concerns. One area of critical importance is the influence of human activities on natural systems and the wildlife within them (Page et al. 1996).

In Canada's four contiguous mountain national parks (Banff, Kootenay, Yoho and Jasper) the grizzly bear (*Ursus arctos horribilis*) is regarded as an umbrella species. Due to its large spatial requirements, maintenance of secure habitat for grizzly bears and other large carnivores in turn secures a high diversity of habitats for other wildlife species using the same area (Page et al. 1996). One tool currently employed to assess and manage grizzly bear habitat inside and outside of national parks is the grizzly bear habitat effectiveness model (Weaver et al. 1985, Weaver et al. 1987, USDA 1990, Gibeau et al. 1996).

The grizzly bear habitat effectiveness model combines measurements of both habitat quality and human disturbance to quantify the ability of an area to support a viable population of grizzly bears (Weaver et. al. 1985). This model is a key component in the development of the grizzly bear cumulative effects assessment (CEA), which was first designed by Christensen and Madel (1982) for the Kootenai National Forest in Montana and later refined for current use in Jasper National Park (Weaver et. al. 1985, USDA 1990, Gibeau et al. 1996, Purves and Doering 1998). Cumulative effects assessment is based on the concept that "cumulative effects occur when perturbations are so crowded collectively in space and time that the ability of the animal(s) to acquire needed resources is significantly impaired. Effects may be assessed at both the individual (micro) and population (macro) levels. Ultimately, these effects accumulate through the integrative dimensions of space and time to change the habitat capability of an area" (Weaver et al. 1987). The inherent habitat value of an area is termed "potential habitat", while the habitat as influenced by human activities is defined as "realized habitat" (Gibeau et al. 1996). Three components exist within the framework of cumulative effects assessment: a habitat component, a displacement component and a mortality component. The habitat and displacement values are incorporated in a model to determine a habitat effectiveness value for an area. The mortality component provides a quantitative assessment of the risk of grizzly bear mortality due to human activity (USDA 1990).

The habitat effectiveness model can be used as a predictive tool using Geographic Information Systems (GIS) to provide an initial quantitative and qualitative assessment of the effects of current human use and proposed developments on grizzly bears. Habitat values for the grizzly bear habitat effectiveness model (i.e., habitat suitability index (HSI) values) were developed for Jasper, Banff, Kootenay, and Yoho National Parks by Kansas and Riddell (1995), who rated ecological land classification polygons on a spatial and temporal basis. Displacement values were based on measures and types of human activity and were used to reduce "potential habitat" to "realized habitat". Habitat effectiveness, as the ratio of realized to potential habitat, ranges from 0-1. A value of zero would indicate that the habitat is effectively unavailable to bears because of the high level of human activity; a value of one would indicate that 100% of the habitat is available (with no human use) to bears. A threshold habitat effectiveness value commonly used in protected areas is >0.8 (80%), which implies that the area, encompassing habitats ranging from no human use to very high levels of human use, should average >80% habitat effectiveness (USDA 1990, Gibeau 1997). If the goal is to maintain areas, at the threshold level, a value of <80% would indicate that management actions should be implemented to regulate human use.

In addition to using the measurement of habitat effectiveness to assess the value of natural landscapes as grizzly bear habitat relative to human disturbance, security area analysis identifies areas that are usable at the scale of the individual foraging radius of an adult female grizzly (Mattson 1993). Security area analysis incorporates habitat quality, minimum area sizes, spacing and connectivity between female home ranges (Gibeau et al. 1996) to define habitat security that would foster wary behaviour in bears (Mattson 1993). Both measurements assess the effects of landscape fragmentation on grizzly bear habitat (Page et al. 1996).

Consequently, a reliable human use data layer is an essential component in all aspects of habitat effectiveness mapping. The overall objectives of this study were to quantify human use within the Maligne Valley of Jasper National Park and to determine the habitat effectiveness in the valley. Specifically we (1) compared levels of use between linear (e.g., trails), point (e.g. campgrounds), and dispersed (e.g., water bodies) landscape feature; (2) tested the reliability of estimated use (expert source data) relative to measured use (empirical data) for habitat effectiveness modeling; and (3) examined predictive relationships between campground data, which are consistently gathered by Parks Canada, and trail use data, which were specifically gathered for the habitat modeling component of this study. The effects of weather (maximum temperature and precipitation) and day of the week (weekends or weekday) were also examined. Finally, we assessed the seasonal changes in habitat effectiveness and security areas for grizzly bears in the Maligne Valley as affected by changes in potential habitat and human use.

STUDY AREA

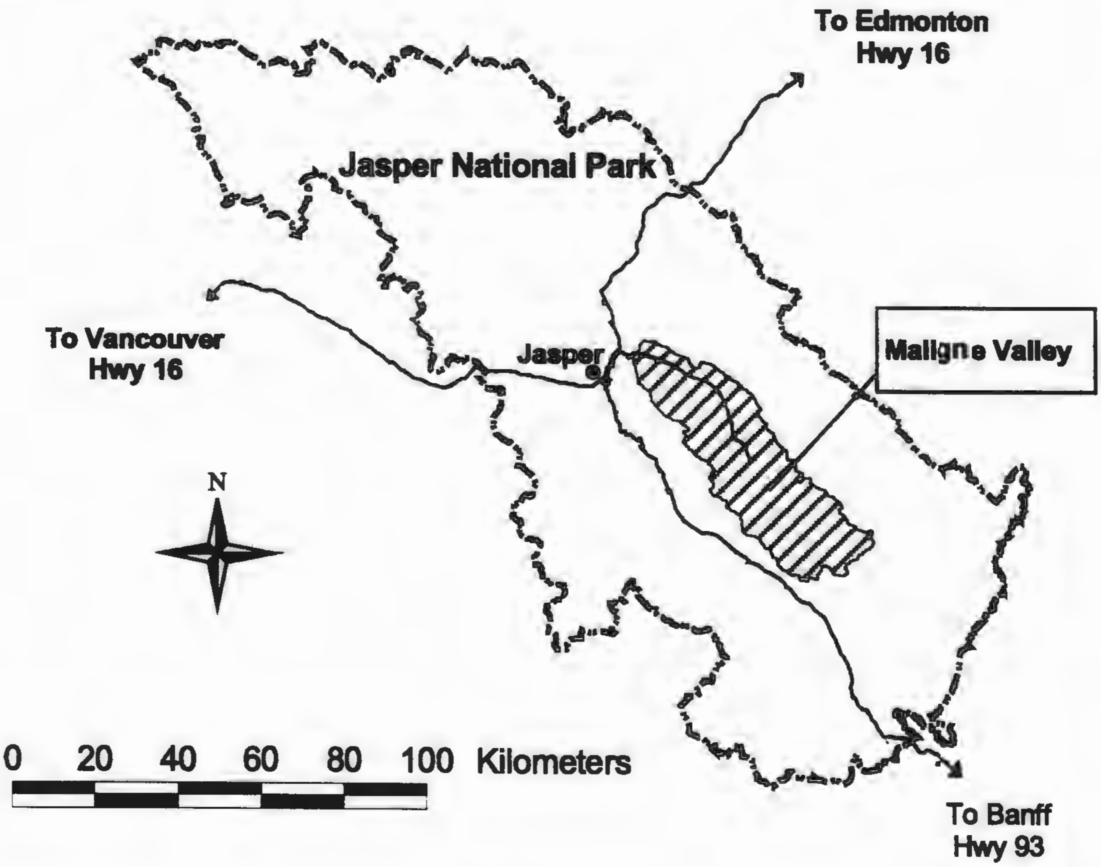
Jasper National Park is the largest (10,878 km^2) and most northerly of the four contiguous Canadian Rocky Mountain national parks (Jasper, Banff, Kootenay and Yoho), which were designated as a UNESCO world heritage site in 1984 (Environment Canada 1988). It lies within the eastern part of the Canadian Cordillera, with the Main Ranges of the Canadian Rockies to the west and the Front Ranges to the east.

Jasper National Park comprises three ecoregions: the montane, the subalpine and the alpine. The montane ecoregion ranges from 1000 m elevation to approximately 1350 m with Douglas fir (*Pseudotsuga menziesii*), white spruce (*Picea glauca*), and aspen poplar (*Populus tremuloides*) as the dominant vegetation. The subalpine ecoregion extends from the upper montane to treeline (approximately at 1900 m elevation). Predominant subalpine vegetation is Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and lodgepole pine (*Pinus contorta*). The alpine ecoregion occurs above the subalpine ecoregion and is dominated by yellow heather (*Phyllodoce glanduliflora*) and white mountain heather (*Cassiope mertensiana*) (Holland and Coen 1983). The park contains several major icefields and their associated river systems, including those of the Maligne River Watershed.

The Maligne Valley is situated in the east central section of the park. The valley is bisected by the Maligne River and is bounded to the west by the Maligne Range and to the east by the Queen Elizabeth Range (Fig. 1). The latter is generally steep and rocky with little

Fig. 1. Study area in the Maligne Valley of Jasper National Park, Alberta, Canada. Solid lines represent roads.


0
1000
2000
km
C A N A D A
ALBERTA
JASPER NATIONAL PARK


To Edmonton
Hwy 16
Jasper National Park
To Vancouver
Hwy 16
Jasper
Maligne Valley
N
0 20 40 60 80 100 Kilometers
To Banff
Hwy 93

vegetation. Mid-slopes of the Maligne Range are characterized by open lodgepole pine-spruce and Engelmann spruce-subalpine fir stands, whereas numerous subalpine and alpine meadows dominate the higher elevations (Holroyd and Van Tighem 1983). Two large lakes are part of the Maligne system - Maligne Lake in the southern section of the valley and Medicine Lake further north. The two lakes differ dramatically since Medicine Lake's water levels fluctuate extensively during the year, while Maligne Lake remains relatively stable. Medicine Lake is part of the karst system found in much of the middle and lower Maligne Valley. The Maligne River flows north through subalpine habitat from Maligne Pass and Maligne Lake, through Medicine Lake, and into the Athabasca River in montane habitat.

The Maligne Valley is accessed by an all-season, paved road, which begins in the montane ecoregion near the confluence of the Maligne and Athabasca rivers. It ascends into the subalpine ecoregion and continues 44 kilometers south to its terminus at Maligne Lake. Overnight accommodation available in the valley beyond the Maligne Youth Hostel includes the Maligne Lake Warden Station, Beaver Warden Cabin and 14 backcountry campsites.

The study area commenced immediately upstream of the Maligne Youth Hostel (UTM MJ 332 636) and continued up the Maligne Valley between the height of land of the Maligne and Queen Elizabeth Ranges to the southern extent of the Maligne River Watershed. It encompasses 891 km^2 or 8.2% of Jasper National Park. This area has relatively homogeneous habitats and types of human activity, which were monitored in relation to landscape features. The areas below the Maligne Youth Hostel were excluded from the study due to the marked difference in the levels, types and seasonality of human activities in this lower section, and the dramatic shift from subalpine to predominantly montane habitat type.

METHODS

Acquisition of Data on Human Activity

Human activities were categorized as linear, point or dispersed in nature, and then as either high or low use. Linear features (n = 43) included trails, some of which were divided into several linear feature segments, the Maligne Lake Road and the motorized boat routes on Maligne Lake. Point features included 14 backcountry campgrounds, 3 cabins, and 6 picnic sites; and dispersed features included Maligne, Medicine and Beaver Lakes, the Maligne River, 3 gravel pits, 1 backcountry ski area, the Maligne Lake Warden Station, and the Maligne Tours facility. High use was defined as >100 people/vehicles per month, while low use was <100 people/vehicles per month (Gibeau et al. 1996).

We used indirect-counting, direct-counting, and self-counting methods to collect empirical human use data in Jasper National Park between April 1 and October 31, 1997. Expert source data for human activity types and levels were also gathered during the month of August through interviews with people possessing extensive knowledge of, and experience in, the area. Both the empirical and expert source human use data sets were associated through a DBASE V for Windows format with an existing Arc/Info GIS human use data layer containing human use features in the study area. Human activity features (e.g., trails, picnic sites) not already present on the data layer were added to the GIS database (Figs. 2, 3).

Indirect-counting techniques included the use of 10 electronic trail counters (TrailMaster®, Lenexa, Kansas) and 3 infrared video cameras (RM-680 Video Surveillance System, Compu-Tech, Inc., Bend, Oregon). The counters recorded a count with the time and date every time an infrared beam linking the receiver and transmitter was broken. An infrared pulsation rate of 3 pulses per 0.15 second was use in an effort to ensure that most trail user types would be detected by the equipment. We mounted the counters 1.5 m above ground level to detect hikers, cyclists and horse use while excluding dogs and smaller wildlife. Counters were placed a minimum of 10 minutes walking time on the trail beyond trail junctions to avoid counting users that were diverting onto a different trail. In cases where trails extended beyond a specific destination point (e.g., picnic site, lake), a second counter was placed on the next segment of the trail. The ten trails selected to be monitored by trail counters are the only maintained hiking trails off the Maligne Lake Road and Maligne Lake. All data were downloaded via a handheld computer, then transferred to a PC, and then converted to a Microsoft Excel® format for analysis.

Fig. 2. Linear (----trails, — roads) and dispersed features (coloured in blue) in the Maligne Valley, Jasper National Park, Alberta.

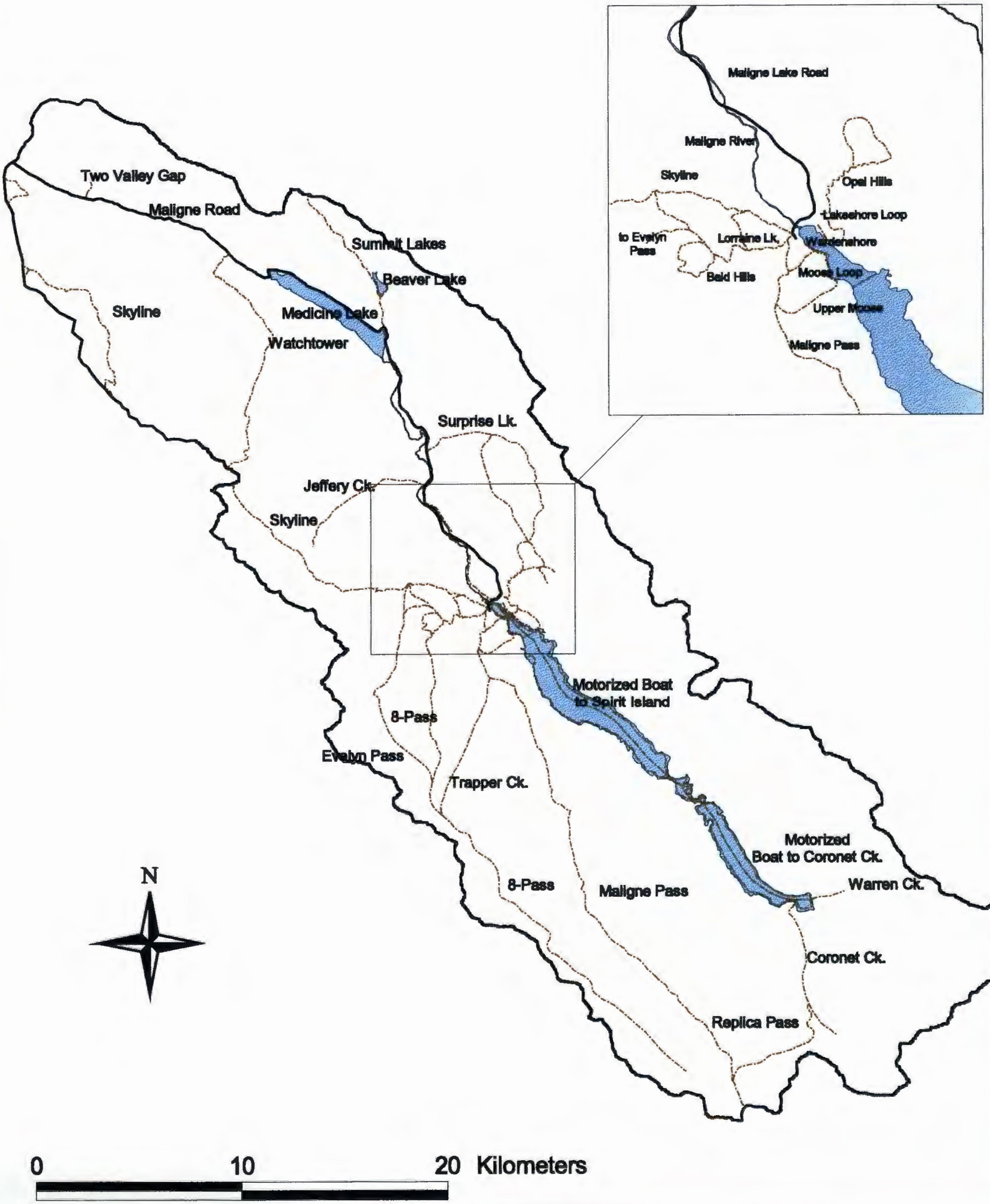

Maligne Lake Road
Maligne River
Skyline
Opal Hills
Lakeshore Loop
to Evelyn Pass
Lorraine Lk.
Bald Hills
Moose Loop
Upper Moose
Maligne Pass
Two Valley Gap
Maligne Road
Summit Lakes
Beaver Lake
Skyline
Medicine Lake
Watchtower
Surprise Lk.
Jeffery Ck.
Skyline
Motorized Boat to Spirit Island
8-Pass
Evelyn Pass
Trapper Ck.
Motorized Boat to Coronet Ck.
Warren Ck.
8-Pass
Maligne Pass
Coronet Ck.
Replica Pass
N
0
10
20 Kilometers

Fig. 3. Point features (▲ campgrounds, ● picnic sites, ■ cabins) in the Maligne Valley, Jasper National Park, Alberta.


Signal
Tekarra
Summit Lake
Beaver Picnic
Beaver Warden Cabin
Watchtower
Shangri-la
Snowbowl
Evelyn Creek
Scout Cabin
Little Shovel
Trapper Picnic
Leah Picnic
Trapper Creek
Trapper Horse
Samson Picnic
Fisherman's Bay
Spindly Creek
Schaffer
Coronet Creek
Old Horse Camp
Mary Vaux
Henry McLeod
N
0
10
20 Kilometers

The camera data were used to validate counter data. To ensure comparable coverage of each counter, the cameras were moved randomly to a new counter location each week. The cameras were activated by an infrared trigger that was mounted on a nearby tree. Cameras were placed as close to the counter locations as possible. All cameras and counters were monitored at least twice a week and camouflaging was used to lessen the chances of equipment detection by hikers. Any detections of the equipment by hikers, as seen by camera footage, were noted, and cameras or triggers were moved to a more concealed location. The cameras monitored two-way traffic to mimic the counting abilities of the counters. As with the counter data, the time and date of each camera activation were automatically recorded on the video tape. After being triggered, cameras ran for 15 seconds on hiker-only trails and for 30 seconds on trails with commercial horse use. The difference in timer settings allowed for long strings of horses to be fully recorded prior to the camera shutting off. All video tapes were reviewed later on a television monitor.

Direct-counting methods included the use of park staff and 28 volunteers to record the location, timing and number of people at linear, dispersed, and point features within the study area. A stratified random sampling design was used to ensure coverage of specific locations relative to weekends, holidays, and peak times of day. In the design, high use trails had twice as much likelihood of being sampled on weekends and holidays as trails suspected to have minimal use (<10 people per month). Sampling times for each trail were divided into either an 0800 - 1200 hr time block or a 1200- 1700 hr time block. Evenings and early mornings were covered by routine warden and volunteer patrols. Direct counting was used for trails that had trail counters on them, but no camera surveillance at that time, and on trails that were considered to have minimal use, but were not equipped with trail counting equipment. Observers also surveyed water bodies for boating and fishing activity and point source locations such as picnic sites because these areas did not lend themselves to electronic surveillance.

Three subsurface road counters recorded traffic volumes, types, and timing of vehicle use along the Maligne Lake Road. They were downloaded twice during the study period with the data formatting being done at the Parks Canada regional office in Calgary, Alberta.

Self-registration counts included backcountry camping permits, summit registries, and commercial tour ticket sales information. Although backcountry camping permits were specific to individual campsites, it was possible to calculate the number of people traveling on a specific trail segment on a certain day from the itinerary associated with the permit. Anyone staying overnight in Jasper's backcountry must register with, and purchase a permit from, the Jasper National Park Trail Office. Although non-registration was rare, regular park warden patrols instructed any unregistered users to register once they were out of the backcountry. Therefore, compliance was assumed to be 100%. Commercial tour operators in the study area provided commercial ticket sales information. These data included the number of people per tour and the number of tours per day.

In general, linear features were surveyed using one or more counting techniques (direct, indirect and self-registration). The ten major access trails were monitored by cameras and counters, while 28 backcountry trails were monitored via self-registration counts (ie., campground permit itineraries, ticket sales). Observers recorded data for the remaining trails. Point features were surveyed using self-registration counts for the fourteen backcountry campgrounds and direct counts at picnic sites. Dispersed (polygon) features were surveyed by direct-counting techniques (Appendix A).

Following the methods of Purves et al. (1992) and Page et al. (1996), expert source data were gathered from interviews with people who were knowledgeable about human use in the Maligne Valley. Experts included backcountry lodge owners, park wardens, and local recreationists. The "expert" was asked to classify human activity by months for the features for which he / she was familiar, on a logarithmic scale as used by Parks Canada (class 0: 0 vehicles / people per month, class 1: 1-10 vehicles / people per month, class 2: 11-100 vehicles / people per month, class 3: 101-1,000 vehicles / people per month, class 4: 1,001-10,000 vehicles / people per month, class 5: 10,001-100,000 vehicles / people per month, class 6: 100,001-1,000,000 vehicles / people per month, and class 7: 1,000,001 vehicles / people per month). Interviews were conducted only for the month of August, which Parks Canada had established as the month of highest use during the year and consequently allocated resources to collect only these data.

Weather data were gathered daily at 0800 hr at a manual weather station at the Maligne Lake Warden Station. Data included maximum, minimum and present temperatures; total

24 hr precipitation; cloud cover; wind direction; relative humidity, and barometric pressure.

Analysis of Data on Human Activity

Data from all counters were graphically represented in hourly blocks in the original TrailMaster® format and analyzed in a minute by minute text display. Occasionally, spikes (uncharacteristically high counts) were observed in the data. As a general rule, spikes were considered to be counts that greatly exceeded the normal number of users present on a particular trail within a specific time span. For example, a counter recording its maximum capacity (8000 counts) within an 8 hr time span, instead of the ususal 2 - 3 week period, would be considered suspect. Spikes were determined by visual examination and subjective evaluation of all count data. For spikes that appeared to have ambiguous starts, two counts at the beginning and two counts at the end of the spike were left in the data set to provide a conservative average number of counts per minute for that particular trail. In some cases, camera and observational data assisted in the recognition of spikes; early morning / late evening spikes were often triggered by animals. Daytime spikes often followed extreme wind events and heavy snowfall. All spike data were set to zero. Seasonal counts and monthly counts (used in the habitat effectiveness model) were tabulated for all features.

The average number of people per day during each week of the study was calculated for each trail monitored by counter, campsite and commercial boat tour operation. The weekly average for the number of people per day was determined based only on the number of days in that week for which data were available; this helped to compensate for data missing due to equipment failure or tampering. Percent changes in use were then calculated on a weekly basis ($[week_x - week_{x+1}]/week_x$) to determine if the changes in human activity during the season were similar between point (campground) and linear (trails) features. The accumulated percent change over the season, calculated as the $\sum$(% change per week), was used to show the seasonal pattern and the timing of the greatest change in human activity for all features, regardless of the absolute numbers of people using them.

We used linear regressions to compare counter data and camera data, and counter and direct-counting information. Camera data were used to assess the accuracy of the counters. After establishing the validity of counter data, a regression was used to determine the accuracy of observer data. For the four trails (Beaver - Jacques Lake, Coronet Creek, and Watchtower) associated with three campgrounds (Jacques Lake, Henry McLeod, and Watchtower), point data were compared with the associated trail counter data using linear regression to determine if there was a predictive relationship between campground use and trail use.

We used multiple regression to determine if the number of people per day varied significantly with temperature, precipitation and day of the week (dichotomous variable for weekdays and weekends) on three trails (Bald Hills, Beaver Lake, and Lakeshore). Each trail represented a different location and degree of hiking difficulty. The Lakeshore trail is a popular, easily accessible short (1 km) walk; Beaver Lake is a slightly longer (2.4 km), more moderate walk; and Bald Hills is a long (8 km) hike to alpine habitat. An R^2 difference test was used to test the significance of the difference in the R^2 of the overall multiple regression model and the nested models, and then a relative Pratt index (d_j) was used to determine the relative importance of each explanatory variable by attributing a proportion of this overall R^2 to each one (Thomas et al. 1996). The R^2 difference test resulted in an F-value, which allowed us to determine the cumulative probability. The relative Pratt index was used to rank variables by relative importance, assuming the variable made an important contribution to the overall R^2. A variable was considered "important" if $d_j > 1 / (2 * [\# \text{ of explanatory variables}])$; Thomas et al. 1996). Linear regression was applied to the empirical and expert source data sets using three approaches: with both data sets classified in the logarithmic class groupings (0-7), with each feature class analyzed separately (point, dispersed, and linear), and with all data grouped into high (>100 vehicles / people per month) or low (<100 vehicles / people per month) classes. All three methods for measuring trail use were used to develop the empirical data set. Counter data were used when other data collection methods were employed on the same trail. The level of significance for all analyses was $\alpha = 0.05$.

Analysis of Habitat Effectiveness and Security Areas for Grizzly Bears

All analyses of habitat effectiveness were done on an Arc/Info GIS at a scale of 1:50,000 to coincide with the habitat data. To minimize the dilution of the effects of human activities on grizzly bear habitat across a very large area (USDA 1990), we divided the Maligne Valley into three bear management units (BMUs): the Lower Maligne (136 km^2), the Middle

Maligne (275 km^2), and the Upper Maligne (408 km^2, which includes 21 km^2 encompassed by Maligne Lake) (Fig. 4). Natural topographic features, such as height of land, shared biophysical and human activity qualities, and distinct differences in the hydrology of the watershed, were used to define the BMUs.

The habitat component of the habitat effectiveness model was based on research by Kansas and Riddell (1995) which classified the original ecosites from the Ecological Land Classification for Jasper National Park (Holland and Coen 1983) into functional units with broad similarities in vegetation cover and land form. All habitat mapping in Jasper National Park was completed prior to this study. Habitat suitability values ranged from 0 to 10, with 0 indicating no suitabile habitat for grizzly bears and 10 signifying habitats of highest value. Kansas and Riddell (1995) categorized habitat suitability into very high (>7), high (5.0 - 6.9), moderate (3.0 - 4.9), and low (<2.9) (Appendix B). The original 0-10 scale was then put into a percentage (i.e., a habitat suitability of "7" became 700%) and was divided by 10 for use in the GIS model (Purves and Doering 1998). This value was termed "potential habitat".

Human activities were categorized into three dichotomous groups: motorized or non-motorized, low use (<100 people per month) or high use (>100 people per month), and location in vegetative cover or non-cover. Each point, linear, and dispersed feature (ie., trail, campground, water body) associated with a human activity was assigned a disturbance coefficient (DC), developed by bear biologists to quantify the effects of human disturbance on habitat use by non-habituated grizzly bears (USDA 1990; Appendix C). Disturbance

Fig. 4. The Lower, Middle, and Upper Maligne Bear Management Units, Jasper National Park.

coefficients ranged between 0 and 1, with 0 indicating total displacement, and 1 implying no displacement of the bears. For example, a non-motorized linear low use feature with cover had a DC of 0.88, while a motorized linear high use feature without cover had a DC of 0.16. A zone of influence (ZOI) was also assigned to each feature type and received the same disturbance coefficient. This zone of influence, developed for the Yellowstone ecosystem and subsequently adopted by Banff, Kootenay and Yoho National Parks (Gibeau et al. 1996), was applied as a region buffer in the GIS to indicate the physical area in which grizzly bears would be disturbed by human activity. All motorized features received a buffer (or ZOI) of 805 m (based on 0.5 mi used in the Yellowstone system), while non-motorized features were given a buffer of 402.5 m. All assumptions for the disturbance coefficients and zones of influence are outlined in the USDA Forest Service (1990) Cumulative Effects Model.

A cumulative disturbance coefficient (CD) was then applied to the potential habitat value for each BMU (Purves and Doering 1998) . The CD was calculated as the product of the overlapping disturbances using the following formula:

$$CD_p = DC_{pai} * DC_{paj} * DC_{pak} \ldots DC_{pax}$$

where CD_p is the cumulative disturbance for the polygon and $DC_{pai} \ldots DC_{pax}$ are the disturbance coefficients for each region with a different zone of influence in which the polygon exists. Realized habitat, as the habitat value after human activities have been accounted for, was calculated as:

$$RH_p = PH_p * CD_p$$

where RH_p is the realized habitat for a polygon and PH_p is the potential habitat for a polygon. Finally, habitat effectiveness for the BMUs was derived from the area of the polygon ($area_p$) and the potential and realized habitats:

$$HE_{bmu} = \left[\sum(RH_p * area_p)/\sum area_p\right] / \left[\sum(PH_p * area_p)/\sum area_p\right]$$

The habitat effectiveness model was run using data for each month between April and October, 1997 for each BMU. Empirical data were used for the monthly model runs. For August, results using empirical data were compared with expert source data. Multiple regression was used to determine the amount of variability in the habitat effectiveness value that could be explained by the variation in the disturbance value and the habitat suitability index. An R^2 difference test and a relative Pratt index were also calculated (Thomas et al. 1996, Zumbo 1997).

The model also was run to determine which features decreased the habitat effectiveness values within a BMU below the selected threshold of >80%. Human use data within the GIS were edited in 16 different scenarios (e.g. removing use on specific trails) relative to their proximity to high or very high habitat polygons, current Jasper National Park Management Plan objectives (Environment Canada 1988), proposed options presented in the Jasper National Park Guidelines for River Use Management (Parks Canada 1998), and the overall feasibility of closing down specific features. Additionally, the model was run with all point features set to zero use, and then with the linear features set to zero use, and, finally, with all polygon (dispersed) features set to zero use to determine which feature types had the greatest influence on the model outcome.

Security area analysis also utilized Arc/Info GIS at a scale of 1:50,000 and the same human use data layer as the habitat effectiveness modeling for the months of April through October 1997. Areas of high human use (>100 people per month) were buffered at 500 m. By preset criteria, security areas were considered to be areas lower than 2300 m (unless vegetated), >500 m from high human use, and >9 km^2 (Purves & Doering 1998, Gibeau et al. 1996). In addition, all water, rock and ice, were considered unsuitable habitat for grizzly bears and were not used in area calculations. Vegetated areas above 2300 m were included since grizzly bears do use these areas in the summer.

The output for the security area analysis classified the land base into four groupings: "unusable" (areas of rock, ice and water, and non-vegetated sites above 2300 metres), "not secure due to human disturbance" (areas that fall within the 500 metre buffer around high human activity features), "not secure due to size" (suitable areas that did not meet the required area of 9 km^2, but met all other criteria and included areas of low human use), and "secure" (all remaining areas). The overall percentage of available secure areas within each BMU was calculated as the proportion of secure areas to the amount of usable habitat. Because Jasper National Park states that >60 of a BMU should be in secure status for grizzly bears (Parks Canada 1997), model outcomes with a BMU less than 60% secure/usable were rerun under different scenarios by varying human use levels to determine which features were affecting security areas within the BMU.

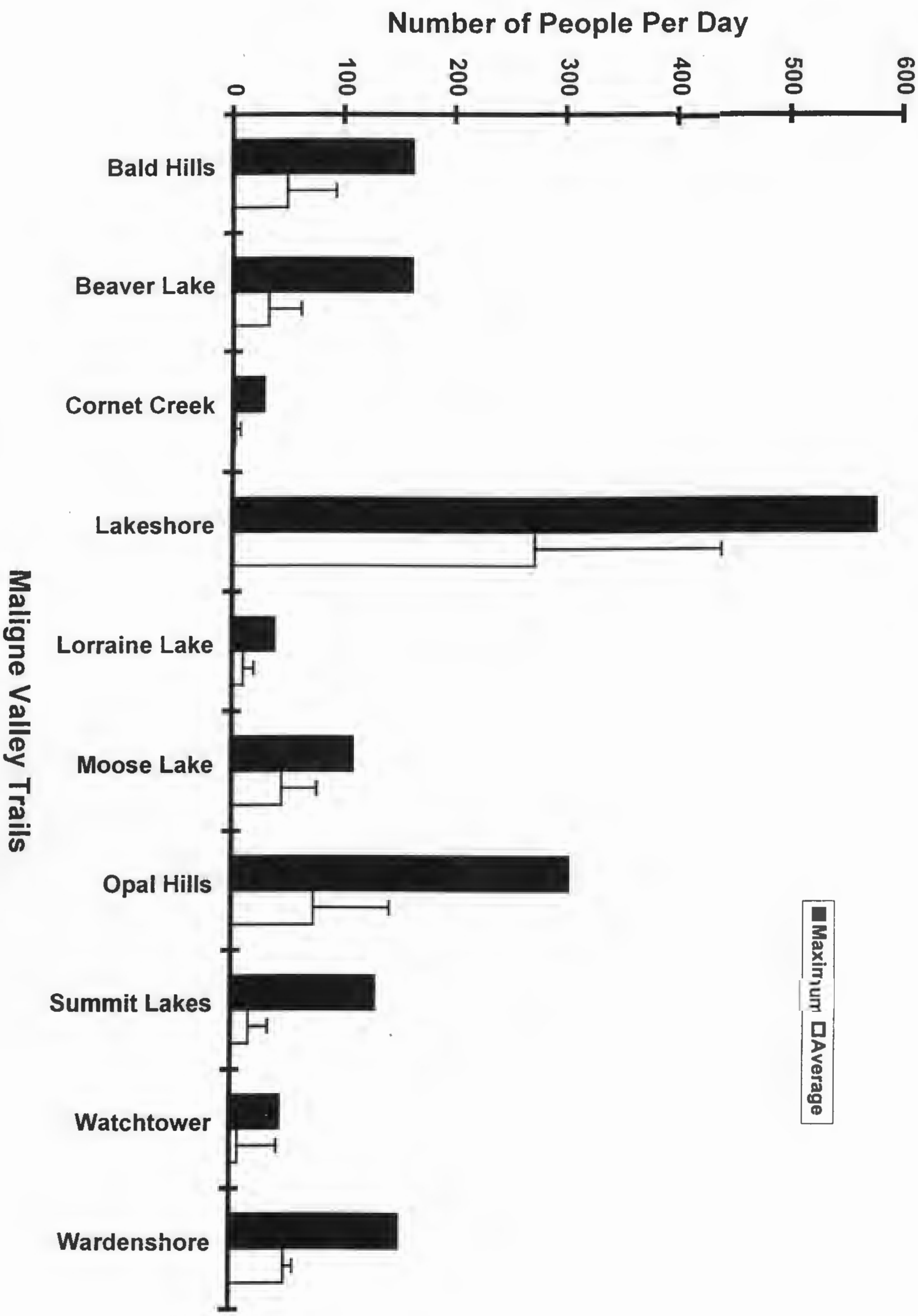
RESULTS

Trends in Human Activity

All trails in the study area experienced days of no human use; however, the maximum number of people per day on a seasonal basis using specific Maligne Valley trails that were monitored by electronic trail counters ranged from 2 to 577 between April 1 and October 31, 1997. Lakeshore trail, at the northern end of the Maligne Lake Road, received the most use and Coronet Creek trail, at the southern end of Maligne Lake, received the lowest use (Fig. 5). All trails except Lakeshore trail had an average level of use < 200 people per day, and only the Lakeshore and Opal Hills trails had maximum use levels > 200 people / day. The greatest number of people recorded on the 10 electronically monitored trails was 1191 on August 2. The greatest total number of people occurred between the hours of 0800 hr and 2030 hr, with the highest use being between 1000 hr and 1730 hr.

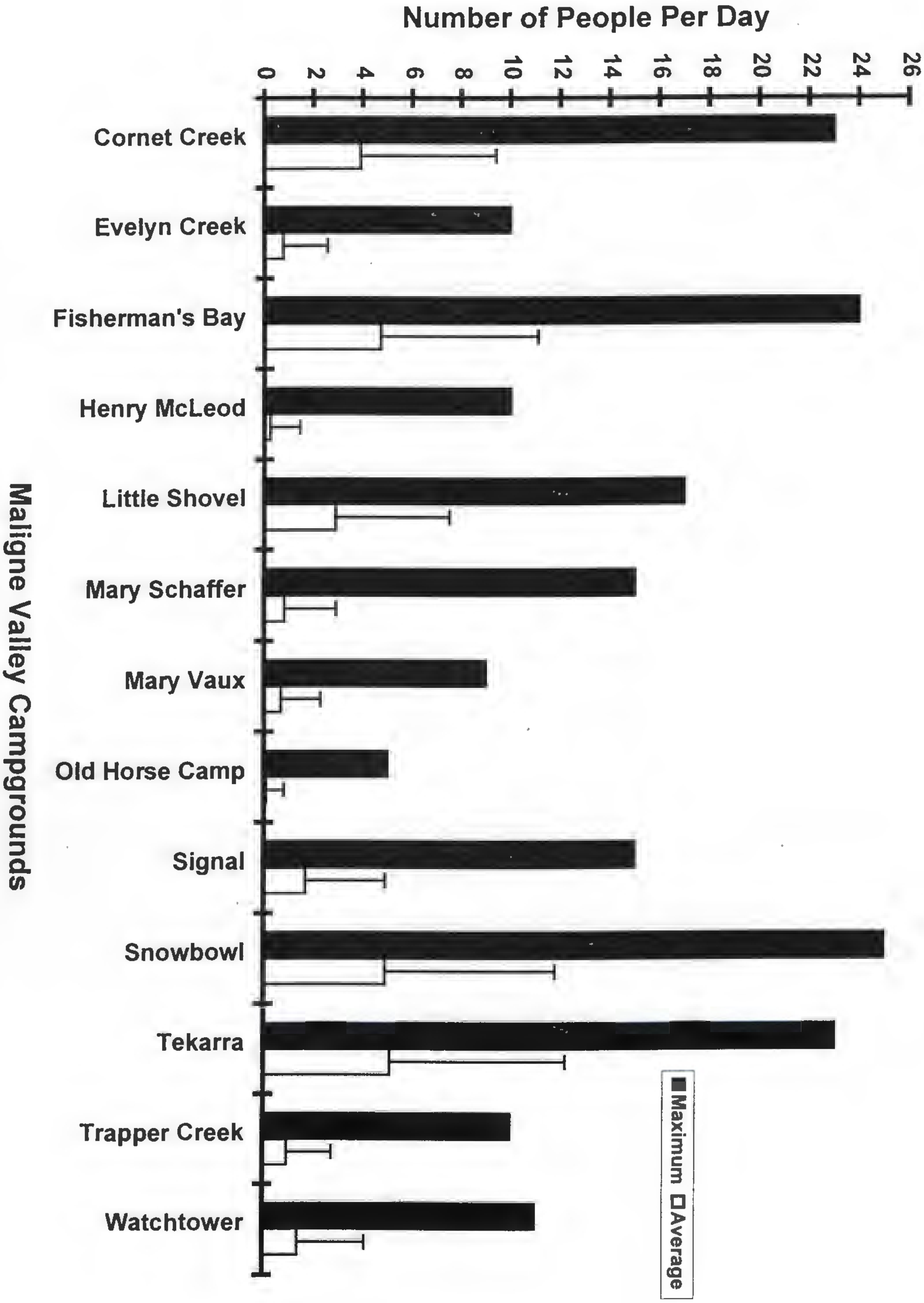
Similarly, all Maligne Valley campgrounds experienced days of no use and hense, seasonal averages were all <6 people / day (Fig. 6). Parks Canada applied a quota system to all Maligne Valley backcountry campgrounds to ensure ≤30 people per night in the campgrounds at all times. On many days, campgrounds on the Skyline Trail (Evelyn Creek, Little Shovel, Snowbowl, Tekarra, and Signal) and on Maligne Lake (Fisherman's Bay and Coronet Creek) met their quota allowances throughout the summer months (June, July,

Fig. 5. The seasonal average ($\bar{x}$ +SD) and maximum number of people per day for 10 Maligne Valley trails monitored by electronic trail counters in Jasper National Park from April 1 to October 31, 1997.



Number of People Per Day
0
100
200
300
400
500
600
Bald Hills
Beaver Lake
Cornet Creek
Lakeshore
Lorraine Lake
Moose Lake
Opal Hills
Summit Lakes
Watchtower
Wardenshore
Maligne Valley Trails
Maximum
Average

Fig. 6. The seasonal average ($\bar{x}$ + SD) and maximum number of campground users, as monitored by self-registration counts on backcountry camping permits issued by the Jasper National Park Trail Office, for 13 Maligne Valley backcountry campgrounds in Jasper National Park, from April 1 to October 31, 1997.


Number of People Per Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Maligne Valley Campgrounds
Cornet Creek
Evelyn Creek
Fisherman's Bay
Henry McLeod
Little Shovel
Mary Schaffer
Mary Vaux
Old Horse Camp
Signal
Snowbowl
Tekarra
Trapper Creek
Watchtower
Maximum
Average

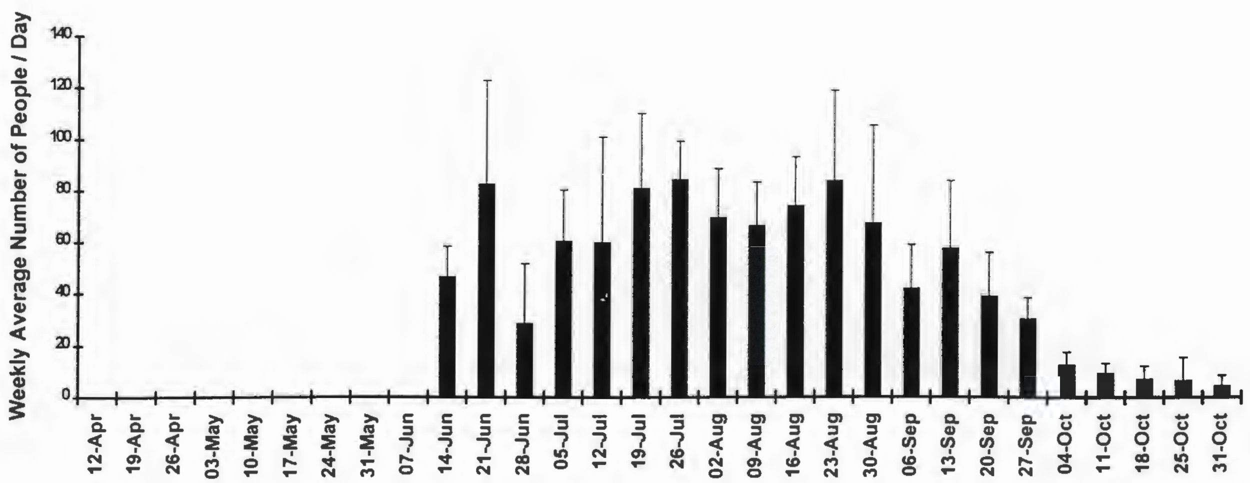
August). No use was ever observed or found in self-registration data at the Trapper Creek horse campground. The maximum total number of people overnighting in the 14 monitored campgrounds was 119 people on August 30.

The maximum number of outbound vehicles per day, as registered on the Maligne Lake road counter near the Jasper Park Lodge turnoff was 1720 vehicles ($\bar{x} = 979 \pm 421$). Only that road counter recorded usable data because of equipment failure from the two other counters on the road towards Maligne Lake. Down-loading and analysis of road data could only be done twice during the study period, and therefore, the equipment problems went undetected until late in the study. The maximum number of motorized commercial boats on Maligne Lake per day was 29 boats ($\bar{x} \pm SD = 19 \pm 6$).

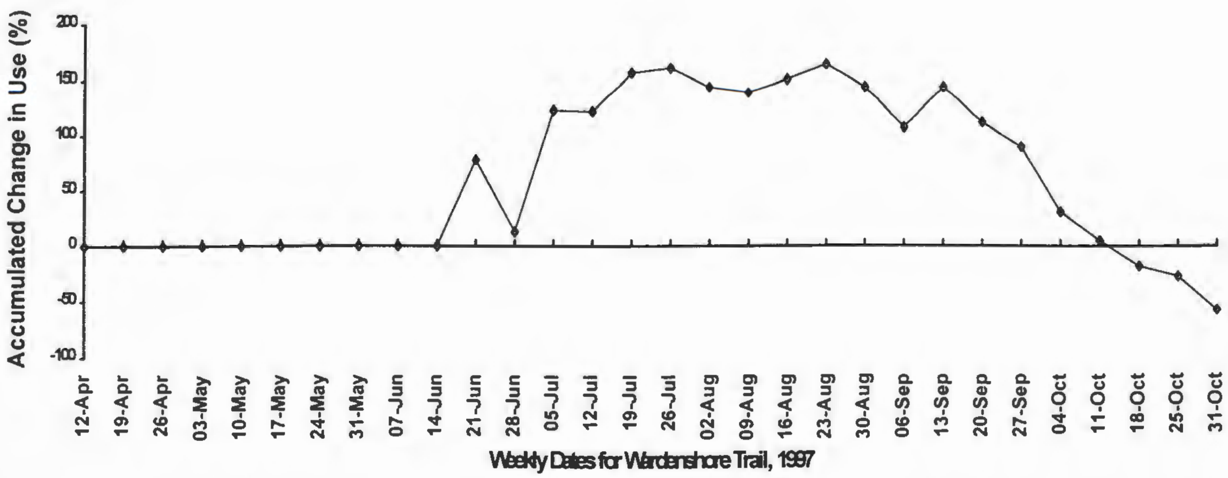
Temporal variation within the 1997 season was observed on a weekly basis. Averaged per week, trail use on 70% of the trails (n = 10) monitored by electronic trail counters typically remained ≤ 100 people / day with a marked decline in use after the September 6 long weekend. An example of this trend in use and the accumulated change in the frequency of use over the season can be seen in the Wardenshore trail data (Fig. 7). The greatest rate of change in hiker use occurred in the week ending July 5, 1997 (Fig. 7B; see Appendix D for data on all linear features monitored with electronic counters). Use monitored on the remaining 30% of the trails (n = 3) monitored by electronic trail counters exceeded 100 people per day, averaged on a weekly basis.

Fig. 7. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Wardenshore trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
140
120
100
80
60
40
20
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

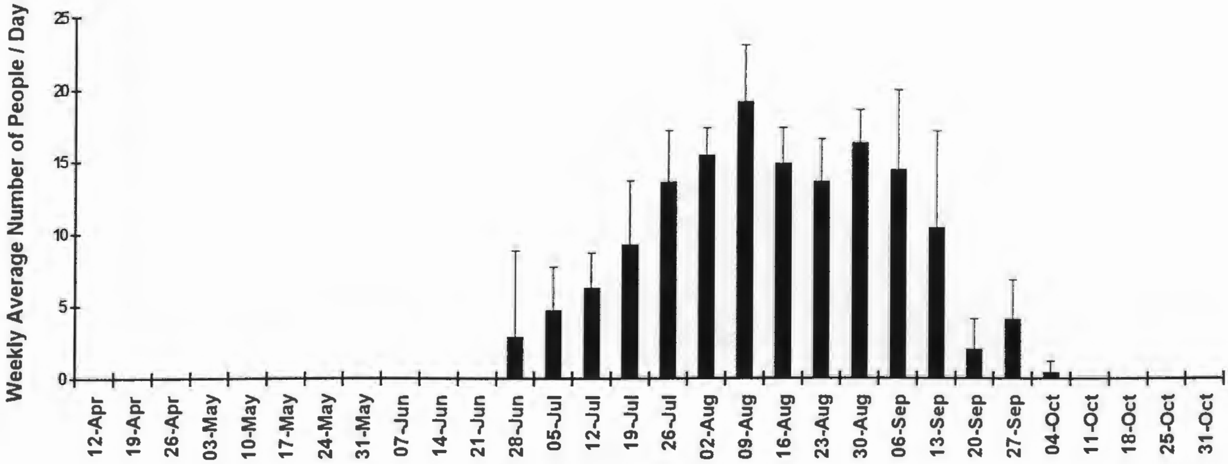

Accumulated Change in Use (%)
200
150
100
50
0
-50
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Wardenshore Trail, 1997

Campground use remained < 30 people / day because of the present quota system for all backcountry campgrounds. Eight of the 13 campgrounds (62%) averaged < 10 people / night on a weekly basis. Three of the remaining higher-use campgrounds (>10 people / night) were on the Skyline Trail while the other 2 high-use campgrounds were on Maligne Lake. This trend in use, as well as the accumulated change in frequency of use over the season is seen in the Skyline trail's Snowbowl campground data (Fig. 8). The greatest rate of change in camper use occurred in the week of July 5, 1997 (Fig. 8B; see Appendix E for data on all campgrounds within the study area).

Of the 25 use features for which we had continuous data (10 trails monitored by trail counters, 13 campgrounds, the Maligne Lake Road, and motorized commercial boat use), 14 (56%) showed the greatest increase in human activity during the week ending July 5 (Fig. 9). At that time, maximum percent changes in trail use increased 1.4 to 10.5 times from the previous week. Several other trails in the study area were at high elevation and remained snow covered and impassible until later in the season. Maximum changes in backcountry campground use increased 1.7 to 21.2 times. As with the trails, many of the popular campgrounds were at high elevations and received a rapid increase in use once the access trails were free of snow. The maximum change in use for the Maligne Road increased 1.3 times during the week of July 5, while motorized commercial boat use on Maligne Lake stayed relatively consistent once the operational season commenced on June 5.

Fig. 8. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Snowbowl campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
0
5
10
15
20
25
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

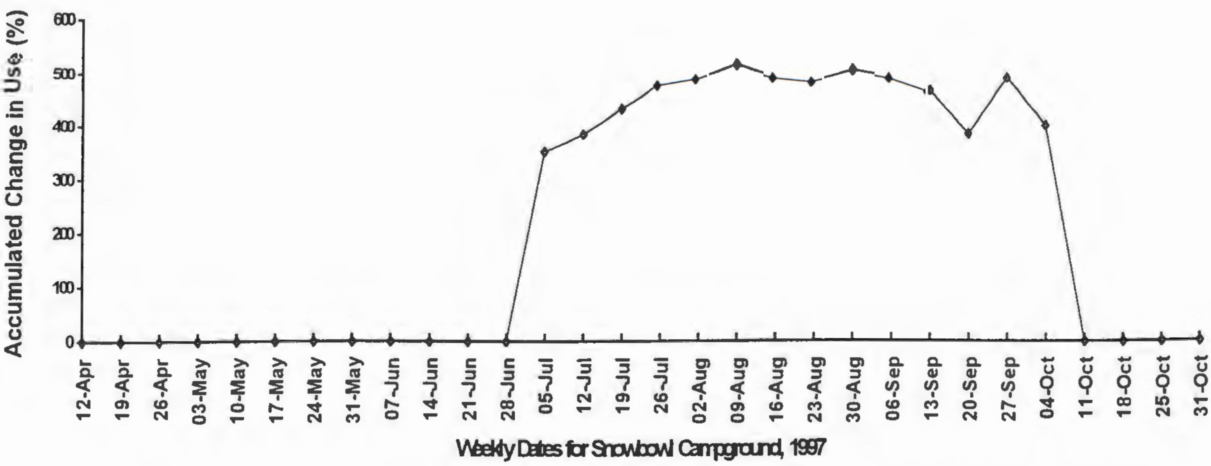
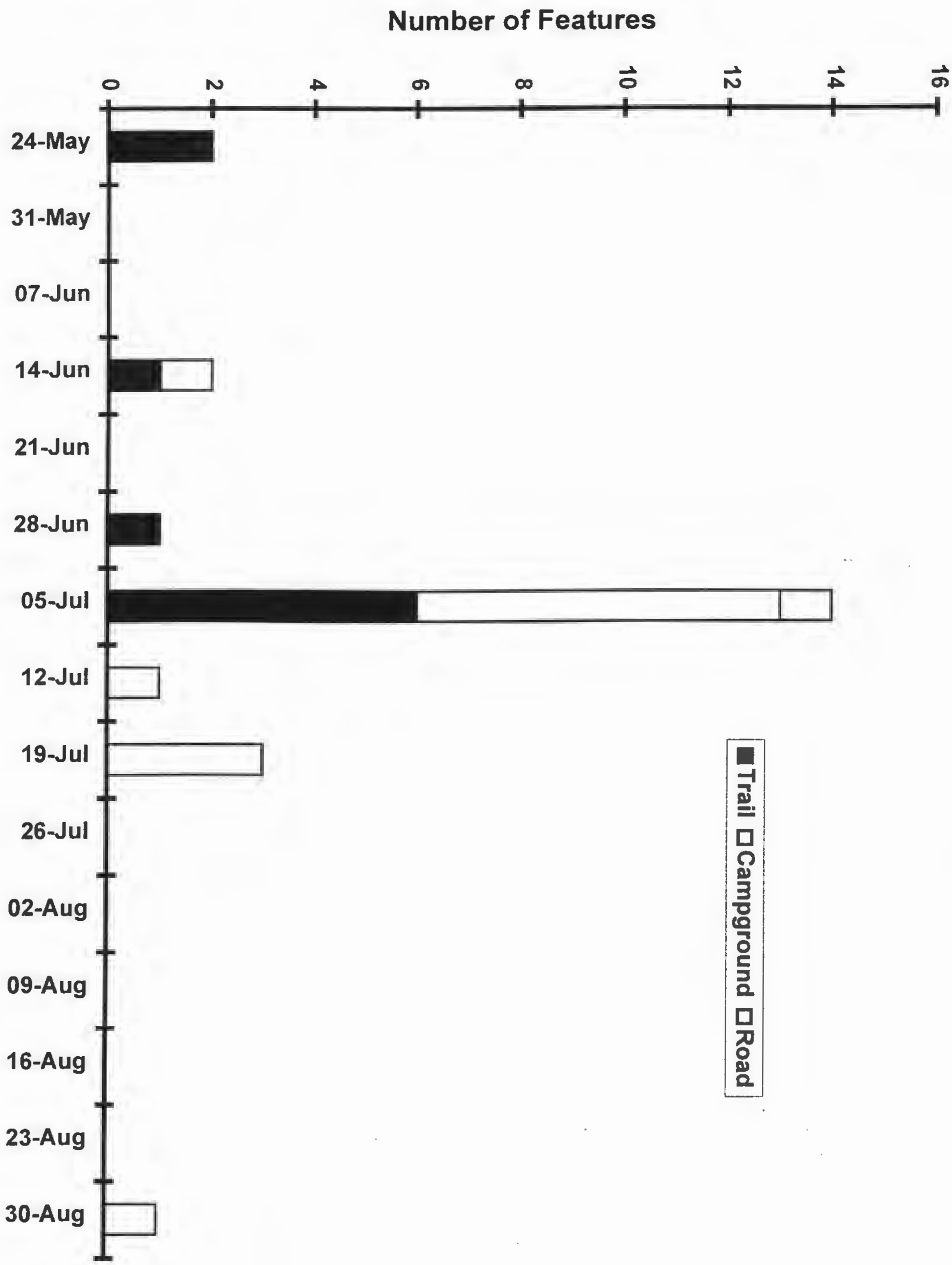

Accumulated Change in Use (%)
0
100
200
300
400
500
600
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Snowbowl Campground, 1997

Fig 9. Timing of the greatest percent change in the frequency of use on the trails (n = 10), campgrounds (n = 13) and Maligne Lake Road in Jasper National Park between April 1 and October 31, 1997. Dates are the end of each weekly period.



Number of Features
0
2
4
6
8
10
12
14
16
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
Trail
Campground
Road

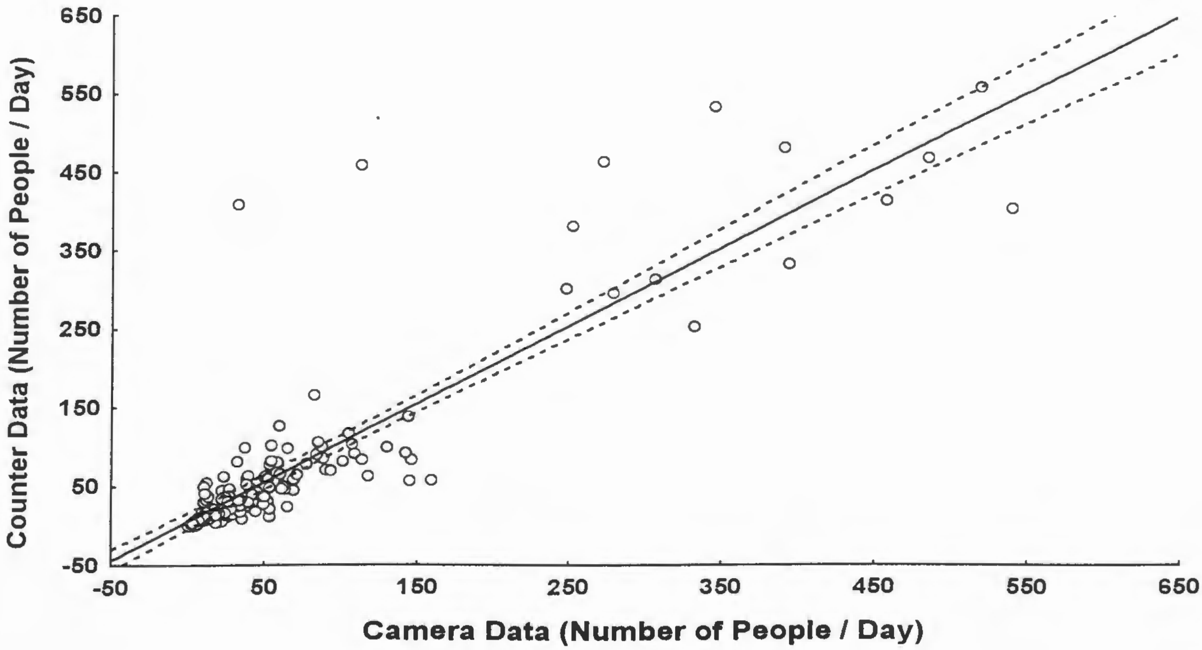
Infrared video camera data obtained from 7200 hours of surveillance explained 79% of the variation in trail counter data, as determined by the regression coefficient, with a slope of the equation very close to 1.0 (Fig. 10A). Direct-counting data from over 860 hours of observations by volunteers and Jasper National Park personnel explained 53% of the variation in counter data with a slope of 0.67 (Fig. 10B).

Although there were significant correlations between campground and trail use, the number of backcountry campground users was not a good predictor of use on the access trails. The campground user numbers for Jacques Lake campground (X), which lies just outside the study area, explained only 39% of the variation in the Summit Lake trail counter data (Y) ($F_{1,118} = 76.68$, $p < 0.001$, $Y = 8.2193 + 1.9845X$) and 32% of the variation in the Beaver Lake trail counter data (X) ($F_{1,159} = 76.39$, $p < 0.001$, $Y = 23.819 + 3.453X$). Coronet Creek campground user numbers (X) explained 29% of the variation in the Coronet Creek trail counter data (Y) ($F_{1,109} = 45.214$, $p < 0.001$, $Y = 0.8850 + 0.5637X$), whereas the Henry McLeod campground data only accounted for 4% of the variability on the Coronet Creek trail ($p<0.001$).

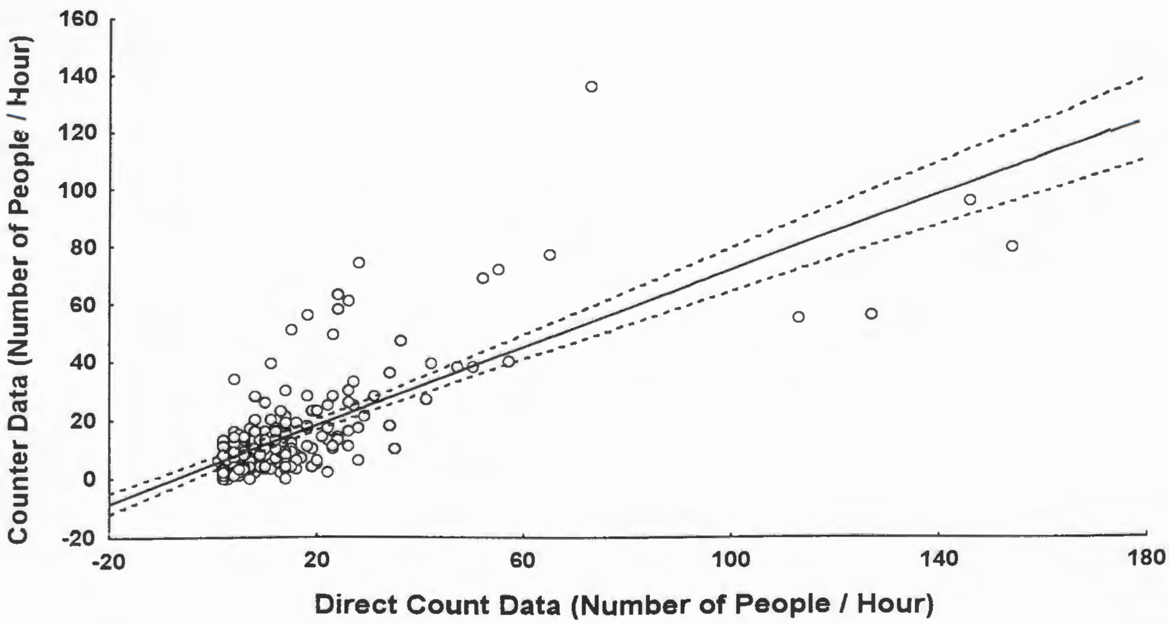
The influence of maximum temperature and day of the week (weekends or weekday) on the level of human use varied among the 3 trails analyzed. Precipitation did not have a significant influence on any of these trails. For the Bald Hills trail going to alpine areas, only maximum temperature was found to have a statistically significant effect on numbers of users (relative Pratt index $d_j = 0.7322$). With an overall R^2 of 0.20, the predictability of the

Fig. 10. Relationships between daily trail counter data (Y) and daily video camera data (X), where Y = 6.13 + 0.99X (n = 156) (A); and between trail counter data (Y) and direct-counting data (X) (B), where Y = 4.87 + 0.67X (n = 194) on Maligne Valley trails between April 1 and October 31, 1997. Dashed lines represent 95% confidence limits.

A


650
550
450
350
250
150
50
-50
-50
50
150
250
350
450
550
650
Counter Data (Number of People / Day)
Camera Data (Number of People / Day)

B


160
140
120
100
80
60
40
20
0
-20
-20
20
60
100
140
180
Counter Data (Number of People / Hour)
Direct Count Data (Number of People / Hour)

model was still very low. An R^2 difference test revealed no statistically significant difference between the overall model predicting trail use with all 3 variables ({counter data = 61.19 + [2.52*maximum temperature] - [1.14*precipitation] - [13.91*dayof the week]}, $F_{3,40} = 3.38$, p = 0.03) and nested models that excluded at least one variable within this original model.

On the Beaver Lake trail midway up the Maligne Valley and accessing the Jacques Lake campground, day of the week (weekends or weekdays) had a statistically significant effect on numbers of users (relative Pratt index $d_j = 0.7265$, $R^2 = 0.20$, p = 0.03). Precipitation ($d_j = 0.2734$) was the second variable of importance. Maximum temperature ($d_j = 0.0001$) was considered unimportant. An R^2 difference test revealed a statistically significant difference between the overall model ({counter data = 39.94 + [0.0028*max temperature] - [0.9901*precipitation] + [15.64*day of the week]}, $F_{3,39} = 3.48$, p = 0.025) and a nested model using only precipitation and day-type as explanatory variables ({counter data = 39.99 - [0.7904*precipitation] + [15.64*day of the week]}, $F_{2,40} = 5.36$, p = 0.99).

Although a relative Pratt index indicated that precipitation ($d_j = 0.4029$) and day of the week ($d_j = 0.4117$) were the only important variables on the Lakeshore trail, there were no statistically significant influences from any of the three variables (maximum temperature, precipitation, and day type; $R^2 = 0.13$, p = 0.14). An R^2 difference test found no statistically significant difference between the original model ({counter data = 334.95 + [2.46*maximum temperature] - [3.609*precipitation] + [40.72*day of the week]}, $F_{3,40} = 2.38$, p = 0.08) and the nested models within the original model.

Finally, the estimated data set (expert source data) and the measured data set (empirical data) were compared to test the reliability of expert source data currently being used in Jasper National Park. Expert source data (X) explained 66% of the variation in the empirical data (Y) on human use when all data were grouped in the same logarithmic classes ($F_{1,104} = 205.4$, $p < 0.001$, $Y = 0.0727 + 0.9212X$, $n = 106$; Fig. 11). When analyzed separately as individual feature types (linear, point, dispersed), expert source data accounted for 72% of the variation in the empirical linear feature values ($F_{1,64} = 165.45$, $p < 0.001$, $Y = 0.1933 + 0.9211X$), 74% of the variation in the dispersed / polygon features ($F_{1,15} = 46.57$, $p < 0.001$, $Y = -0.4067 + 0.9981X$), and only 30% of the variation in the point features ($F_{1,21} = 10.53$, $p < 0.004$, $Y = 0.0963 + 0.9312X$). With the combined feature classes grouped as either high use (>100 people per month) or low use (<100 people per month), as used in the habitat effectiveness model (Gibeau et al. 1996), the expert source data explained only 47% of the variation in the empirical data ($F_{1,104} = 93.62$, $p < 0.001$, $Y = 0.2804 + 0.7710X$). Many of the discrepancies in linear features between the expert source and empirical data sets occurred in the lower logarithmic groupings of class 0 and class 1 (Fig. 12), whereas point features differed most often in classes 2 and 3.

Fig. 11. Relationships between empirically collected data (Y) and the expert source data (X), when the empirical data set on human use was classified by the same logarithmic scale as that used for the expert source data (class 0 = 0 - 1 people / month, class 1 = 1 - 10 people / month , class 2 = 11 - 100 people / month, class 3 = 101 - 1000 people / month, class 4 = 1,001 - 10,000 people / month, class 5 = 10,001 - 100,000 people / month; Purves et al. 1992). The dashed lines represent the 95% confidence ellipsoid. Numbers in parentheses indicate sample sizes.

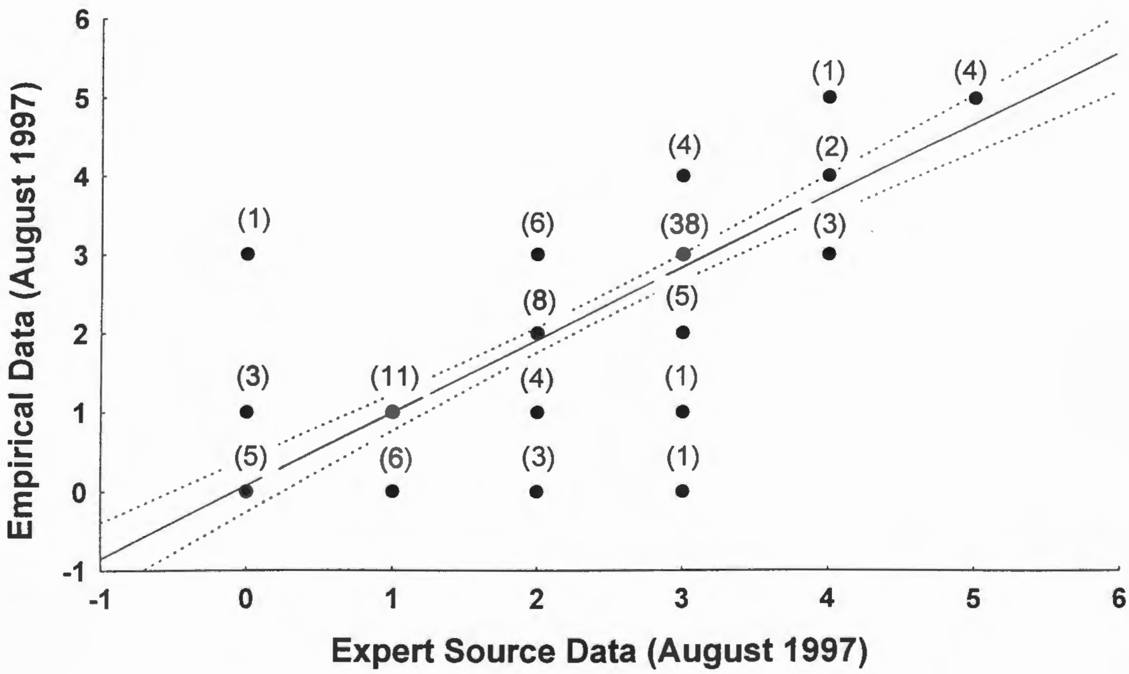
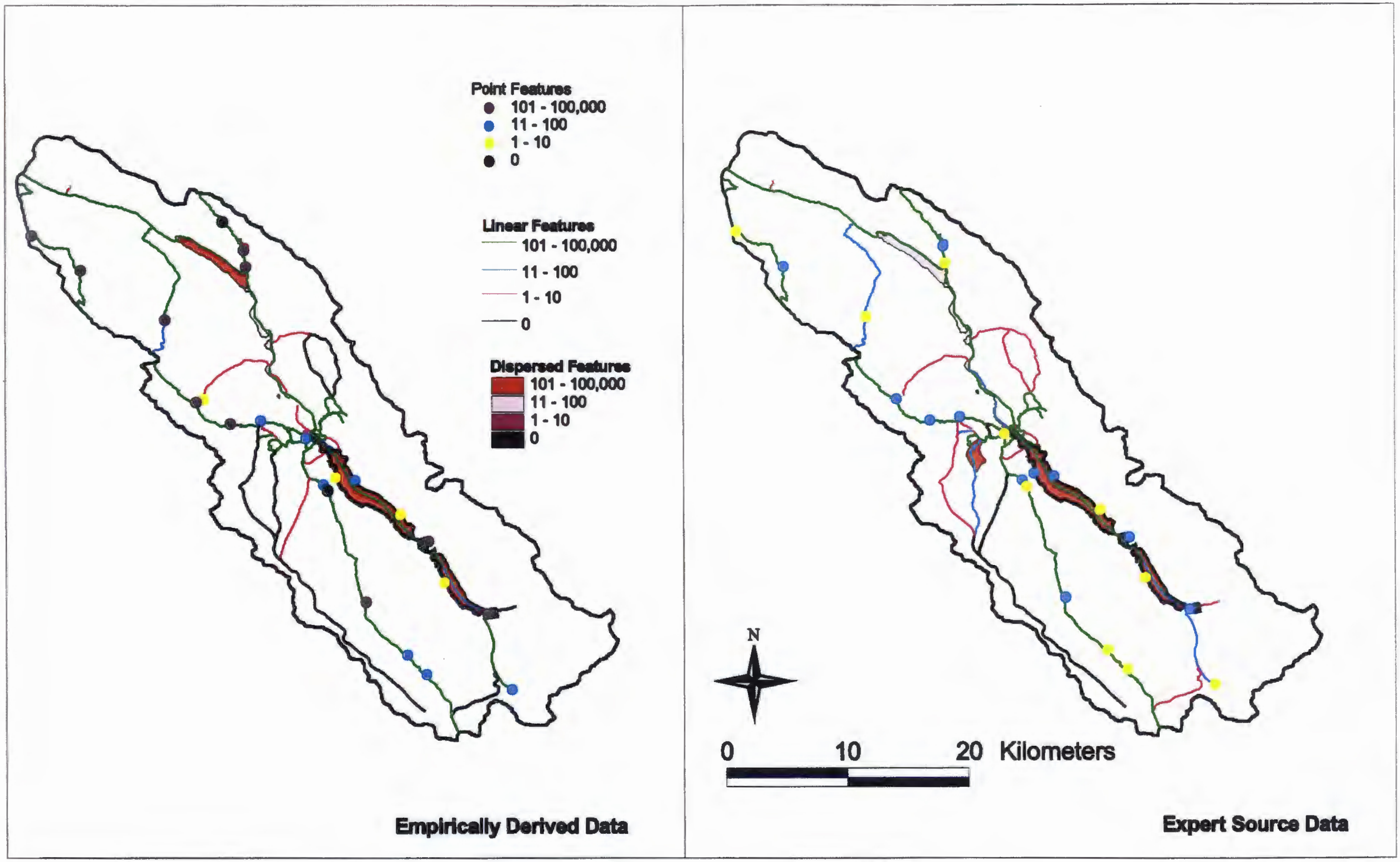

Empirical Data (August 1997)
Expert Source Data (August 1997)
(1)
(4)
(4)
(2)
(1)
(6)
(38)
(3)
(8)
(5)
(3)
(11)
(4)
(1)
(5)
(6)
(3)
(1)

Fig. 12. Map of human use features in the study area showing the differences in estimated use (expert source data) and measured use (empirical data) when use levels were classified on a logarithmic scale


Point Features
101 - 100,000
11 - 100
1 - 10
0
Linear Features
101 - 100,000
11 - 100
1 - 10
0
Dispersed Features
101 - 100,000
11 - 100
1 - 10
0
Empirically Derived Data
N
0
10
20 Kilometers
Expert Source Data

Effects of Human Activity on Habitat Effectiveness for Grizzly Bears

During the 7 months of the study, an average of 40% of the Maligne Valley had a habitat suitability for grizzly bears of zero ("nil") (Table 1). Much of this 40% was excluded from analyses of habitat effectiveness because of elevational and topographic constraints. The percentage of the valley classified as "very high" habitat suitability never exceeded 18%, and "high" valued habitat ranged from 15% to 25%, depending on the month. August was the month with the habitat most highly suited for grizzly bears, and June was the lowest.

Habitat effectiveness values in all three bear management units during July and August were less than the >80% threshold value set by Parks Canada (1997). The September value for the Lower Maligne BMU was also below the 80% threshold value (Table 2). Potential and realized habitat quality was highest for all three BMU's in August, except for the Upper Maligne BMU which had its highest realized habitat value in April. The months of greatest human disturbance were July and August while the lowest amount of disturbance occurred in April and May. The habitat effectiveness values declined in the months when human activity was at highest levels, with the decline in effectiveness being greatest for the Upper Maligne area (see Appendix F for monthly levels of human activity for all monitored features).

Habitat potential and the cumulative disturbance coefficient explained 92% of the variation in the calculated habitat effectiveness value. A relative Pratt Index (d_j) indicated

Table 1. Variation in habitat suitability for grizzly bears in the Maligne Valley as rated from nil (0) to very high (10) using groupings derived from Kansas and Riddell (1995).

	Habitat Suitability Ratings (% of study area)				
Month	Nil	Low	Moderate	High	Very High
April	40	11	18	15	17
May	40	5	26	23	7
June	40	7	36	16	1
July	41	8	10	25	16
August	40	8	10	24	18
September	41	6	12	23	18
October	40	12	10	22	16

Table 2. Monthly habitat effectiveness values for each bear management unit in the Maligne Valley, Jasper National Park, using empirically gathered human use data from April 1 - October 31, 1997. Results for expert source data obtained in August were also included. Potential and realized (including effects of human disturbance) habitats are categorized as very high (>70), high (50 - 69), moderate (30-49), and low (<29). Cumulative disturbance coefficients represent the overall effect of human activity on bears, where a value of zero implies total displacement of grizzly bears and a value of 1 implies no displacement. The habitat effectiveness values ≤ 80% represent areas that are considered highly threatened, while areas > 90% are considered secure.

Month	BMU	Potential Habitat	Realized Habitat	Cumulative Disturbance	Habitat Effectiveness
April	Lower Maligne	43.95	36.03	0.89	82%
	Middle Maligne	35.01	29.19	0.90	83%
	Upper Maligne	25.28	23.39	0.96	93%
May	Lower Maligne	41.08	34.09	0.88	83%
	Middle Maligne	34.74	29.82	0.91	86%
	Upper Maligne	24.32	23.05	0.97	95%
June	Lower Maligne	35.19	29.26	0.88	83%
	Middle Maligne	30.45	25.51	0.89	84%
	Upper Maligne	20.96	16.89	0.87	81%
July	Lower Maligne	48.25	37.81	0.85	78%
	Middle Maligne	37.93	30.27	0.87	80%
	Upper Maligne	25.77	20.20	0.88	78%
August - Empirical	Lower Maligne	51.20	40.20	0.85	79%
	Middle Maligne	39.99	32.01	0.87	80%
	Upper Maligne	27.37	21.54	0.88	79%
August - Expert	Lower Maligne	51.20	40.54	0.86	79%
	Middle Maligne	39.99	31.69	0.86	79%
	Upper Maligne	27.37	20.72	0.86	76%
September	Lower Maligne	48.41	38.15	0.85	79%
	Middle Maligne	38.01	30.95	0.88	81%
	Upper Maligne	26.32	22.43	0.91	85%
October	Lower Maligne	46.00	37.45	0.88	81%
	Middle Maligne	36.18	30.34	0.90	84%
	Upper Maligne	25.40	22.05	0.92	87%

that disturbance was the most important variable ($d_j = 1.069$) in the model. An R^2 difference test showed that there were no significant differences between the overall model ({habitat effectiveness = -54.69 + [0.075*habitat-value] + [151.53*use]}, $F_{2,21} = 129.39$, $p ,< 0.001$) and the nested models.

Several scenarios for which the habitat effectiveness model was run with curtailed levels of human activity resulted in defining actions that would increase habitat effectiveness values above the 80% threshold and allowed us to assess the relative impact of different landscape features. The elimination all point features (i.e., campgrounds) had no effect on overall habitat effectiveness values, whereas the elimination of either linear or dispersed features contributed to varying degrees depending on the bear management unit and the month (Appendix G). The Maligne Lake Road accounted for the greatest decrease in habitat effectiveness in the Lower Maligne BMU (up to 17% in August), while overall motorized boat use (both commercial and warden service use) decreased habitat effectiveness in the Upper Maligne BMU by a maximum of 2%.

Relative to security areas for grizzly bears, the ratios for secure habitat to usable habitat for grizzly bears exceeded the 60% threshold value set by Parks Canada (1997) for all bear management units, except for the Upper Maligne BMU in August (56.0% using the empirically derived data sets; Table 3) . The empirical data resulted in a lower security area

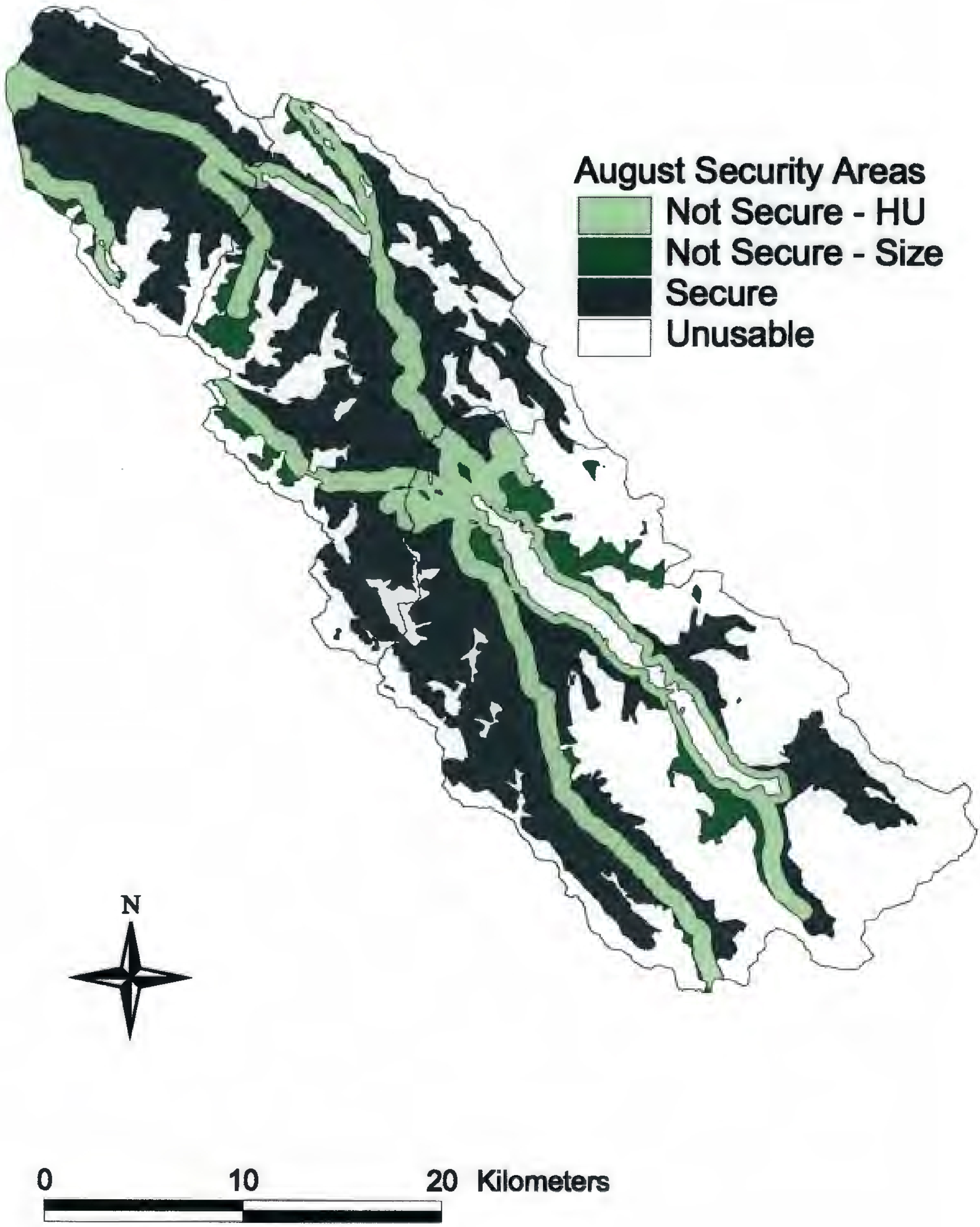
Table 3. Security areas, area size and percentage of BMU size, for grizzly bears in the Maligne Valley, Jasper National Park. Areas are considered "not-secure" if they do not meet the usable habitat size requirement of >9 km^2 because of physically small areas or because areas have been reduced in size by human use and its associated buffering within the security area model. Usable habitat includes all areas that would normally be considered grizzly bear habitat (ie., not rock and ice, or non-vegetated areas above 2300 m) and is represented as a percentage of the entire BMU. The secure / usable ratio is the percentage of secure area within the BMU relative to usable habitat.

Month	BMU	Secure	Not-secure (due to size)	Not-secure (due to use)	Usable	Secure/Usable
April	Lower Maligne	93km^2 (68.7%)	0.0%	10.1%	78.8%	87.2%
	Middle Maligne	153.8km^2 (56.0%)	0.2%	8.6%	64.8%	86.4%
	Upper Maligne	210.8km^2 (43.9)	0.2%	3.9%	48.1%	91.4%
May	Lower Maligne	93.4km^2 (68.7%)	0.0%	10.1%	78.8%	87.2%
	Middle Maligne	156.4km^2 (56.9%)	0.2%	7.7%	64.8%	87.8%
	Upper Maligne	218.5km^2 (45.6%)	0.2%	2.3%	48.1%	94.8%
June	Lower Maligne	92.9km^2 (68.2%)	0.0%	10.5%	78.8%	86.6%
	Middle Maligne	148.3km^2 (54.0%)	0.3%	10.6%	64.8%	83.3%
	Upper Maligne	171.9km^2 (35.8%)	3.0%	9.2%	48.1%	74.6%
July	Lower Maligne	78.2km^2 (57.5%)	1.1%	20.1%	78.8%	73.0%
	Middle Maligne	122.9km^2 (44.7%)	4.2%	15.9%	64.8%	69.0%
	Upper Maligne	156.2km^2 (32.6%)	4.2%	11.3%	48.1%	67.8%

August - Empirical	Lower Maligne	78.2km² (57.5%)	1.1%	20.1%	78.8%	73.0%
	Middle Maligne	122.9km² (44.7%)	4.1%	16.0%	64.8%	69.0%
	Upper Maligne	129.0km² (26.9%)	4.8%	16.3%	48.1%	56.0%
August - Expert	Lower Maligne	81.7km² (60.1%)	1.1%	17.6%	78.8%	76.3%
	Middle Maligne	134.7km² (49.0%)	1.9%	13.9%	61.8%	75.6%
	Upper Maligne	140.8km² (29.4%)	3.2%	15.5%	48.1%	61.1%
September	Lower Maligne	78.2km² (57.5%	1.1%	20.1%	78.8%	73.0%
	Middle Maligne	124.4km² (45.3%)	4.2%	15.4%	64.8%	69.9%
	Upper Maligne	207.8km² (43.3%)	0.3%	4.5%	48.1%	90.2%
October	Lower Maligne	93.4km² (68.7)	0.0%	10.1%	78.8%	87.2%
	Middle Maligne	152.2km² (55.4%)	0.8%	8.6%	64.8%	85.5%
	Upper Maligne	212.1km² (44.2%)	0.2%	3.6%	48.1%	92.0%

rating than the expert source data set for all BMUs. Ratios of secure / useable habitat reached the lowest levels in July and August because of increased human activity. Throughout the three BMUs, areas considered not-secure for grizzly bears because of human use were concentrated along the Maligne Lake Road, along high-use trails, and on both sides of Maligne Lake as mapped for August (Fig. 13; Appendix H). Areas rated as not-secure because of physical size requirements usually occurred between areas with human use and the unusable areas of high elevation rock and ice.

Fig. 13. Security area ratings for grizzly bears inhabiting the three bear management units for the Maligne Valley in August, 1997. Areas not considered secure were separated based on insufficient size or effects of human use (HU).


August Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers

DISCUSSION

The collection of data on the distribution of recreational activities, trends in seasonal use, total visitation, and types of human use in the Maligne Valley followed guidelines described in Hollenhorst et al. (1992) and Mitchell (1994, 1995) and complimented those used at Lake O'Hara in Yoho National Park (Kelly and Wright 1997). The sampling strategy allowed coverage of a large area within a short field season using limited resources. It also accommodated the varied nature of human use within the study area in which some trails experienced extremely high levels of use while others, especially winter routes, were used rarely from April to October. By using direct and indirect counting, and self registration counts, we were able to monitor the variety of point, linear, and dispersed features within the study area.

Electronic video cameras were an efficient method for validating data from electronic trail counters. Observers also provided reliable data for validating the trail counters, but without a large number of volunteers, data collection would have been more difficult. Observers were extremely useful in areas that did not lend themselves to electronic surveillance, such as Maligne Lake. Complete reliance on observers, however, limited our ability to obtain census-level data because these areas only received coverage during set time periods. Therefore, it is likely that human use was underestimated for features within the empirical data set that relied entirely on observational data (i.e., lakeshore picnic sites). In addition, using a number of observers reflected varying levels of diligence in data collection, and could potentially lack the consistency found with the trail monitoring equipment. To maintain reliability in the trail monitoring equipment, it was imperative that it be checked regularly. The presence of spikes in the data sets resulted in the loss of data for that time period. Even though equipment tampering was rare, when it did occur, as much as a week of data were lost for a particular trail and trail counts would be set to zero for that time period. In these situations, trail counters also potentially could have underestimated of human activity.

Using backcountry campgrounds to predict levels of use on their associated trails was generally not effective, likely because of the amount of day use on the trails. Campground data, however, can provide good information on the number of overnight trail users and for use of backcountry trails, offering the only access to these campgrounds, which are not equipped with electronic surveillance equipment. Backcountry campground patrols from the warden service reported a high level of compliance amoung campground users, but it must be recognized that not all backcountry permit holders stay in the campground indicated on the permit, especially in inclement weather.

Multiple regression of trail selection patterns in relation to the effects of weather and day of the week (weekend or weekday) revealed that different trails could possibly be grouped by different user types. Human use on the trail with the greatest change in elevation, Bald Hills trail, was more affected by colder days than the Lakeshore trail, which has easy access and no elevation gain (i.e., Lakeshore). The Beaver Lake trail, which accesses both the Jacques Lake campground and Beaver Lake (a popular fishing location) was more affected by weekend use (i.e., Beaver Lake). Further research relative to this topic would aid trail planning and strategies for distribution of human use in areas shared by grizzly bears and park visitors. Schueck and Marzluff (1995) also stressed the importance of accounting for weather prior to making conclusions about the effects of human activities in ecological research. It is important to note, however, that people's responses to weather-related factors might be on a different temporal scale than the 24 hr period for which weather data were gathered. Noting the date that trails are free of snow is also important in mountain environments.

One field season of data collection was useful for comparing human use of different feature types, but did not allow for yearly climatic variations. The "ice-off" date for Maligne Lake in 1997 was June 5, whereas in 1998 it was May 14 (one of the earliest on record). Winter snow packs can vary dramatically from year to year in Jasper National Park and often determine the timing and amount of access to trails and backcountry campgrounds. These variations could affect the grizzly bear habitat effectiveness and security area values on a yearly basis. For example, the amount of area considered "not- secure" was greatest in July and August (Table 3) because of the reduction in the habitat available to the bears, resulting from improved trail access following snow melt. Because 1997 was a year of high snow pack, levels of human use should be considered conservative for April, May, and June, and habitat effectiveness values may have been higher than in other more typical years.

Expert source data gathered during the same time period as the empirical data provided a temporal comparison of the two methods for collecting information on levels of human activity. Expert source data are currently used for ecological studies within Banff, Kootenay, and Yoho National Parks (Purves et al. 1992, Page et al. 1996, and Gibeau et al. 1996) and for habitat effectiveness, security area, and linkage zone analyses in Jasper National Park's ecosystem management applications (Parks Canada 1997, Purves and Doering 1998). Our study demonstrated that, within logarithmic classes, expert source data slightly overestimated empirically gathered data for linear and dispersed features. Differences often occurred in the lower logarithmic groupings for the linear features (1-10 versus 11-100 vehicles / people per month). These differences had little or no effect on the outcome of the habitat effectiveness model since the model responded to a >100 vehicles / people per month cut-off point for high and low displacement categories. Data for point features (ie., campgrounds, picnic sites) obtained from expert sources typically underestimated use. This discrepancy between the two data sets would be the easiest one to correct by using the campground permit data gathered by the Jasper National Park Trail Office. Again, the differences between point data gathered by empirical and expert source methods had little or no effect on the habitat effectiveness and security area results within the study area. Currently, the two data sets resulted in similar or identical habitat effectiveness values, but further research would be useful to determine whether these differences in levels of use would result in greater discrepancies in habitat effectiveness values for BMUs with more area in habitats of high or very high suitability.

For most of the monthly model outcomes in this study, a decrease in habitat effectiveness values appears to coincide with an increase in habitat suitability value and a corresponding increase in human use. This relationship exists due to the multiplicative nature of the habitat effectiveness model because areas of higher habitat value are more strongly influenced by human use (as represented by the disturbance coefficient, DC). For example, an area with a habitat value of 10 and a DC of 0.45 is reduced to a value of 4.5 (a decrease from very high habitat suitability to moderate habitat suitability). An area with a habitat value of 1 and a DC of 0.45 is reduced to a value of 0.45, but in the latter case there is no change in the original low habitat suitability rating.

Jasper National Park used the DCs and ZOIs for the Yellowstone ecosystem, with minor modifications for Banff National Park, since both areas are considered protected areas surrounded by multiple use lands (Gibeau et al. 1996) and were therefore expected to exhibit similar parallels between human influences on grizzly bear habitat use. The elevational cut-off separating suitable from unsuitable non-vegetated habitat was reduced from 2400 m, as used in Banff, to 2300 m in Jasper to accommodate the difference in latitude between Jasper and Banff (Purves and Doering 1998, Gibeau et al. 1996).

Using Parks Canada's current threshold of >80% for habitat effectiveness (Parks Canada 1997), the Maligne Valley did not meet these standards for July, August or September (for the Lower Maligne BMU only). The Lower Maligne BMU was slightly smaller than the minimum size used in Banff National Park (Gibeau et al. 1996), but was retained as such due to strong topographic influences. The size of this BMU was similar with some of the female grizzly bear home range sizes found in Russell et al.'s (1979) grizzly bear study in Jasper National Park, but could still have limitations when incorporated into the grizzly bear model. Nonetheless, the lowest habitat effectiveness value was 78% (Table 2) and it can be assumed that any increase in human activity on low use features, or any additional development in the valley, would continue to compromise the estimated amount of habitat available to grizzly bears. As mentioned, empirical measures of human use in this study may have been conservative in cases where suspect counts were removed from electronic trail counter data, and where observers were unable to obtain census level data. Yearly variation in "ice off" dates for the lakes and snow levels on the trails would also effect use numbers in May and June, with 1997 being a much later year than 1998. Additionally, the values derived from this study did not incorporate the effects of trails and other human use features adjacent to the study area boundary. The buffering of these features would add to the reduction of habitat effectiveness in the Maligne Valley. In contrast, assumptions of the model, which would increase habitat effectiveness if they were not met, include those times when backcountry users did not stay at the permitted campground because of inclement weather and when people using the trails did not travel the entire segment for which the use and its associated buffer were assigned. Threshold values currently are under review by bear management specialists and may be raised for some areas (i.e., >90%) and decreased in others (M. L. Gibeau, personal communication, April 4, 1997).

In manipulating the habitat effectiveness model to increase values to >80% (Appendix G), a feature of significant size or several features in combination needed to be removed to cause any change in the overall value. Consequently, greater effects were observed for linear and dispersed features than for point features because of their size and associated zones of influence. The proximity of the feature to high or very high value habitat was a primary factor in the model responsiveness. Deficits in security area size were easier to "correct" because areas of usable habitat that could be reconnected by removing a feature (i.e., trail, campground) were simple to identify on the map output. In many situations, the features that were modified in the computer model to increase habitat effectiveness in a specific BMU were those that were easier to manage logistically (i.e., closing a trail rather than the main access road into the valley). Such modifications might not prove realistic in practice, however, because it is difficult to enforce the closure of remote trails and such actions deny backcountry users their park experience. In cases such as the Lower Maligne BMU, all features except the Maligne Lake Road needed to be removed to bring the habitat effectiveness level above 80%. In so doing, one of Jasper's most popular backpacking routes, the Skyline Trail, would be closed for use despite the fact that the Maligne Road accounts for almost all of the decline in habitat effectiveness in the entire BMU.

Another strong influence on model responsiveness is how and where the bear management units were established. Since the model is based on various assumptions and landscape divisions, only validation of the model (i.e., collaring and tracking bears to determine habitat use and displacement behaviours) would ensure that the BMUs, displacement coefficients, zones of influence, and study area boundaries were applicable. We have assumed that Gibeau's data on habitat use by bears in response to disturbance (Gibeau et al., 1996), currently being gathered in Banff National Park, can be used to refine Jasper National Park's model, since both parks employ the same ecological land classification (Holland and Coen 1983, Holroyd and VanTighem 1983) and grizzly bear habitat model (Kansas and Riddell 1995). The major limitations to this assumption are that habitat value is accurately predicted by the availability of vegetative habitat and that the vegetation classification systems used for mapping are accurate predictors of food and cover value for grizzly bears. Both parks also have non-hunted grizzly bear populations and similar visitor use patterns (within the park boundaries). The effect of the latter on habitat effectiveness may be most limited in the model by logarithmic groupings of people (encompassing a wide range of visitor use within a single category) over a monthly time step (which may not be the appropriate temporal scale eliciting response by bears). Behavioural differences are also likely between habituated and non-habituated bears. Therefore, in addition to tracking different animals to validate the model and its numerous assumptions, further research should implement a sensitivity analysis of the habitat effectiveness model to determine which component is most sensitive to or has the greatest impact on the outcome.

MANAGEMENT IMPLICATIONS

Many studies indicate that human activities can adversely affect grizzly bear movements, behaviours, and habitat use (Elgmork 1978, Jope 1985, McLellan and Shackleton 1989, Purves et al. 1992, Interagency Grizzly Bear Committee 1994, Mace and Waller 1996). The grizzly bear habitat effectiveness model, which has met with approval from many agencies responsible for grizzly bear management (e.g., Weaver et al. 1985, Weaver et al. 1987, Apps

1993) and has been developed for over a decade, and security area analysis, allow for human activities to be included in habitat evaluation modelling for grizzly bears (Gibeau et al. 1996, Page et al. 1996). Prior to these GIS applications, the habitat suitability index was one of the few ways of quantifying habitat values for grizzly bears (Kansas and Riddell 1995). Our study complements other cumulative effects research on grizzly bears in the Rocky Mountains (USDA 1990, Gibeau et al. 1996, Martin 1996, Northern East Slopes Environmental Resource Committee 1998).

The extent to which human activities displace grizzly bears is not precisely known, but experience in many national parks has shown that grizzly bears habituated to road side or developed areas are often removed from the population through highway mortalities or management actions. Relocation of habituated bears is often unsuccessful. The ability to predict bear-human conflict areas and habitat fragmentation for grizzly bears is a strong tool in times when grizzly bear habitat is declining and visitation to our natural areas is rapidly increasing (Hummel and Pettigrew 1992, Page et al. 1996).

As expected from the model, when human activities increased in areas of high habitat suitability for grizzly bears in this study, habitat effectiveness values decreased. With the increase in human activities, there was also an increase in buffer distances and consequently an additional reduction in usable security areas. Including a sensitivity analysis into the habitat effectiveness model would provide a more succinct indication of the types of human activities and habitats that influence the model's output. Further research to set priorities and alternatives should be implemented to determine if there are some types of human activity (e.g., horse use versus hiking versus canoeing) which might be more compatible with bear behaviour than others.

Within our study, an increase in human use corresponded with the end of the school year and the beginning of the July long weekend. This rise in human activity coincided with an increase in grizzly bear habitat suitability resulting from snowmelt and changes in plant phenology. The planning and regulation of trails and other features such as picnic sites, roads and campgrounds to ensure the avoidance of high and very high value habitats for grizzly bears would help to maintain higher levels of habitat effectiveness and security areas. For example, closing the Skyline Trail in the Lower Maligne BMU in August (>700 people / month) to maintain secure connections between habitats of high suitability (Figs. 2, 13) would increase habitat effectiveness values by 2% to values above the 80% threshold. Similarly, by eliminating the 4 motorized boat surveys, conducted by Parks Canada, for waterfowl along the Maligne Lake shoreline in July, and restricting use on the Maligne River, habitat effectiveness in the Upper Maligne BMU would increase 3% and exceed threshold levels. Any new facilities in the valley should be placed only in areas with low habitat suitability and efforts should be made to determine if rerouting of some trails could provide secure corridors for movement by bears.

Given present park objectives for grizzly bear management, the greatest challenge for Parks Canada is to maintain or increase current levels of habitat effectiveness above the 80%

threshold while regulating increasing recreational demands and expectations. In using the predictive nature of the habitat effectiveness model and the modeling options presented by GIS, managers are able to build scenarios that allow for an overall assessment of present and proposed developments on the landscape. These options remain, however, only if the human use and habitat suitability databases are kept current.

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APPENDIX A

Sampling methods and frequencies for all human use features

in the Maligne Valley, Jasper National Park, from April 1 to October 31, 1997.

Table A1. Sampling methods and frequencies for all human use features in the Maligne Valley, Jasper National Park, from April 1 to October 31, 1997.

LOCATION	ID. #	TYPE	COUNTER	CAMERA	DIRECT c	SELF-REG a
8 Pass	1718	line			winter route	X
Bald Hills - 8 Pass	1721	line			winter route	X
Bald Hills Road	1731	line	X	6	19(26)	
Beaver Lake - Parking Lot	1910	line	X	6	19(33)	
Beaver Lake Fishing Trail	4122	line			19(33)	
Big Bend Picnic	3088	line			11	X
Cornet - Maligne	1945	line				X
Cornet - Mary Vaux	1714	line				X
Cornet Trail	1943	line	X	3	7	X
Evelyn Creek Trail	1739	line			2	
Evelyn Creek Trail	1738	line			19	
Fisherman's Bay Warden	4127	line				X
Fishing Trail	4123	line			5	
Home Bay Loop	20215	line			67	
Jacques Lake - Summit	1908	line				X
Jeffrey Creek	1755	line				X
Lake - Upper Moose Loop*	1729	line	X	5	19(7)	
Lake Loop Trail	1775	line	X	6	59(19)	
Lookout Trail	1777	line	*		45(19)	
Lorraine Trail	1734	line	X	5	15(19)	
Maligne - Avalanche	1713	line				X
Maligne Lake to C.C	4128	line			51	X
Maligne Lake Duck	4129	line				X
Maligne Lake to Isle	4126	line			67	X
Maligne Lk. Area Road	2568	line			daily	
Maligne Pass - Moose Loop	1728	line	X	5	35(19)	
Maligne Pass - Upper Moose	1726	line			12	X
Maligne Pass Trail	1722	line			8	X
Maligne Pass Trail	1724	line			8	X
Maligne Pass Trail	1717	line			8	X
Maligne Pass Trail	1723	line			8	X
Maligne Pass Trail	1719	line			8	X
Maligne River Fishing (West)	4116	line			2	
Maligne Road	2551	line	X		daily in April	
Maligne Road Trail	1776	line			2	
Moose Loop Trail	1727	line	X	5	19(16)	
Notch - Tekarra	1765	line			3	X
Old Horse - Mary Vaux	1715	line			3	X
Old Maligne Road	4124	line			3	
Opal - North Surprise	1749	line			4	
Opal - Surprise Lake	1748	line			4	
Opal Hills	1744	line	***		18(32)	
Opal Hills	1745	line	***		18(32)	
Opal Hills Loop	1746	line	X	6	18(32)	
Road - Surprise Creek	1754	line			6****	
Rockslide Loop	4117	line			6	
Sewage Lagoon Road	4115	line			4	X
Signal Mountain Fire Road	1769	line			3	X
Skyline Trail	1741	line			3	X
Skyline Trail	1742	line			3	X
Skyline Trail	1733	line			22	X
Snowbowl - Curator	1756	line			3	X
Spirit Island Trail	4118	line				X
Summit - Beaver Lake	1909	line	X	5	19	
Tekarra - Signal Creek	1766	line			3	X
Tekarra-Upper Road	1769	line			3	X
Trapper Creek	1720	line			7	
Two Valley Gap (Upper)	4121	line			9****	
Two Valley Gap(Lower)	4120	line			9****	

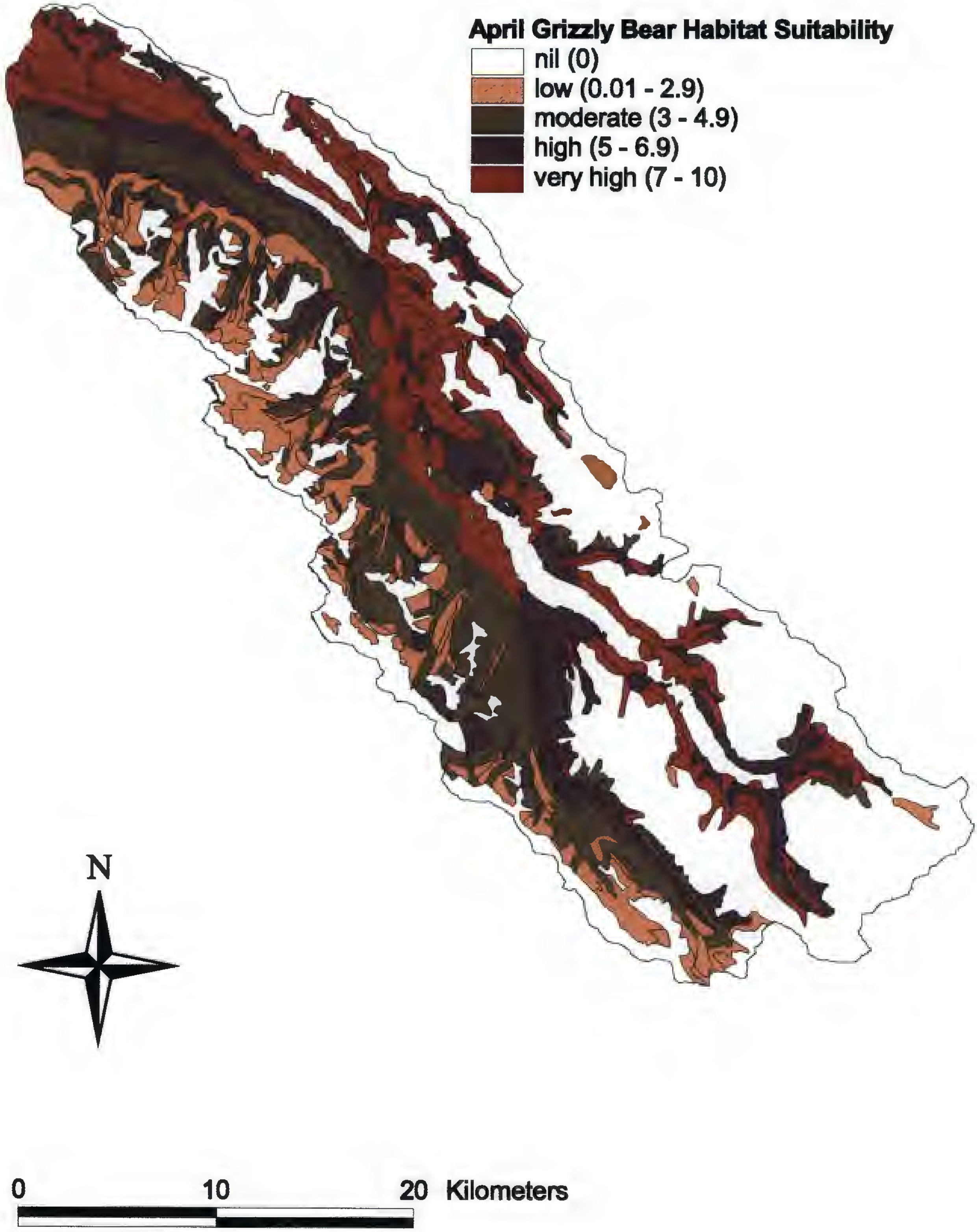
Upper Bald Hills Road	1732	line	**		19(26)	
Upper Moose Loop Trail	1725	line			4	
Warren CK. Trail	4119	line			1	
Watchtower	1759	line			4	X
Watchtower - Road	1760	line	X	5	7(2)	X
Z-Drop Photo Trail	4125	line				X
Beaver Lake Cabin	3514	point				X
Beaver Shelter	3513	point			19(33)	
Cornet Creek Campground	3570	point				X
Evelyn Creek Campground	3558	point				X
Fisher Bay Campground	3569	point				X
Henry McLeod Campground	3533	point				X
Horse C/G - Maligne Pass	3555	point				X
Leah Ck. Picnic	2102	point			19(48)	
Little Shovel Campground	3559	point				X
Mary Vaux Campground	3562	point				X
Old Horse Campground	3553	point				X
Samson Ck. Picnic	2103	point			19(30)	
Schaffer Campground	3554	point				X
Scout Cabin / Pit	3080	point				X
Shangri-La Cabin	20200	point				X
Signal Campground	3567	point				X
Snowbowl Campground	3563	point				X
Spindly Creek Picnic	20155	point			19(30)	
Summit Lake Campground	3512	point				X
Tekarra Campground	3566	point				X
Trapper Ck. Picnic	2101	point			19(48)	
Trapper Creek Campground	3556	point				X
Watchtower Campground	3564	point				X
Bald Hills Hike / Ski	20217	polygon			19(26)	
Beaver Lake Fishing	20201	polygon			19(26)	
Gravel Pit	4083	polygon			daily	X
Maligne - Home Bay to Islan	20053	polygon			18(38)	
Maligne Bridge 1 - 2	4103	polygon			18(53)	
Maligne Home Bay	20214	polygon			18(65)	
Maligne Lake Day Use Area	4076	polygon			daily	
Maligne Lake South	20153	polygon				X
Maligne Lake Warden Area	3557	polygon				X
Maligne River	4105	polygon			10(30)	
Maligne River Below Big Ben	4104	polygon			10(24)	
Maligne River; Home Bay	4102	polygon			10(30)	
Medicine Lake Fishing	20194	polygon			13(13)	
Medicine Lake North	4130	polygon			13(10)	
Medicine Teahouse Pit	4080	polygon			daily	X
Pit 28	4081	polygon			daily	X

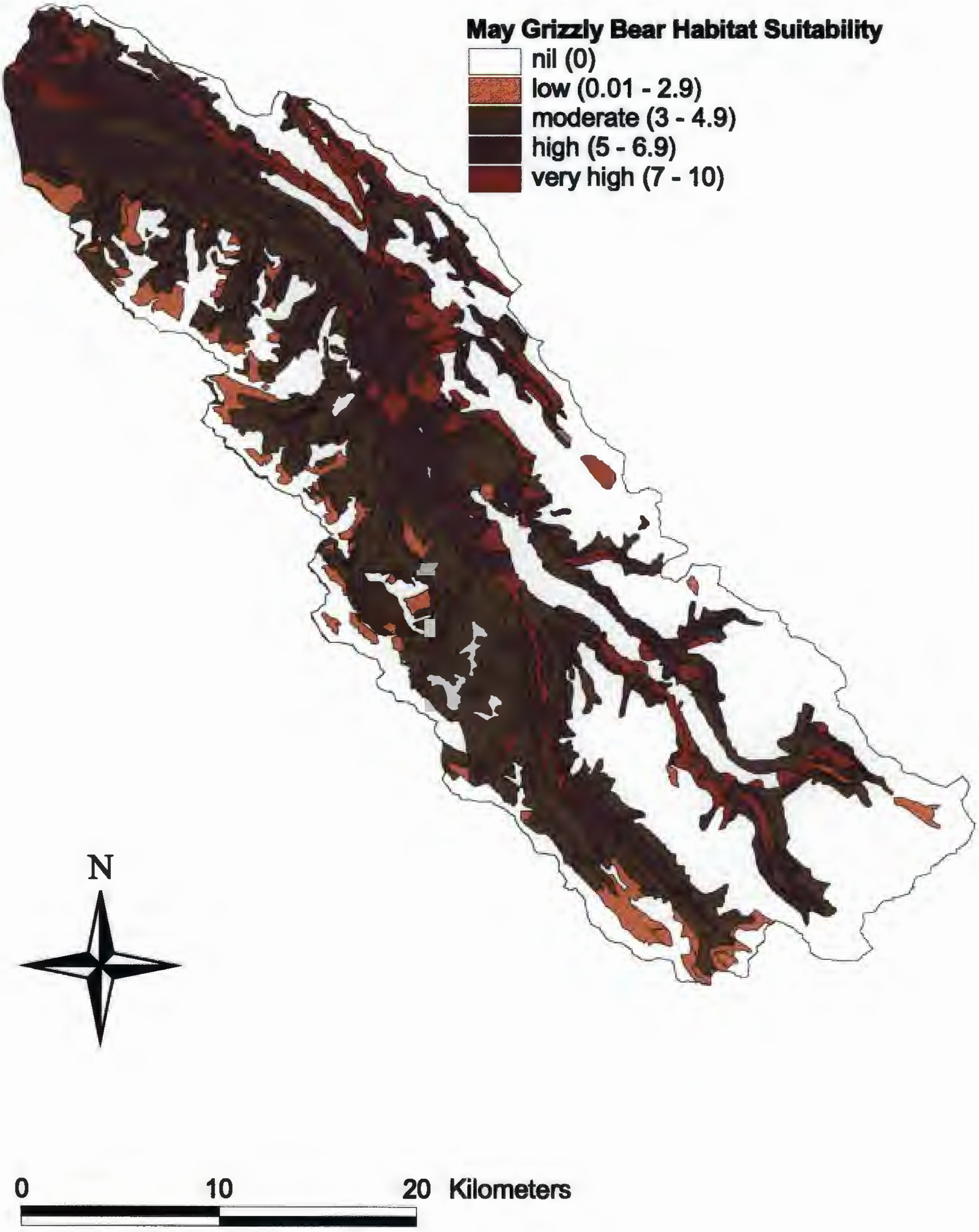
a. monitoring continuously
b. number of weeks monitored
c. number of days monitored
*** also known as Wardenshore**
**** part of the Bald Hills trail**
***** part of the Opal Hills trail**
****** also monitored by vehicle counts**
parentheses indicate the number of additional days of sampling during routine patrols

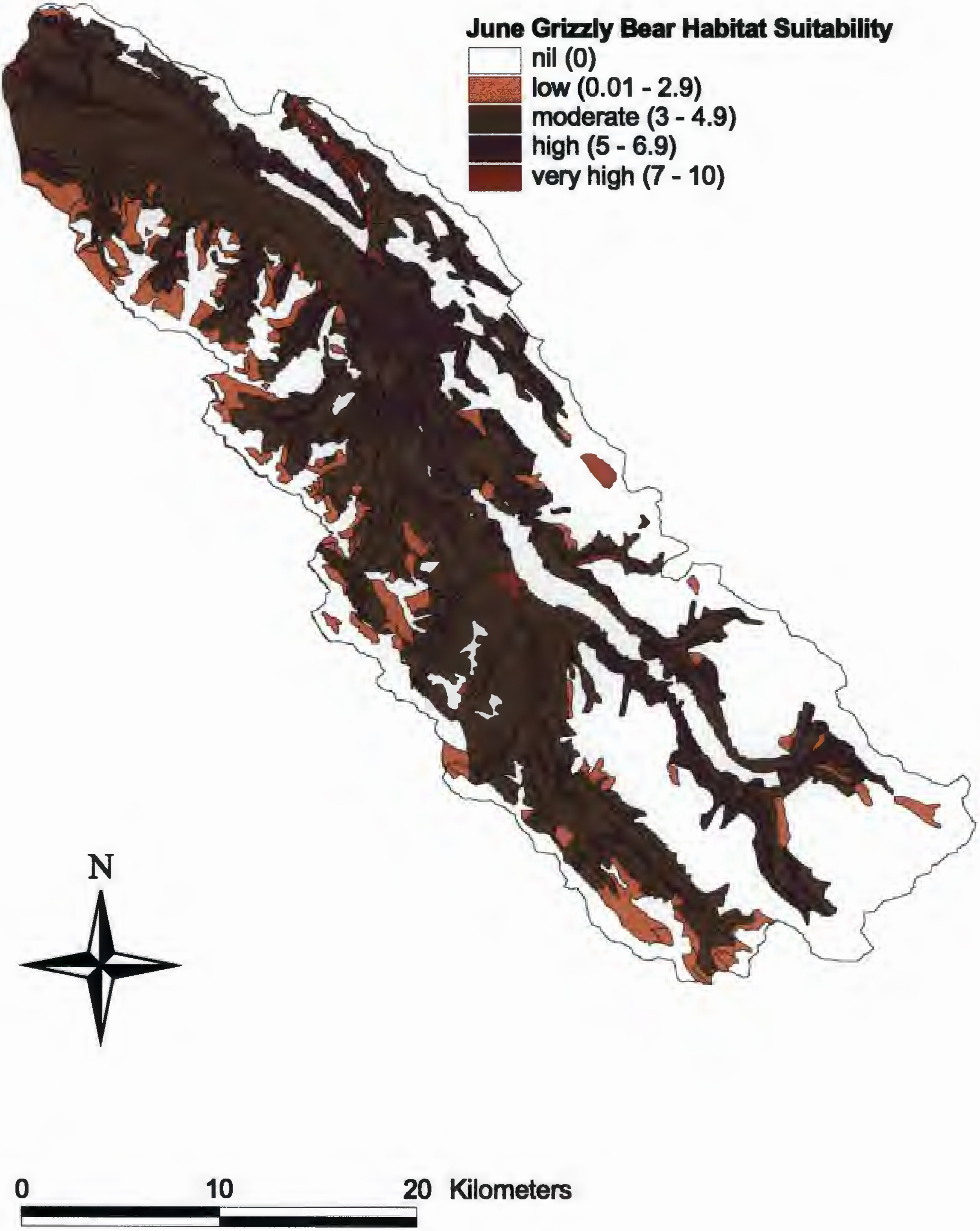
APPENDIX B

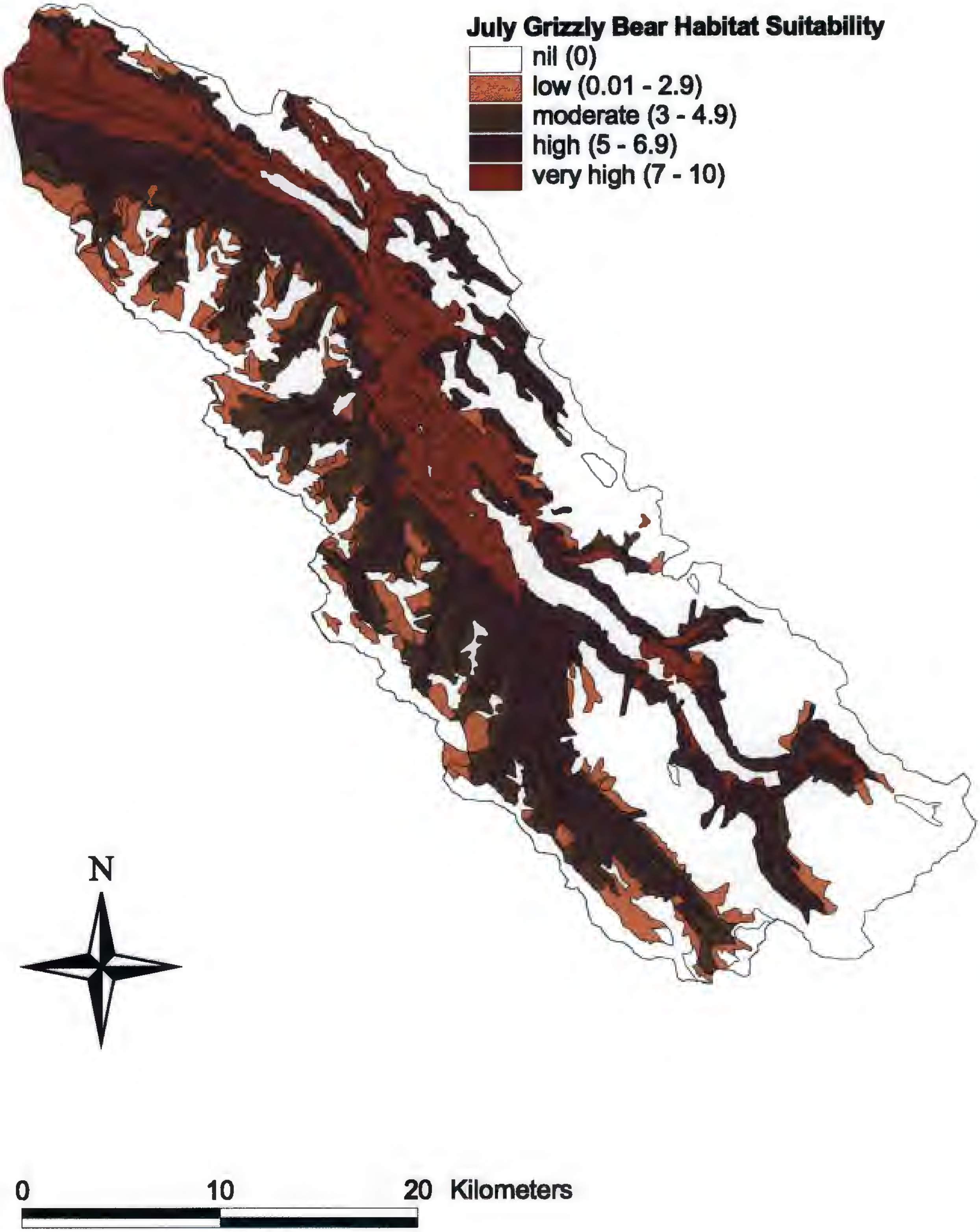
Monthly habitat suitability maps for

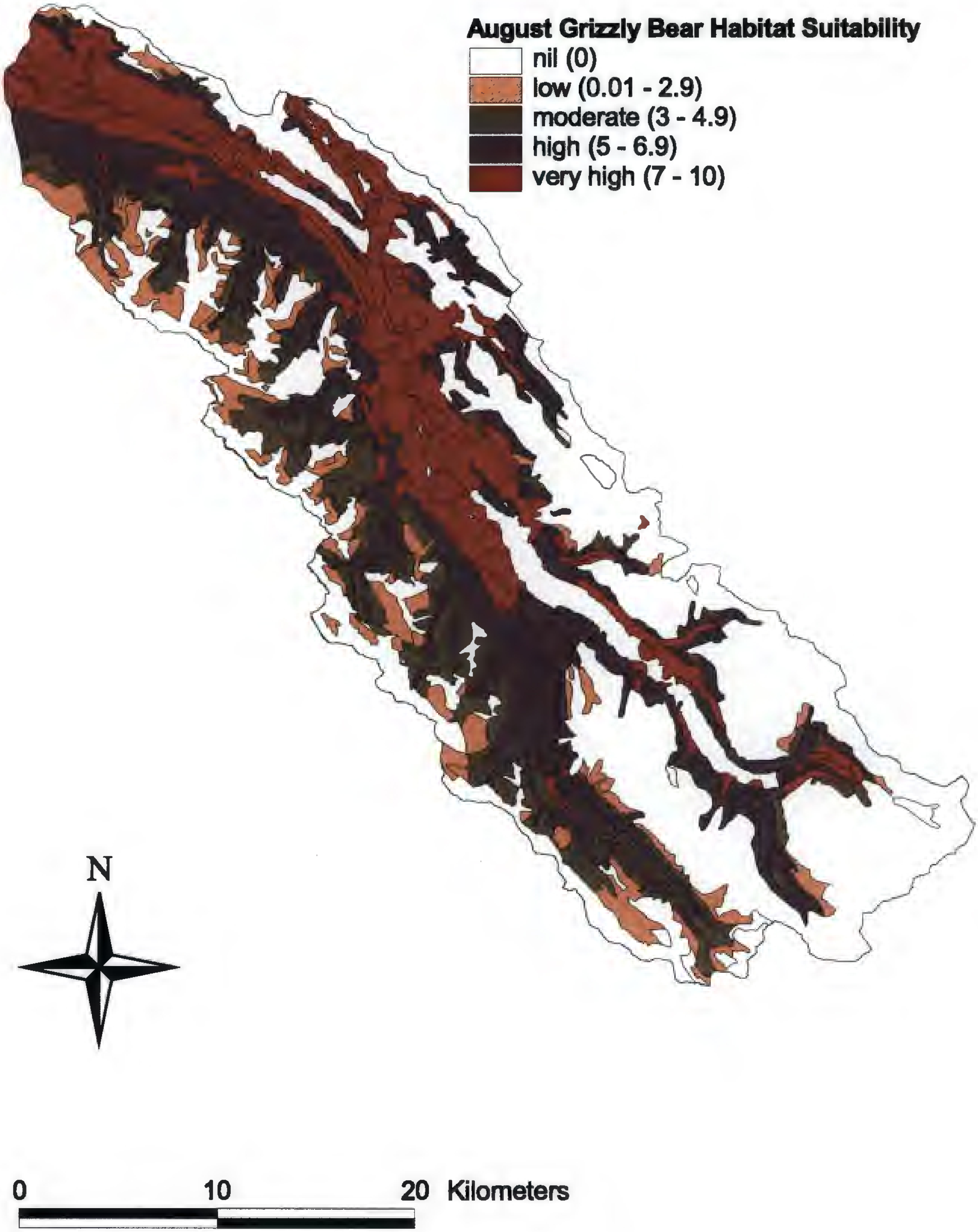
the Maligne Valley from April to October.

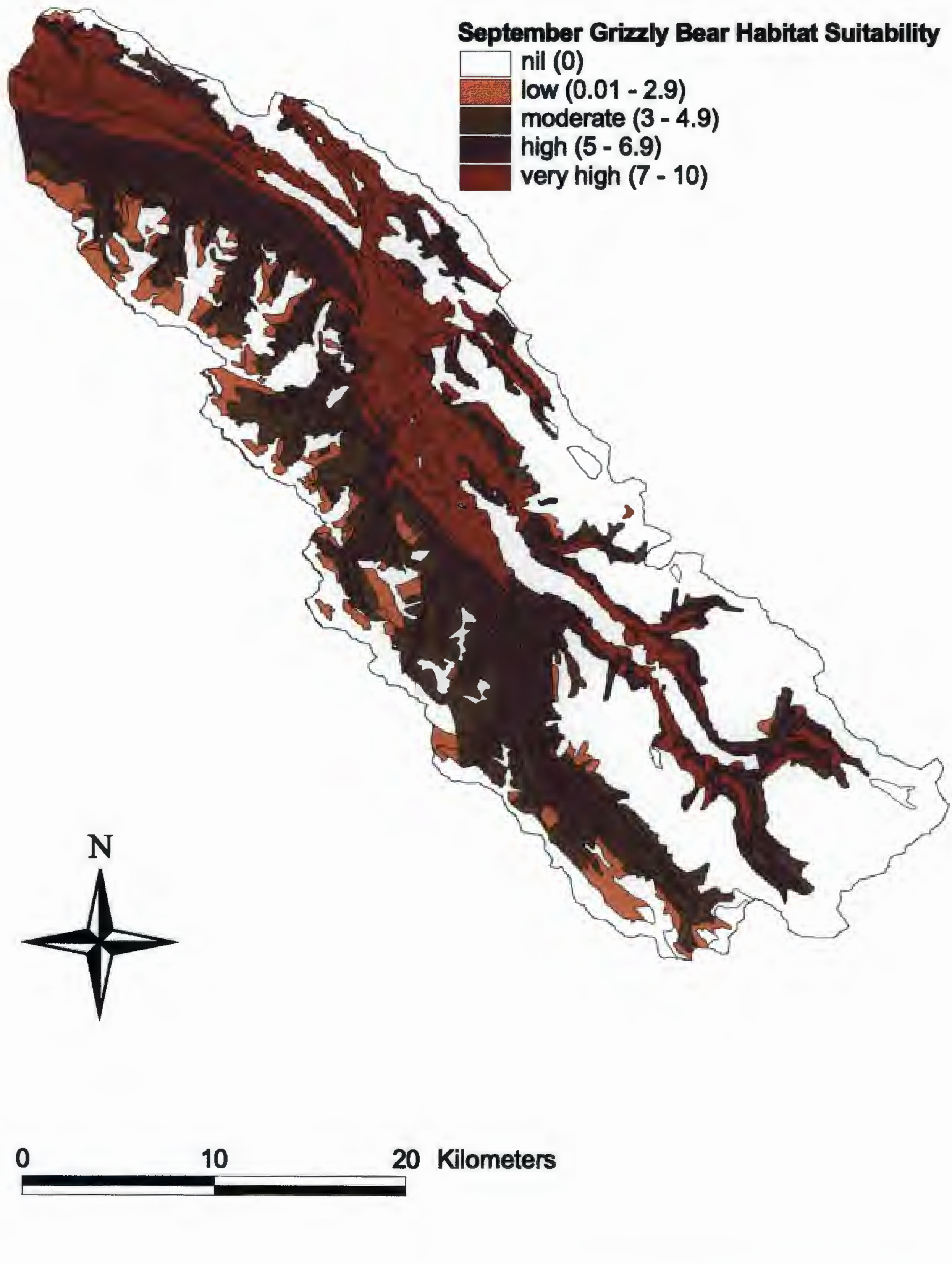

April Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers

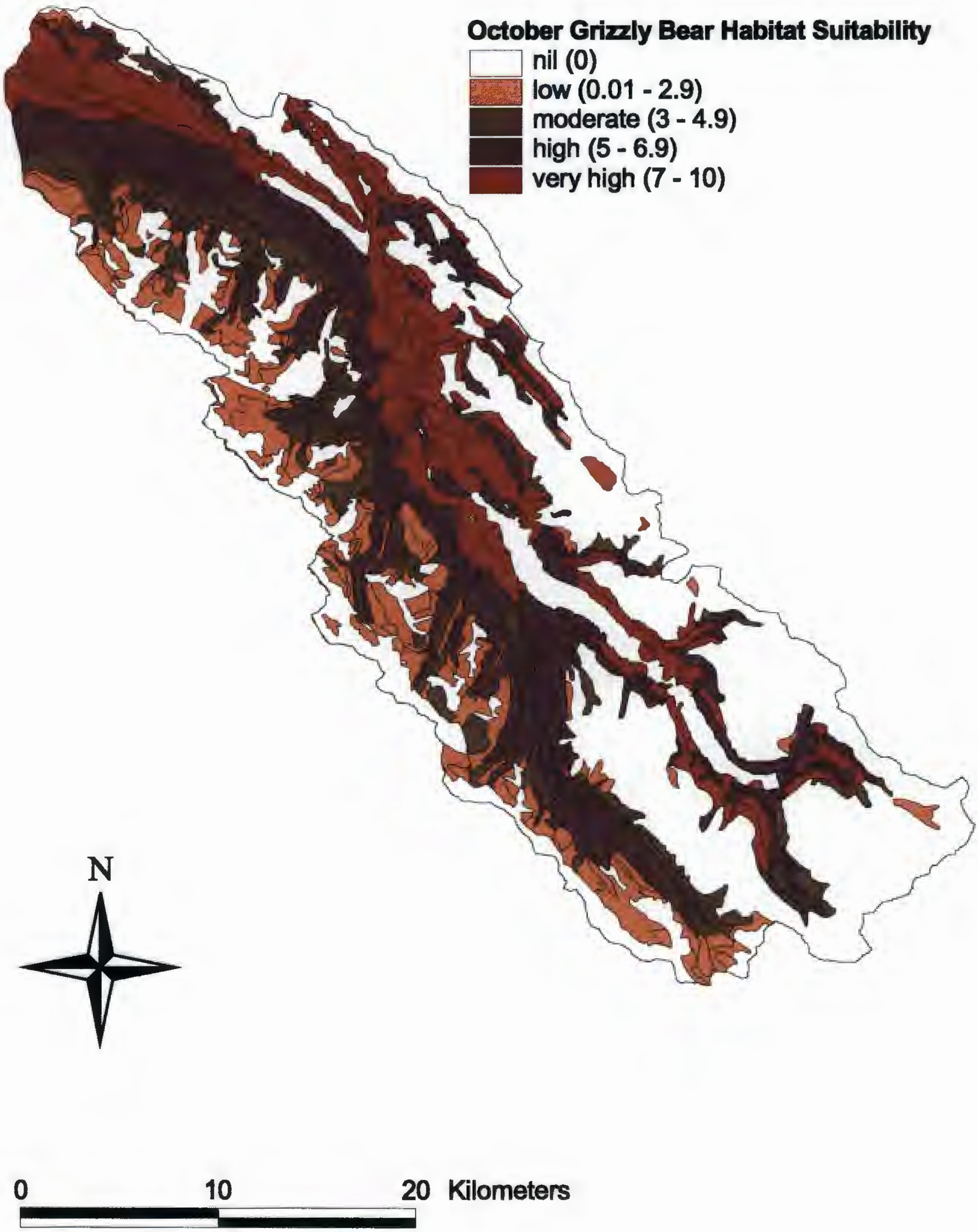

May Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers


June Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers


July Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers


August Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers


September Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers


October Grizzly Bear Habitat Suitability
nil (0)
low (0.01 - 2.9)
moderate (3 - 4.9)
high (5 - 6.9)
very high (7 - 10)
N
0
10
20 Kilometers

APPENDIX C

Displacement coefficients (DC) and zones of influence (ZOI) in the habitat effectiveness model for the Maligne Valley, Jasper National Park, 1997.

Table C1. Displacement coefficients (DC) and zones of influence (ZOI) in the habitat effectiveness model for the Maligne Valley, Jasper National Park, 1997.

Motorized Point Features	DC	ZOI (m)
high use* / cover	0.37	805.0
high use / non-cover	0.16	
low use** / cover	0.73	805.0
low use / non-cover	0.64	
Motorized Linear Features		
high use / cover	0.37	805.0
high use / non-cover	0.16	
low use / cover	0.73	805.0
low use / non-cover	0.64	
Motorized Dispersed Features		
high use / cover	0.37	805.0
high use / non-cover	0.16	
low use / cover	0.73	805.0
low use / non-cover	0.64	
Non-Motorized Point Features		
high use / cover	0.50	402.5
high use / non-cover	0.33	
low use / cover	0.88	402.5
low use / non-cover	0.83	
Non-Motorized Linear Features		
high use / cover	0.65	402.5
high use / non-cover	0.56	
low use / cover	0.88	402.5
low use / non-cover	0.83	
Non-Motorized Dispersed Features		
high use / cover	0.50	402.5
high use / non-cover	0.33	
low use / cover	0.88	402.5
low use / non-cover	0.83	

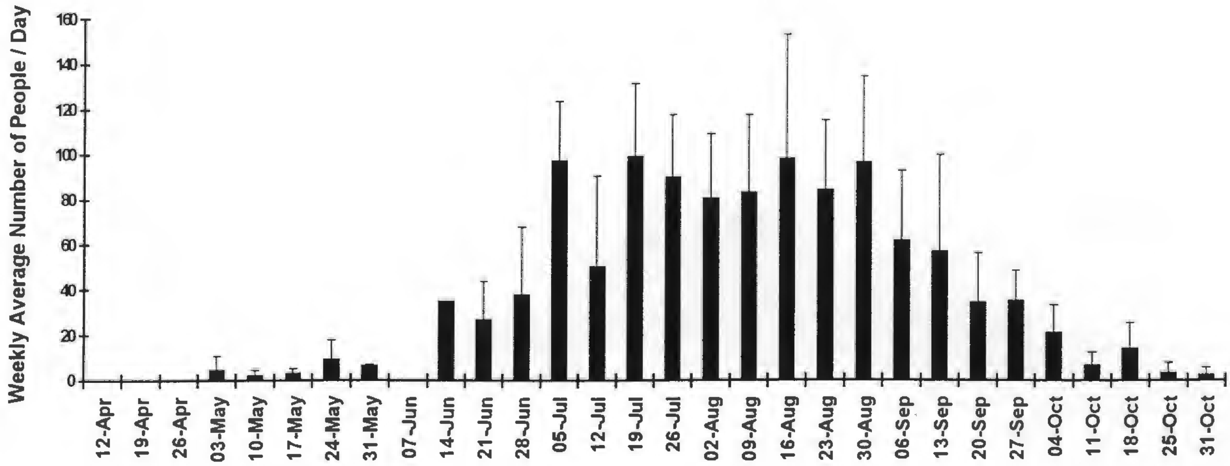
*high use >100 people / vehicles per month
**low use ≤100 people / vehicles per month

APPENDIX D

The weekly average number of people per day and the change in frequency of use accumulated over the season on electronically surveyed trails in the Maligne Valley, Jasper National Park, from April 1 to October 31, 1997.

Fig. D1. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Bald Hills trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
160
140
120
100
80
60
40
20
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

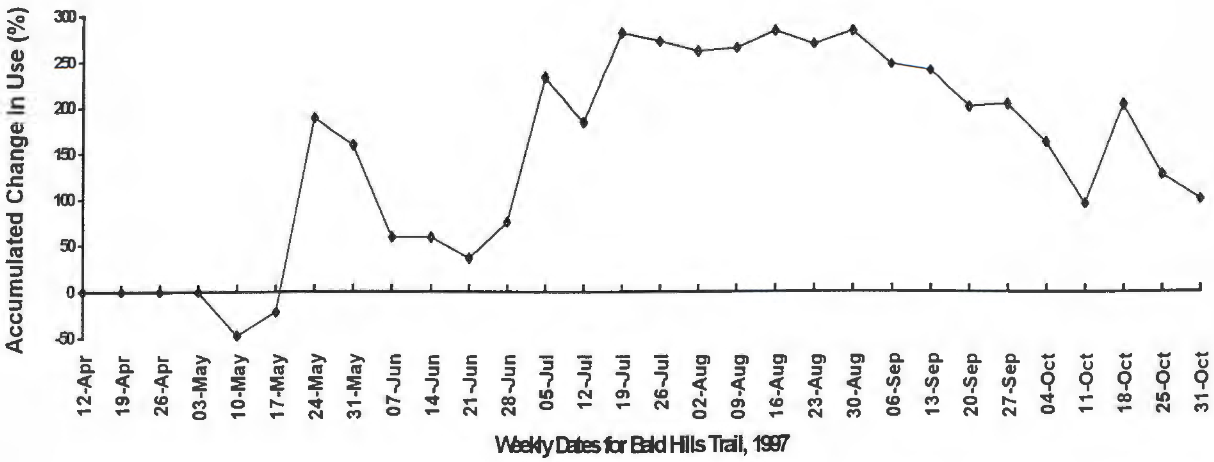
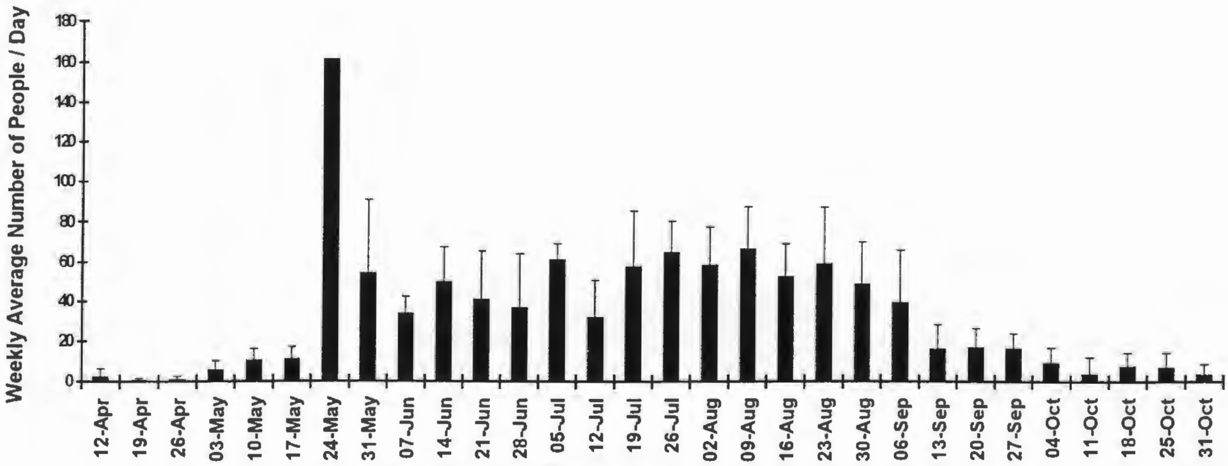

Accumulated Change In Use (%)
300
250
200
150
100
50
0
-50
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Bald Hills Trail, 1997

Fig. D2. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Beaver Lake trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
0
20
40
60
80
100
120
140
160
180
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

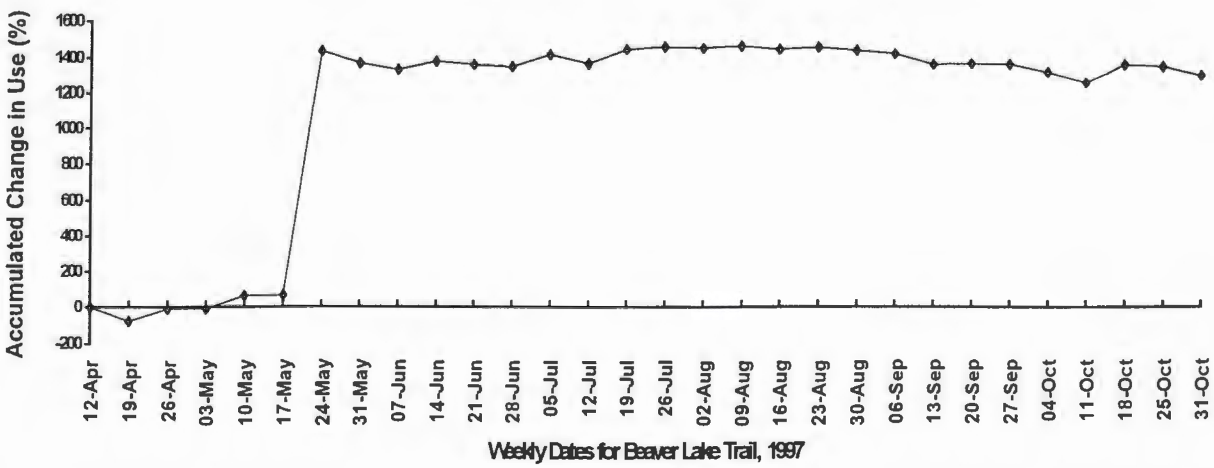
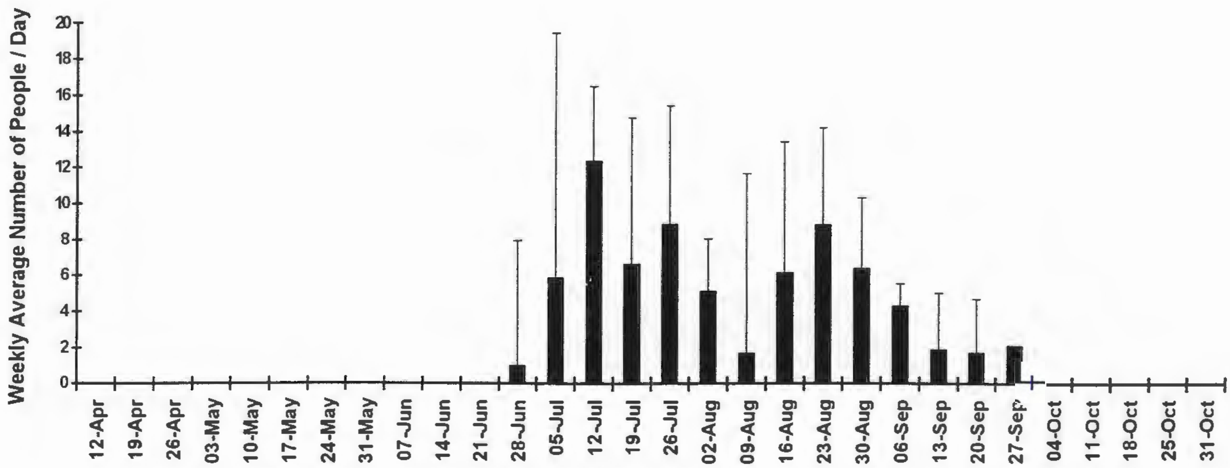

Accumulated Change in Use (%)
-200
0
200
400
600
800
1000
1200
1400
1600
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Beaver Lake Trail, 1997

Fig. D3. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Coronet Creek trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
0
2
4
6
8
10
12
14
16
18
20
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

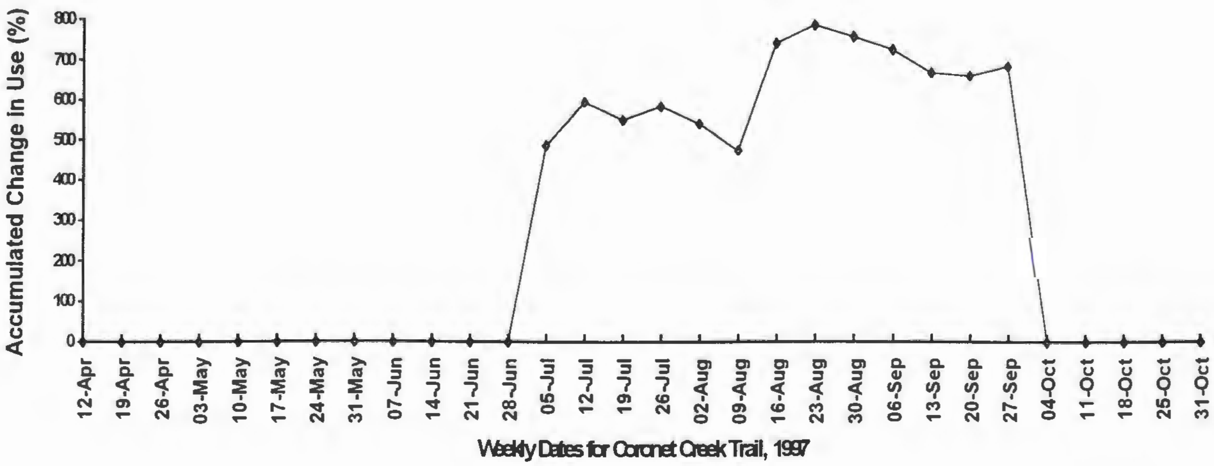
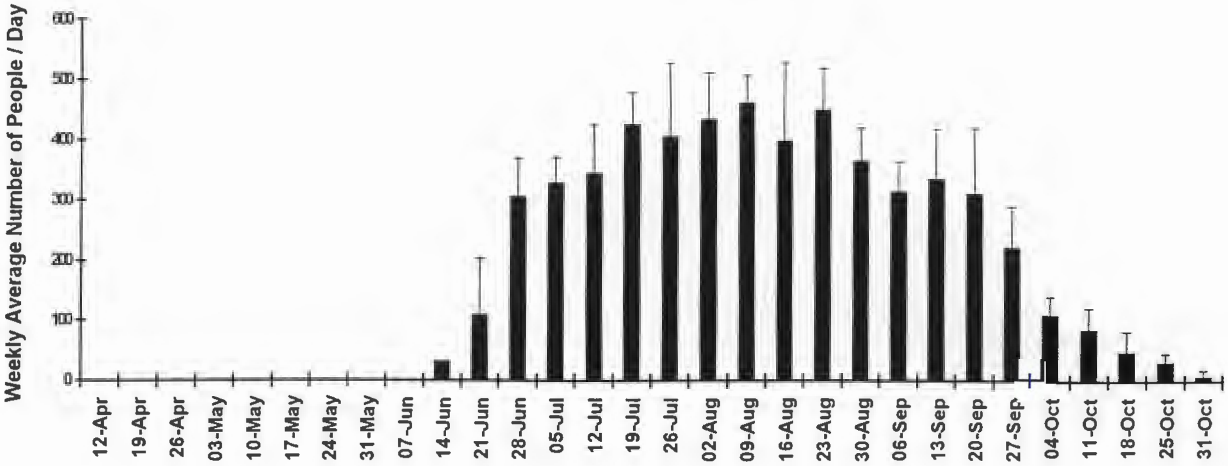

Accumulated Change in Use (%)
0
100
200
300
400
500
600
700
800
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Coronet Creek Trail, 1997

Fig. D4. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Lakeshore trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
600
500
400
300
200
100
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

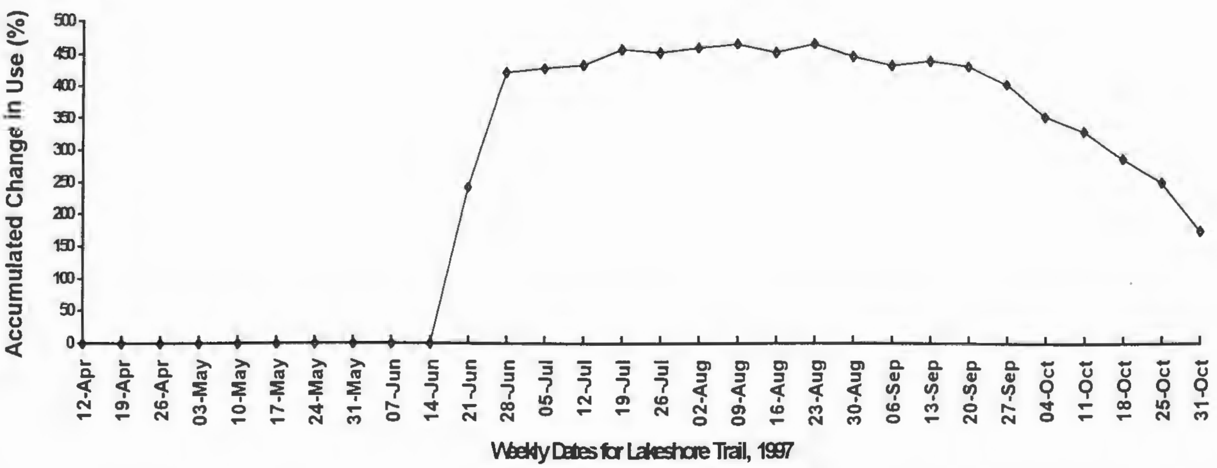
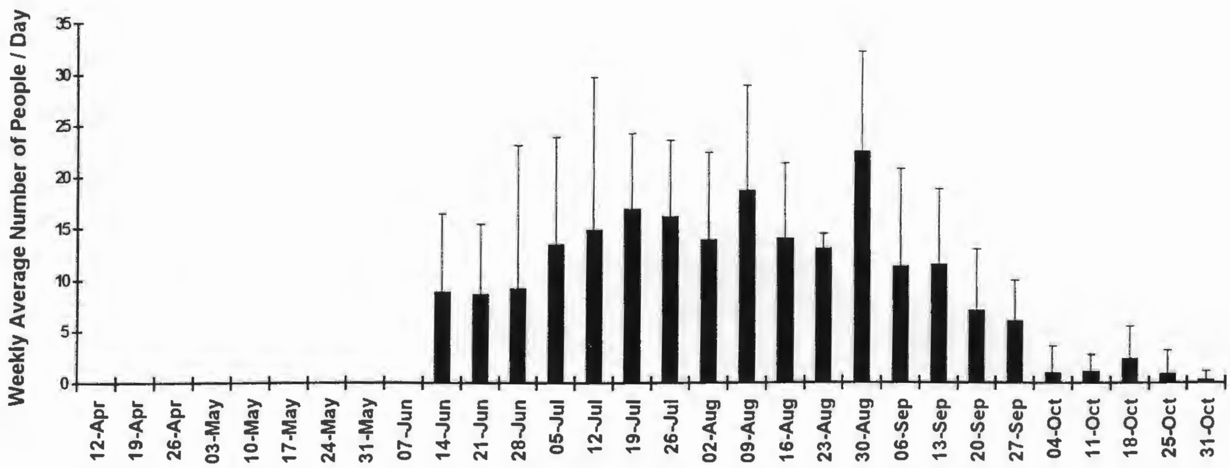

Accumulated Change in Use (%)
500
450
400
350
300
250
200
150
100
50
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Lakeshore Trail, 1997

Fig. D5. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Lorraine Lake trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
35
30
25
20
15
10
5
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

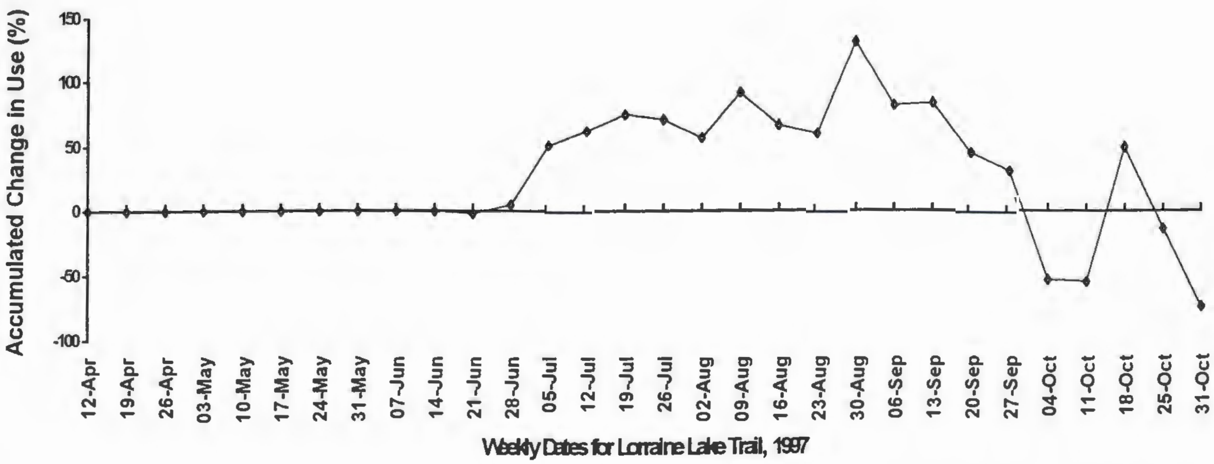
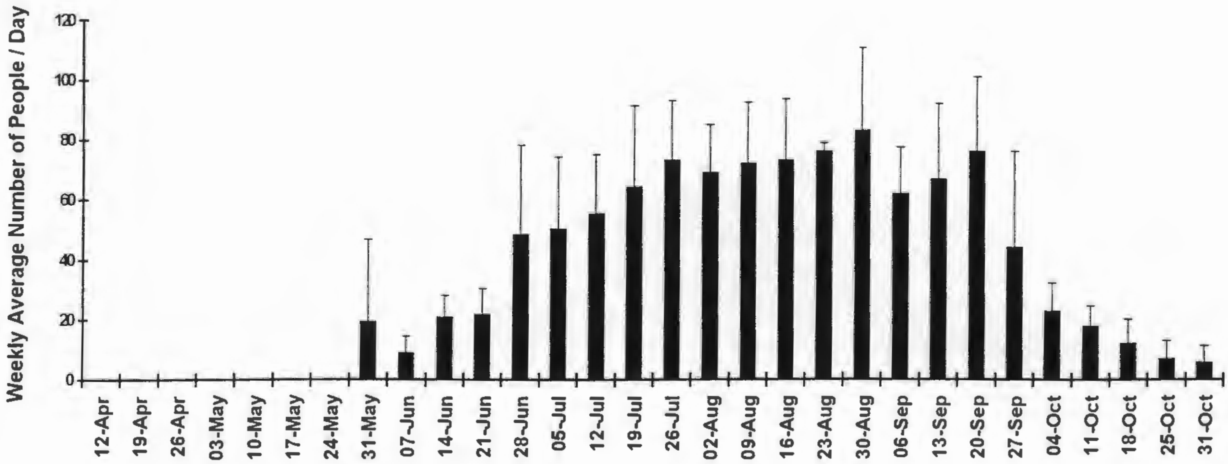

Accumulated Change in Use (%)
150
100
50
0
-50
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Lorraine Lake Trail, 1997

Fig. D6. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Moose Lake trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
120
100
80
60
40
20
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

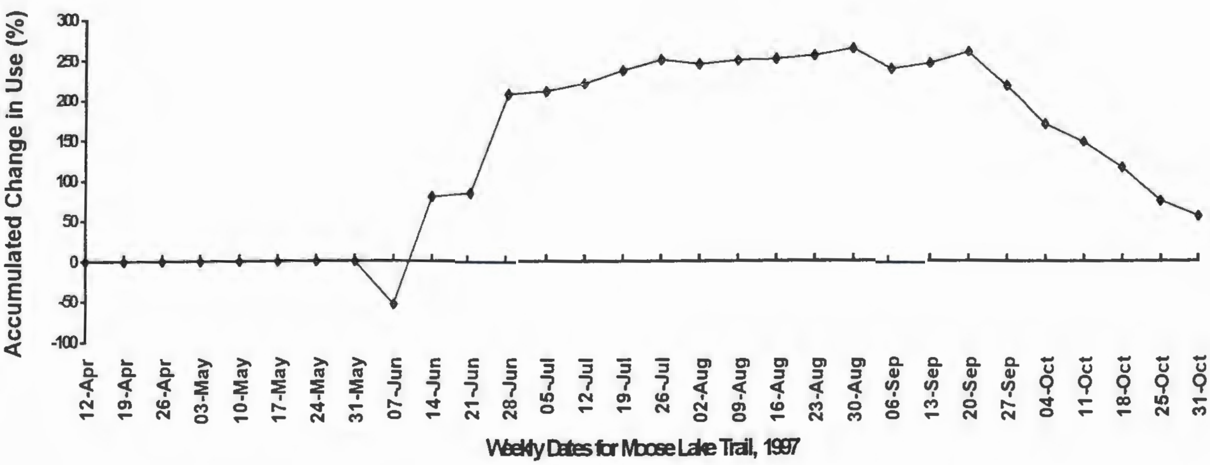
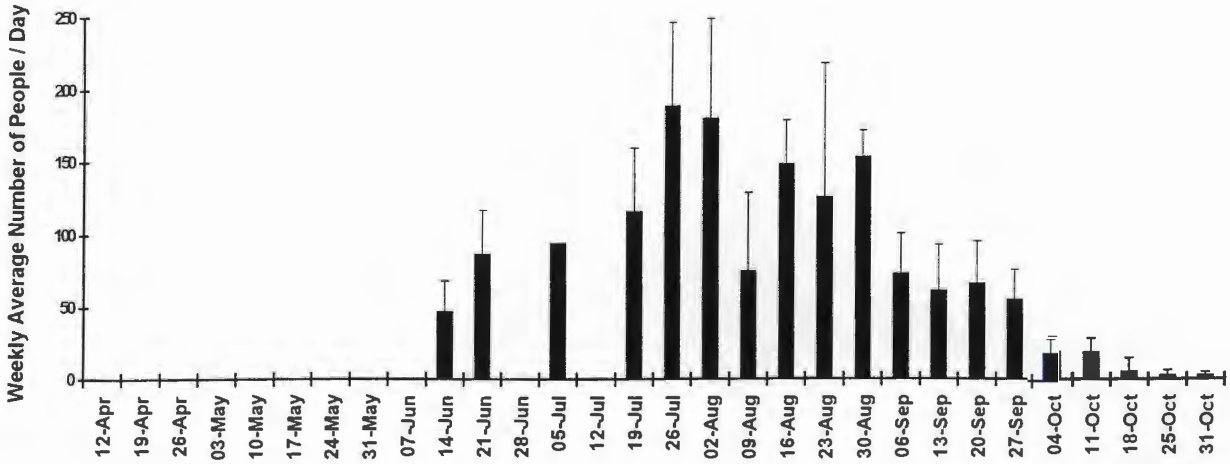

Accumulated Change in Use (%)
300
250
200
150
100
50
0
-50
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Moose Lake Trail, 1997

Fig. D7. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Opal Hills trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
250
200
150
100
50
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

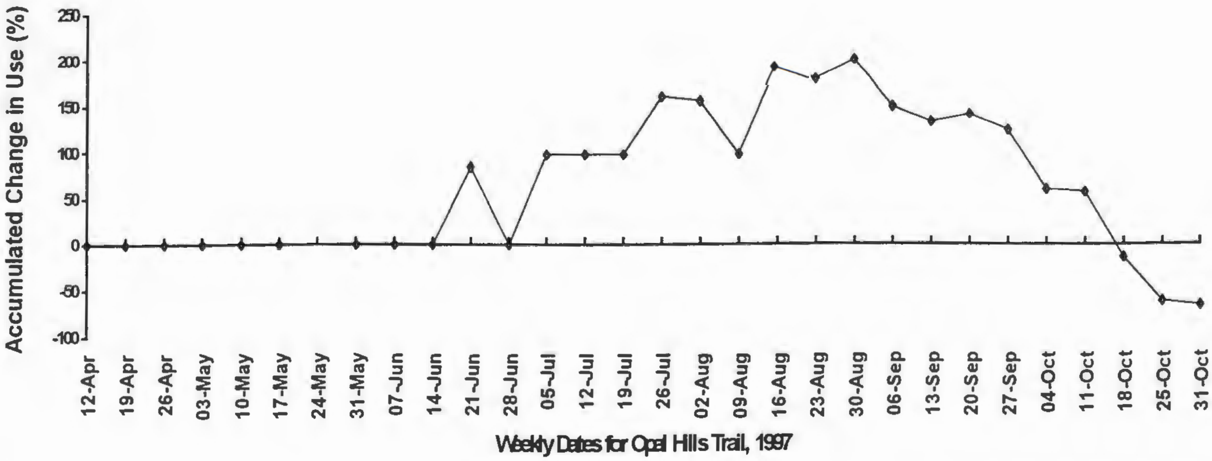
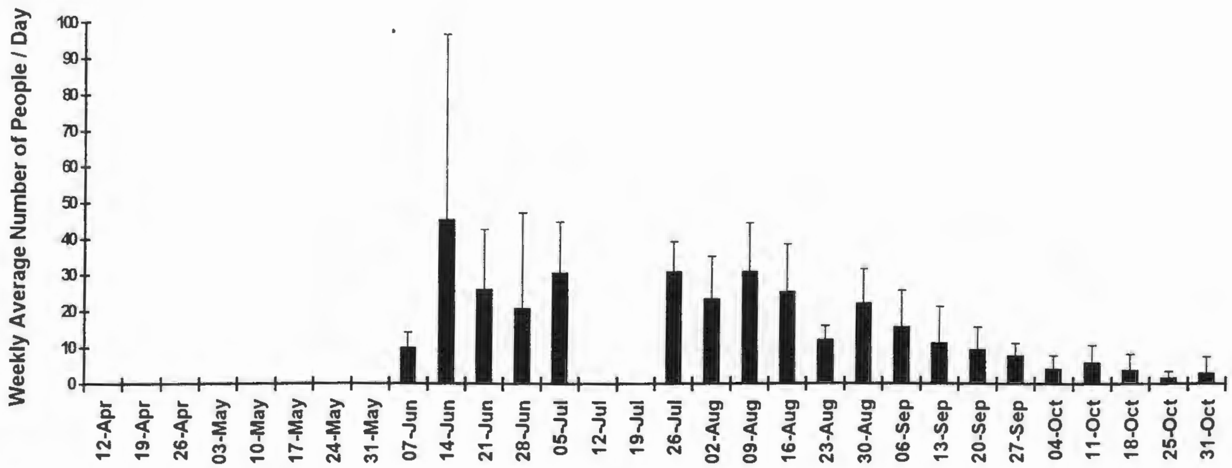

Accumulated Change in Use (%)
250
200
150
100
50
0
-50
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Opal Hills Trail, 1997

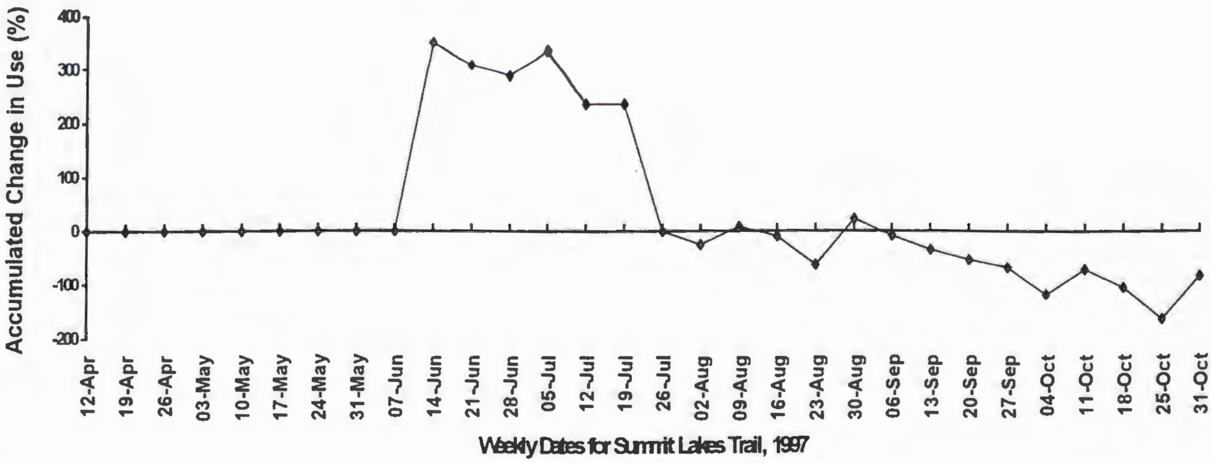
Fig. D8. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Summit Lake trail in Jasper National Park. Dates are the end of each weekly period.

A



Weekly Average Number of People / Day
0
10
20
30
40
50
60
70
80
90
100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

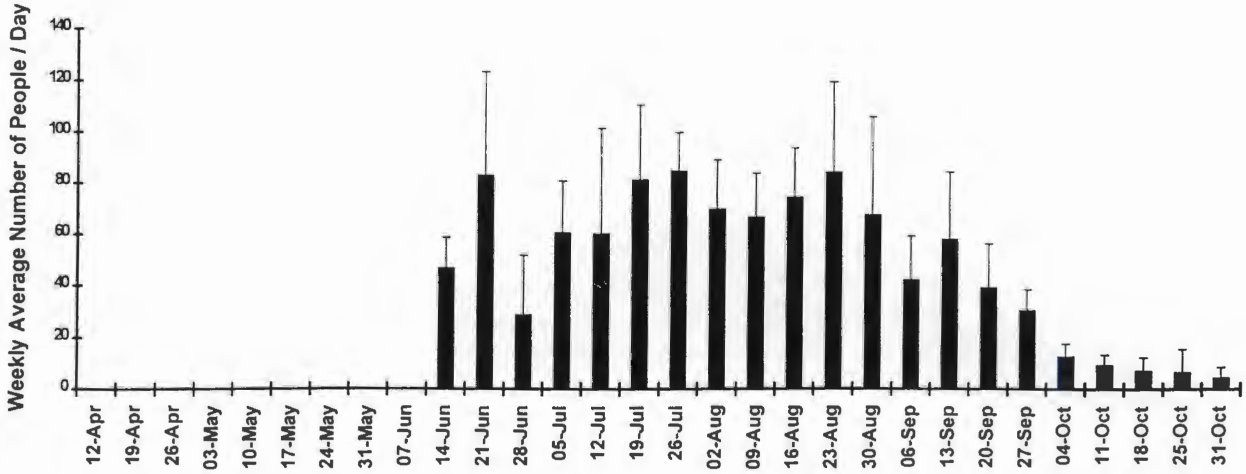
B



Accumulated Change in Use (%)
400
300
200
100
0
-100
-200
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Summit Lakes Trail, 1997

Fig. D9. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Wardenshore trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
140
120
100
80
60
40
20
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

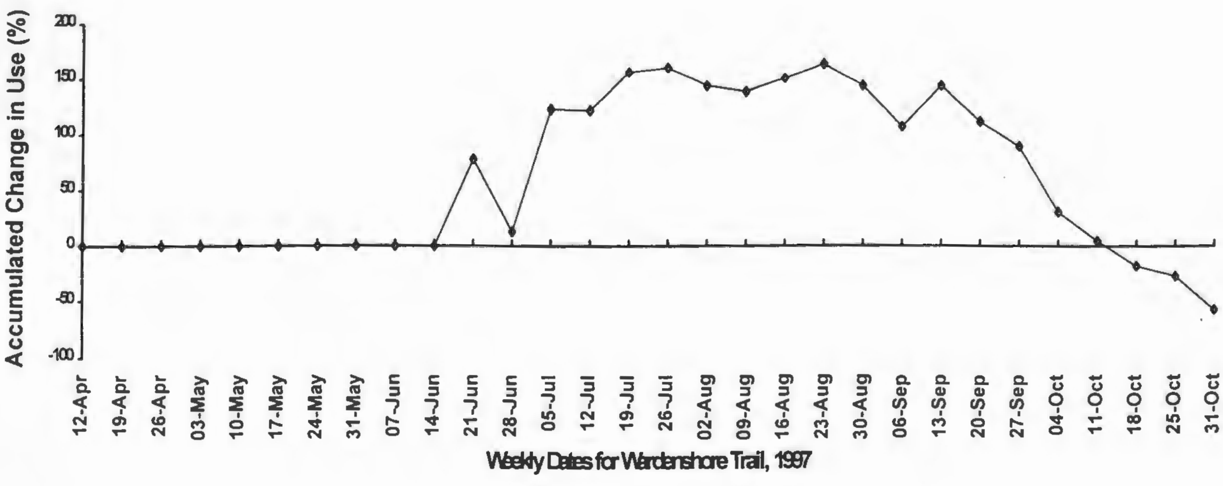
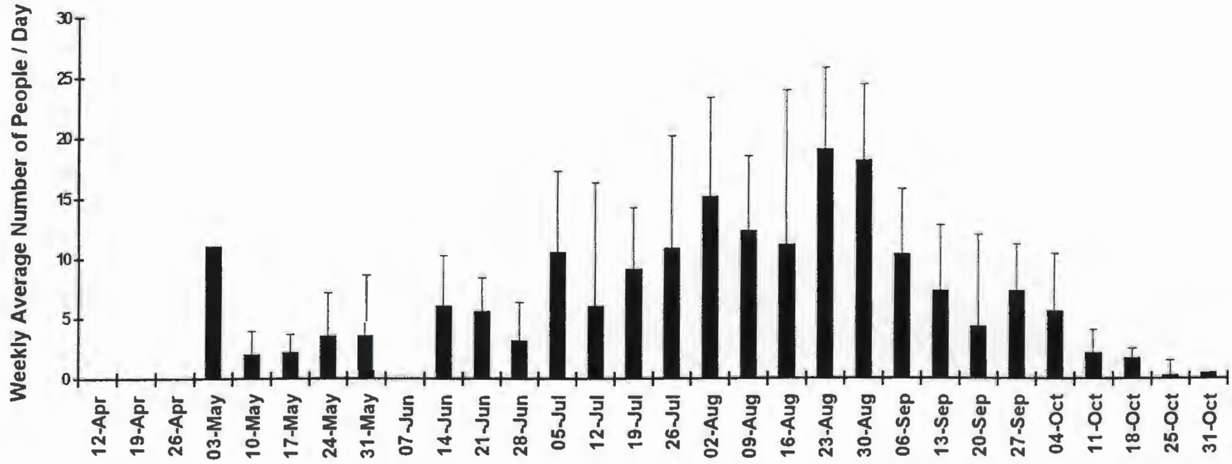
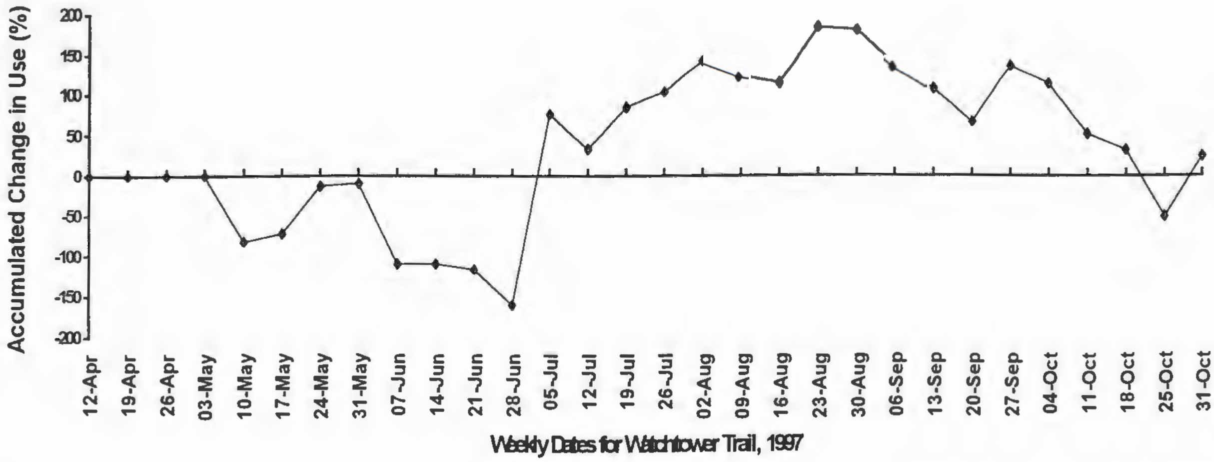

Accumulated Change in Use (%)
200
150
100
50
0
-50
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Wardenshore Trail, 1997

Fig. D10. The average number of people per day ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for the Watchtower trail in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
30
25
20
15
10
5
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

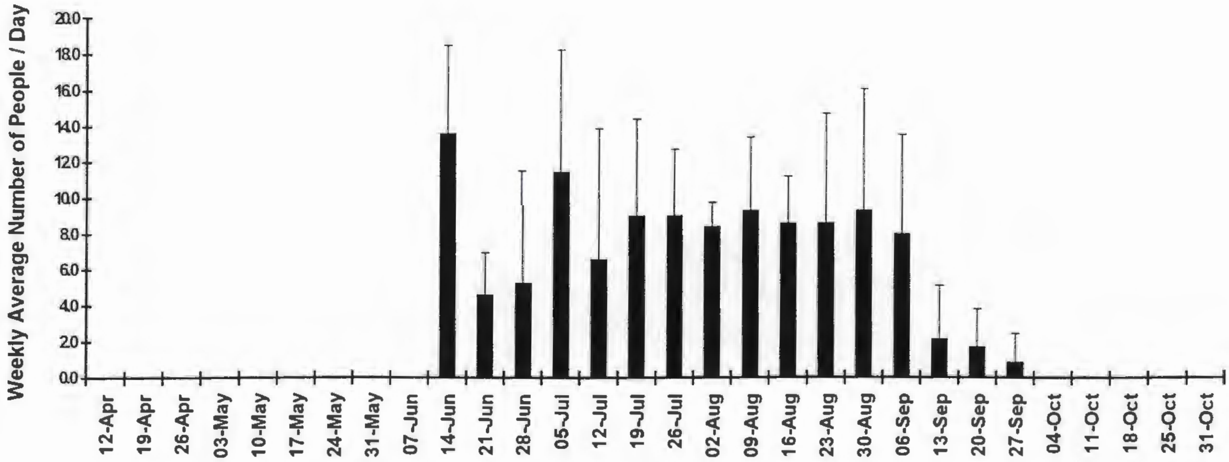

Accumulated Change in Use (%)
200
150
100
50
0
-50
-100
-150
-200
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Watchtower Trail, 1997

APPENDIX E

The weekly average number of campground users and the change in frequency of use accumulated over the season in the Maligne Valley, Jasper National Park, from April 1 to October 31, 1997.

Fig. E1. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Coronet Creek campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

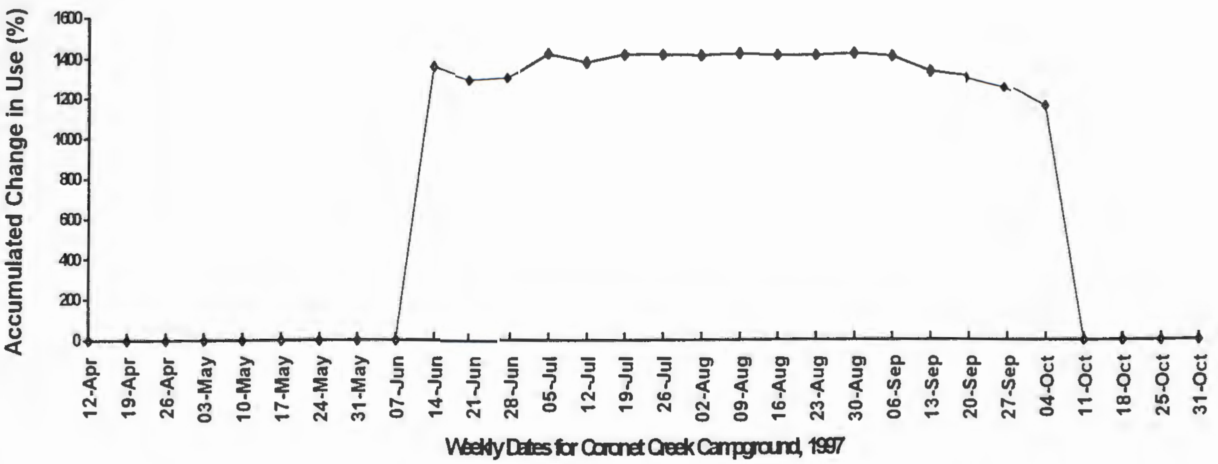
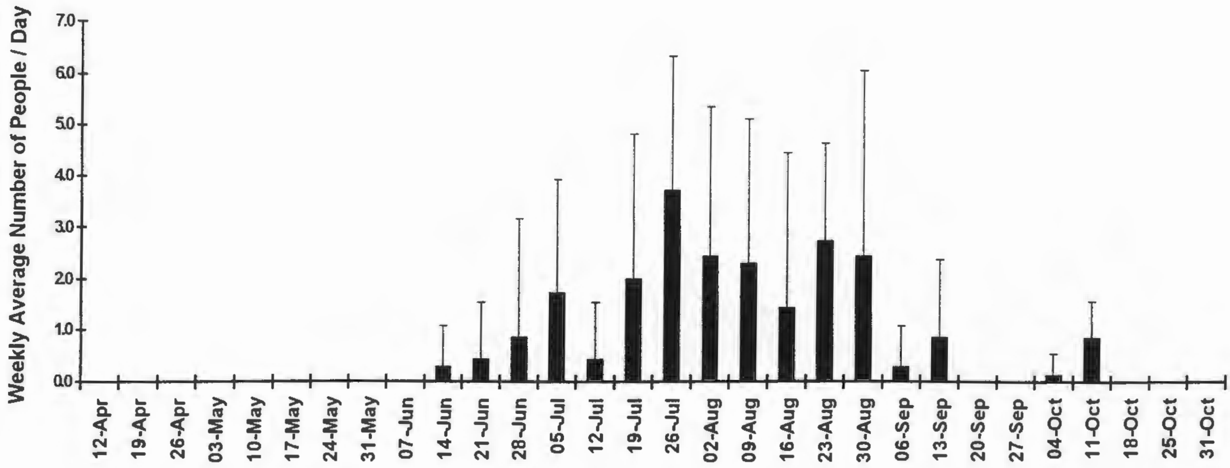

Accumulated Change in Use (%)
1600
1400
1200
1000
800
600
400
200
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Coronet Creek Campground, 1997

Fig. E2. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Evelyn Creek campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

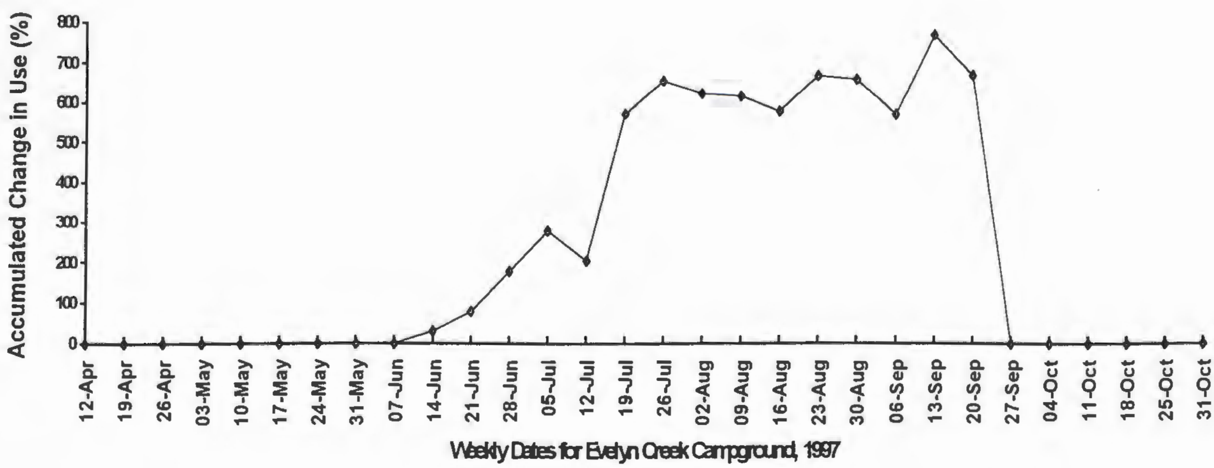
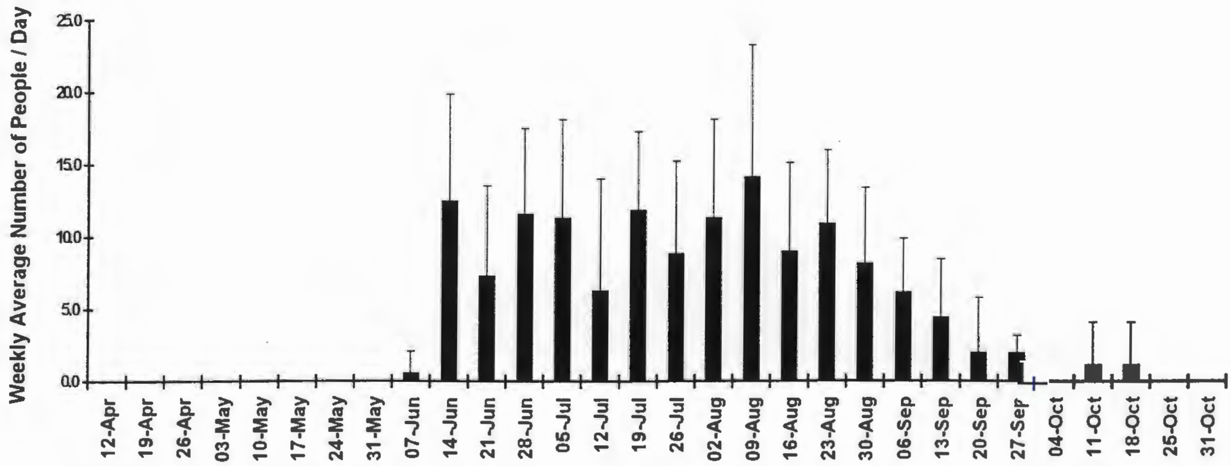

Accumulated Change in Use (%)
800
700
600
500
400
300
200
100
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Evelyn Creek Campground, 1997

Fig. E3. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Fisherman's Bay campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
25.0
20.0
15.0
10.0
5.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

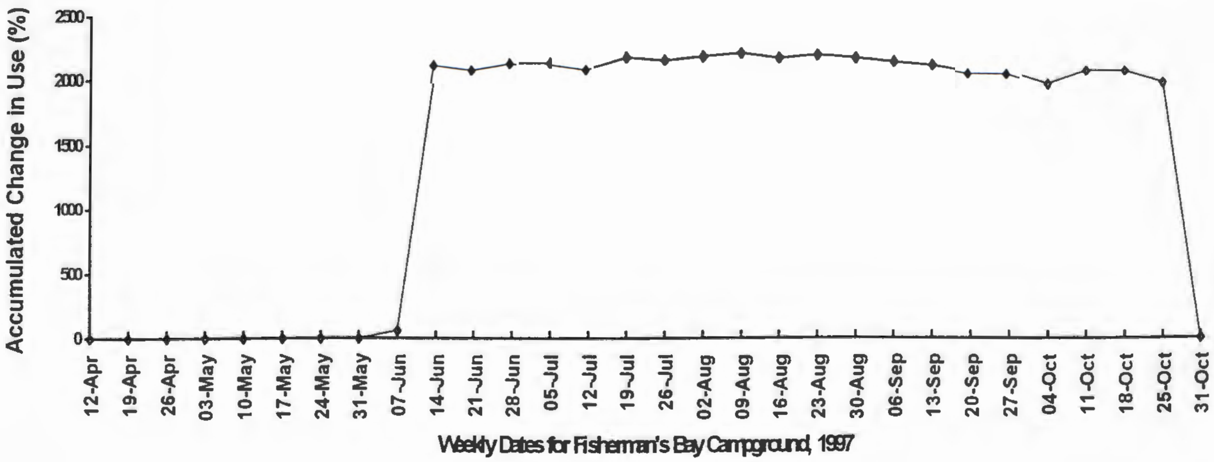
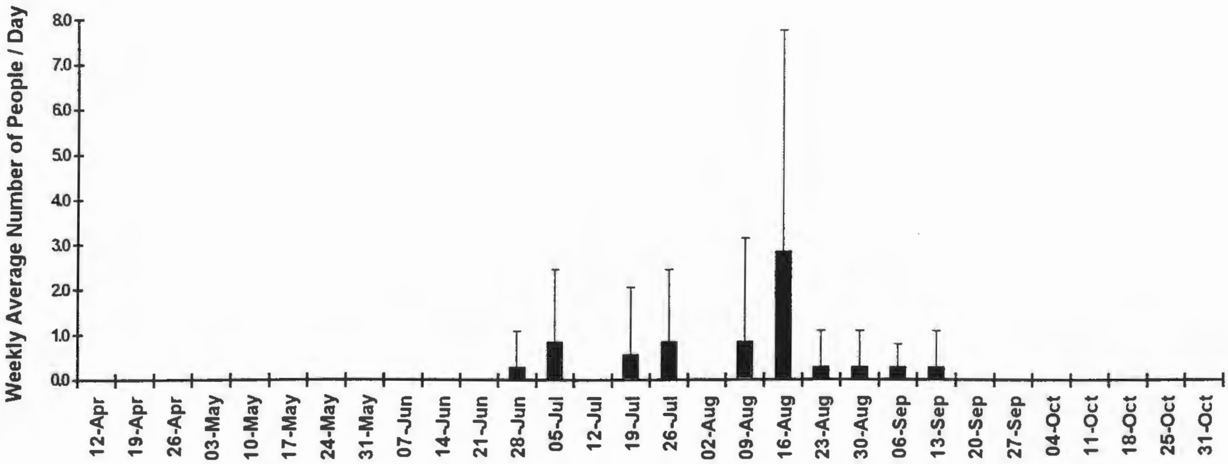

Accumulated Change in Use (%)
2500
2000
1500
1000
500
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Fisherman's Bay Campground, 1997

Fig. E4. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Henry McLeod campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

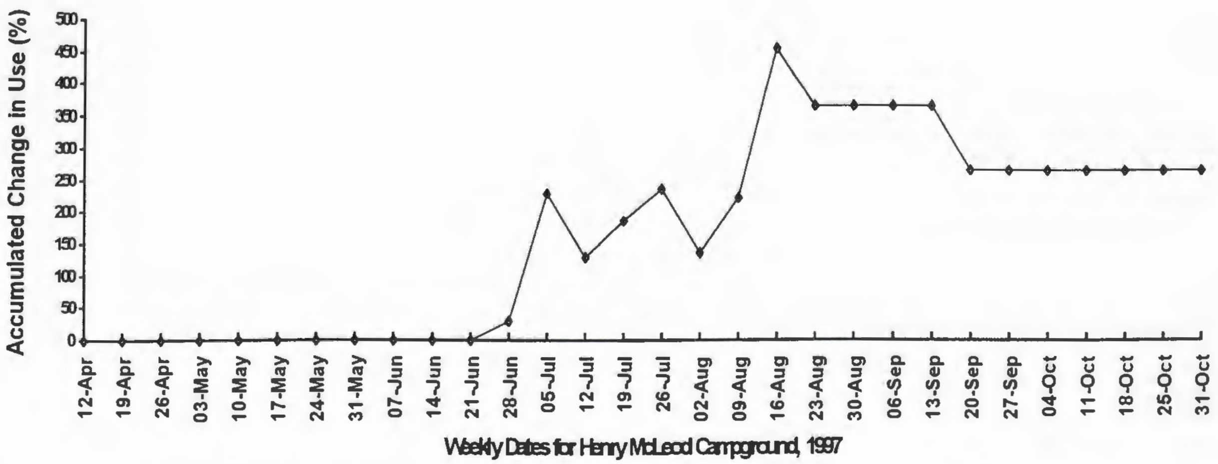
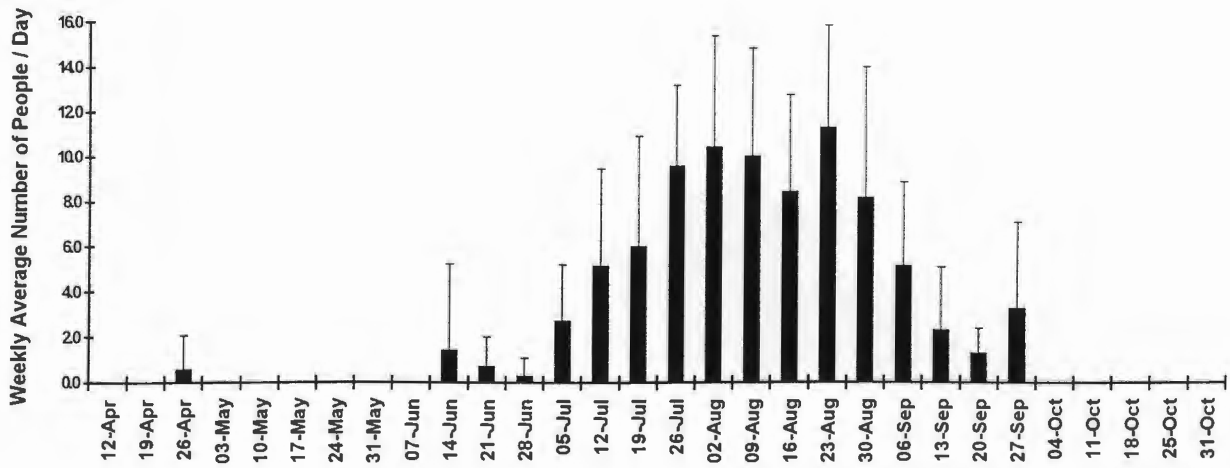

Accumulated Change in Use (%)
0
50
100
150
200
250
300
350
400
450
500
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Henry McLeod Campground, 1997

Fig. E5. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Little Shovel campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

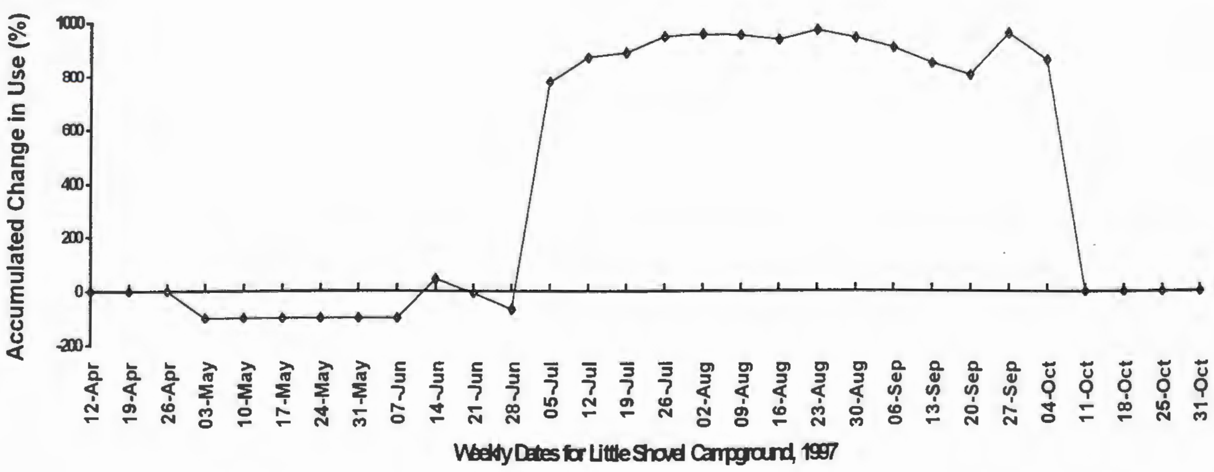
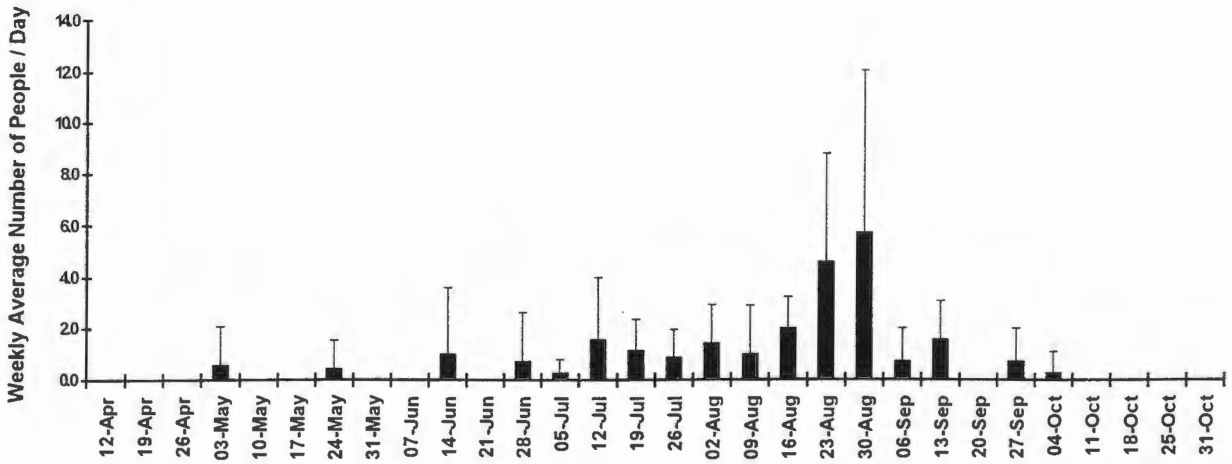

Accumulated Change in Use (%)
1000
800
600
400
200
0
-200
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Little Shovel Campground, 1997

Fig. E6. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Mary Schaffer campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

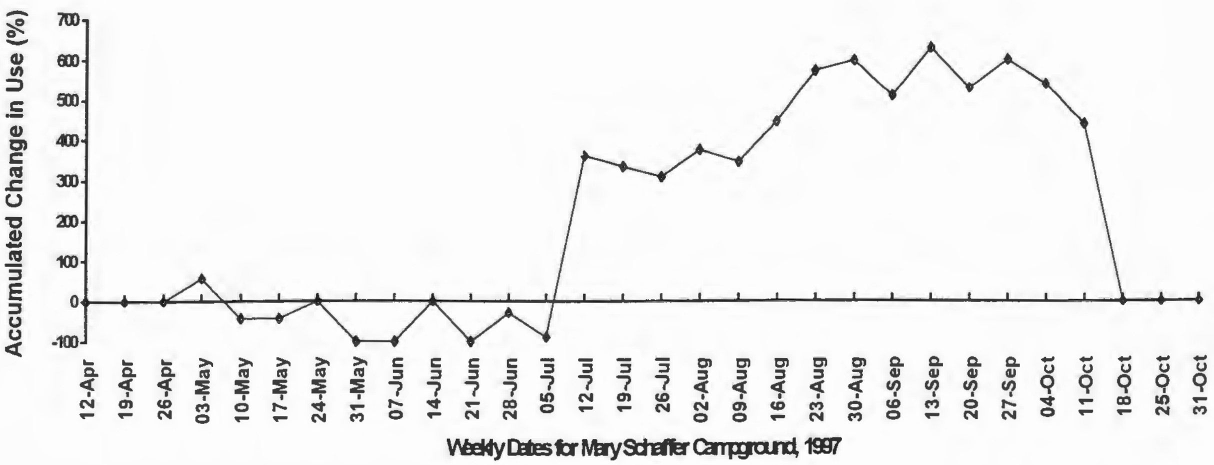
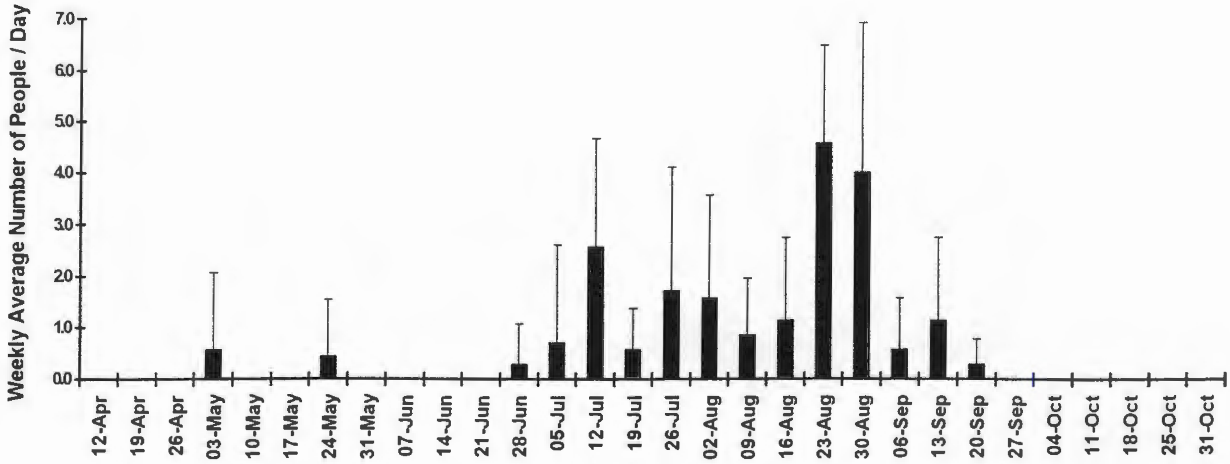

Accumulated Change in Use (%)
700
600
500
400
300
200
100
0
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Mary Schaffer Campground, 1997

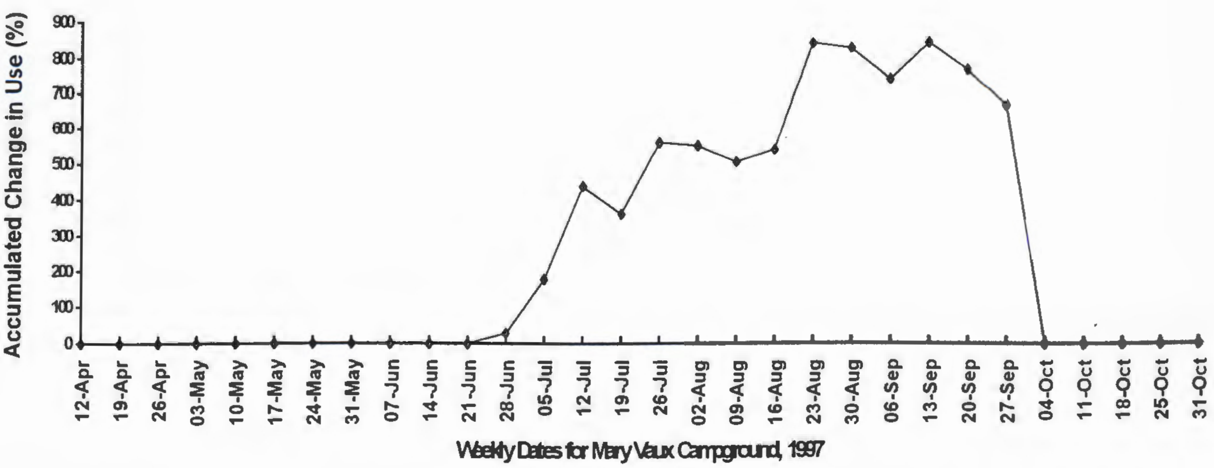
Fig. E7. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Mary Vaux campground in Jasper National Park. Dates are the end of each weekly period.

A



Weekly Average Number of People / Day
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

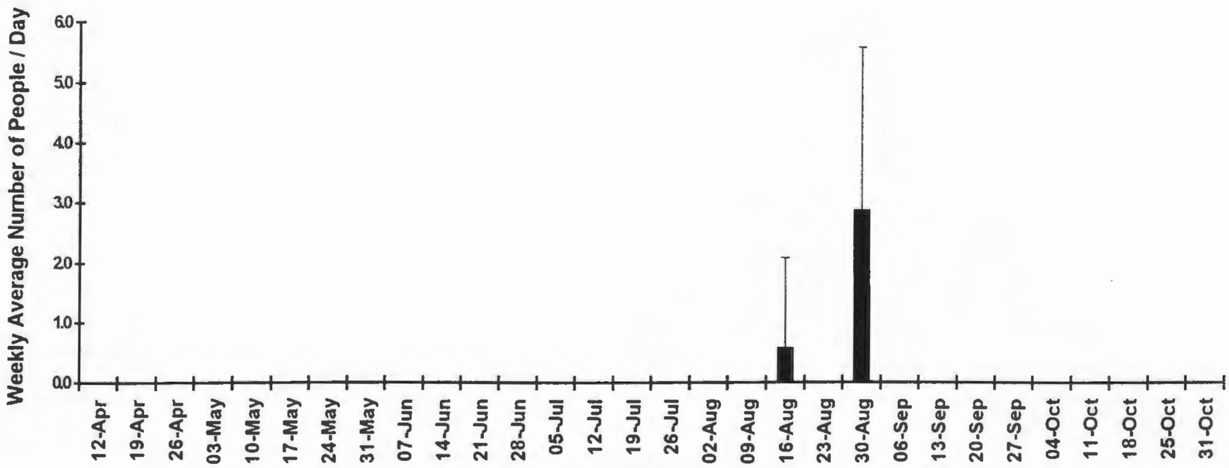
B



Accumulated Change in Use (%)
900
800
700
600
500
400
300
200
100
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Mary Vaux Campground, 1997

Fig. E8. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Old Horse Camp campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

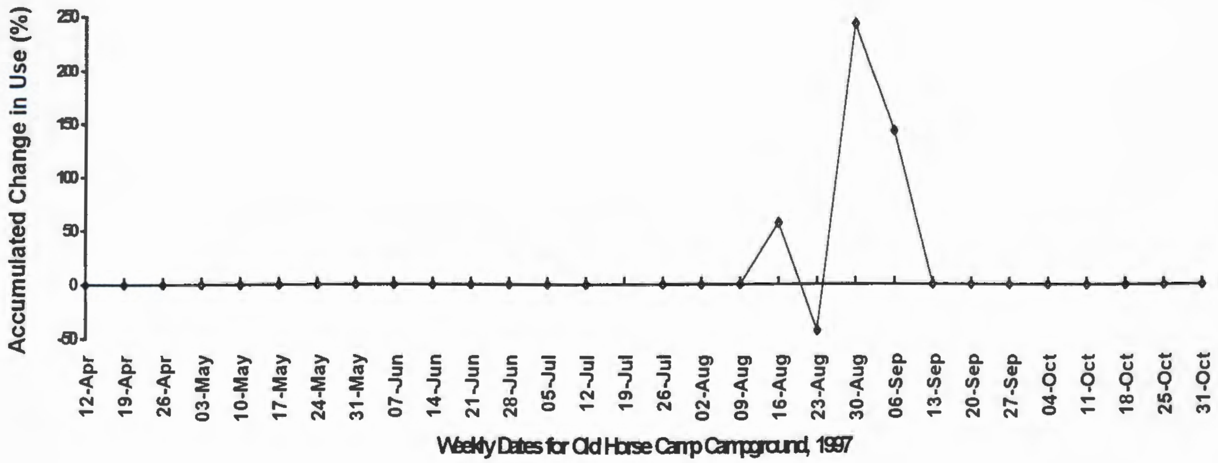
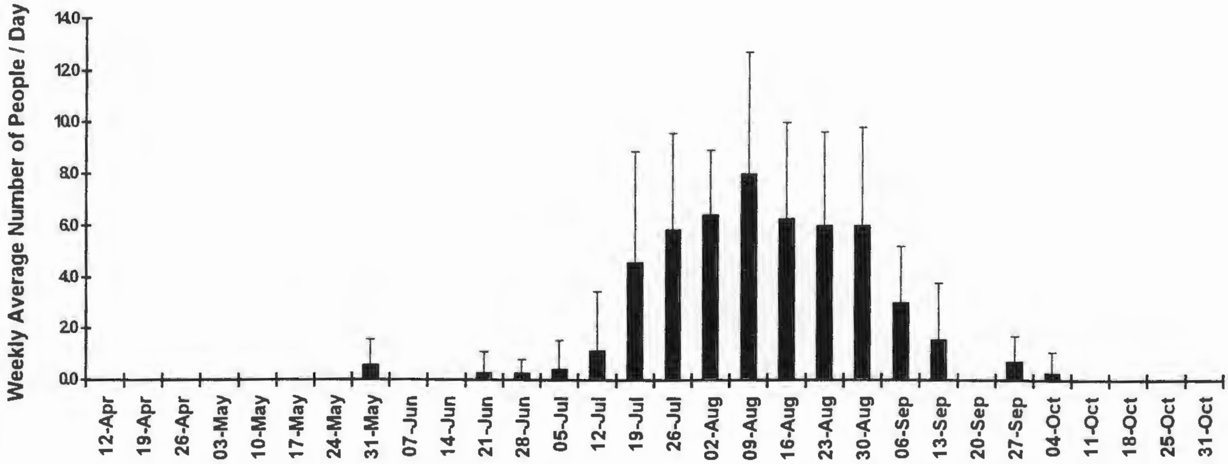

Accumulated Change in Use (%)
250
200
150
100
50
0
-50
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Old Horse Camp Campground, 1997

Fig. E9. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Signal campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

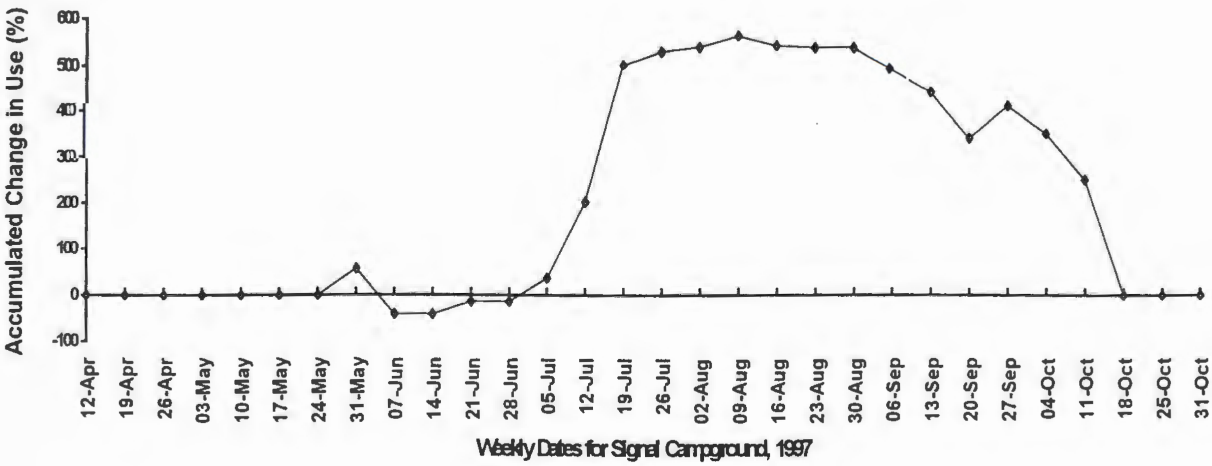
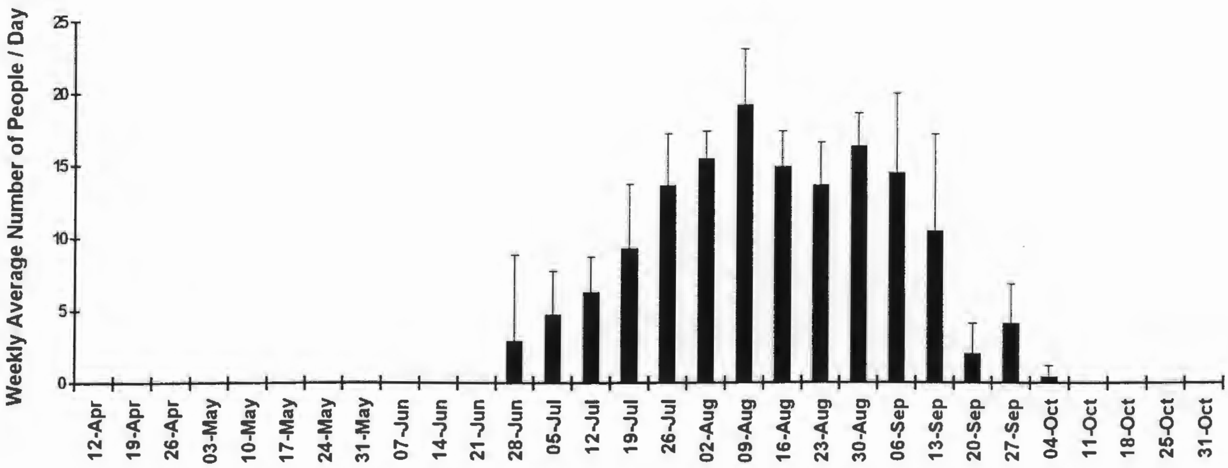

Accumulated Change in Use (%)
600
500
400
300
200
100
0
-100
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Signal Campground, 1997

Fig. E10. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Snowbowl campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
0
5
10
15
20
25
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

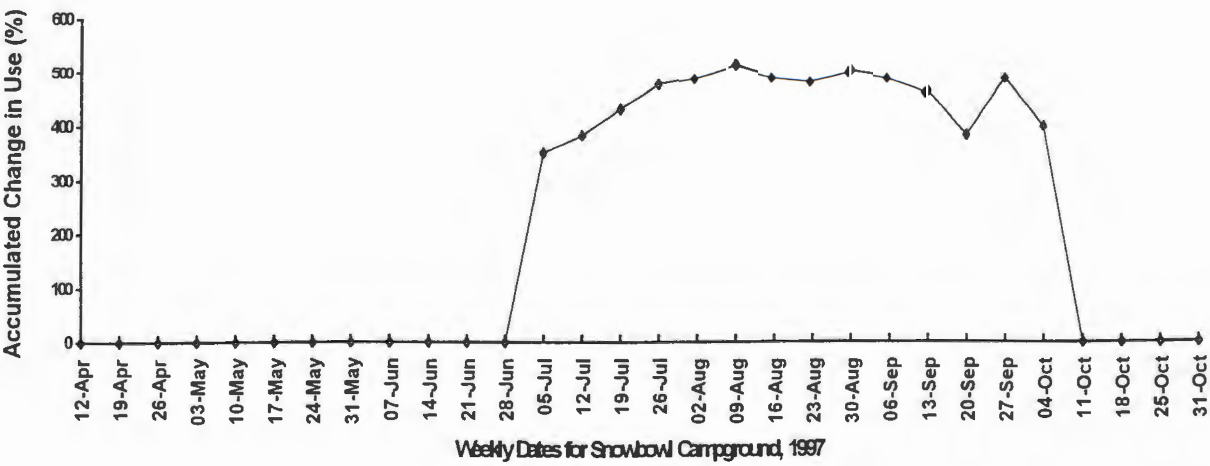
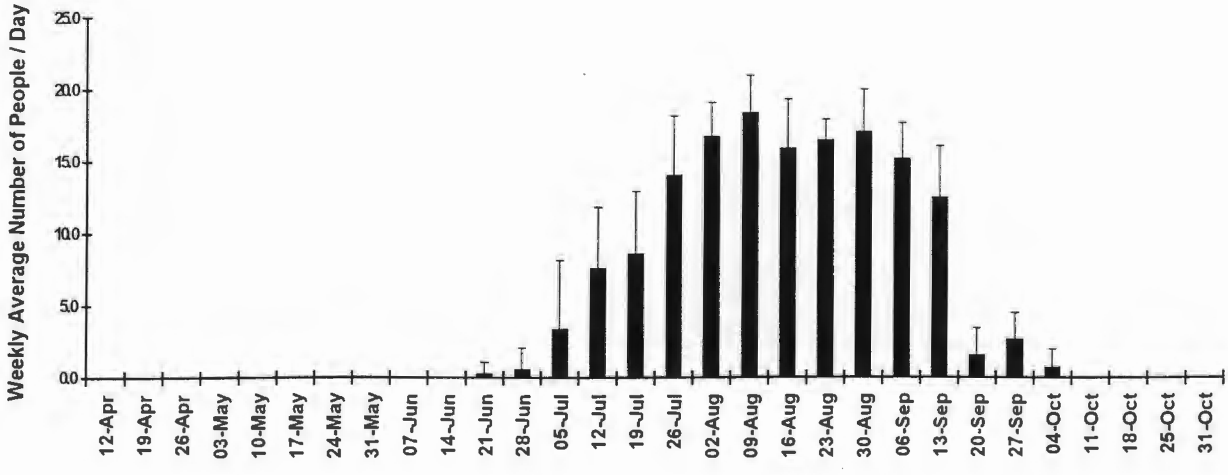

Accumulated Change in Use (%)
0
100
200
300
400
500
600
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Snowbowl Campground, 1997

Fig. E11. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Tekarra campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
0.0
5.0
10.0
15.0
20.0
25.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

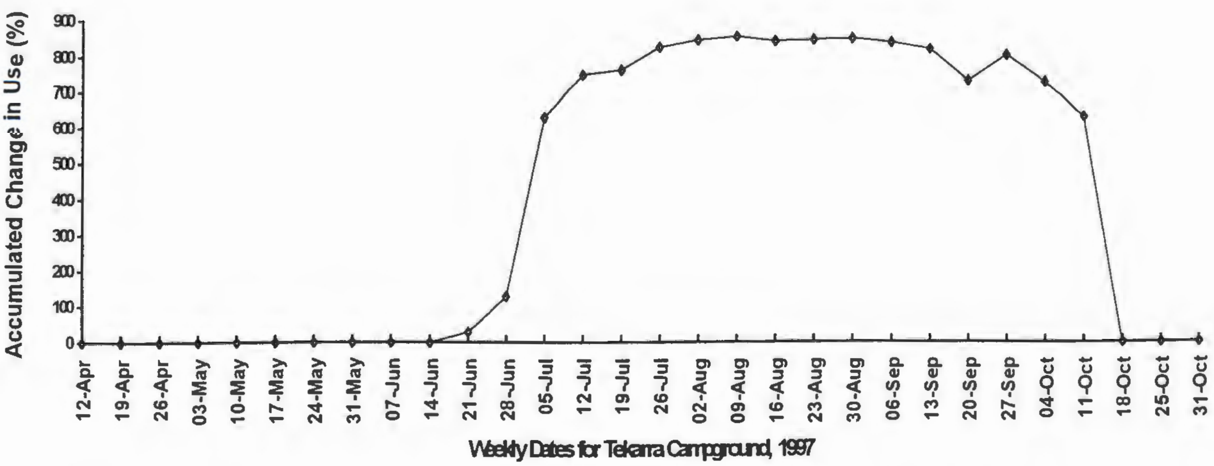
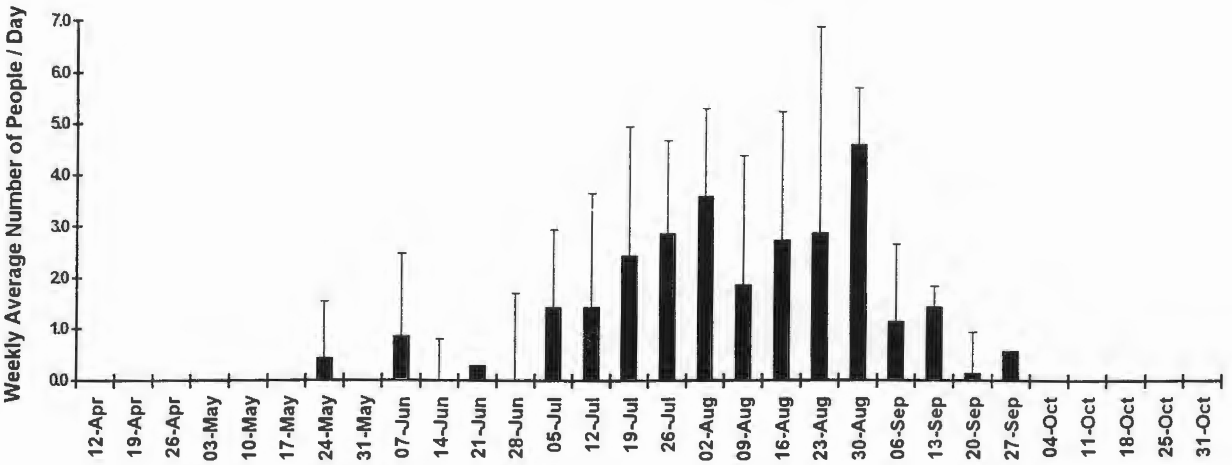

Accumulated Change in Use (%)
0
100
200
300
400
500
600
700
800
900
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Tekarra Campground, 1997

Fig. E12. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Trapper Creek campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B

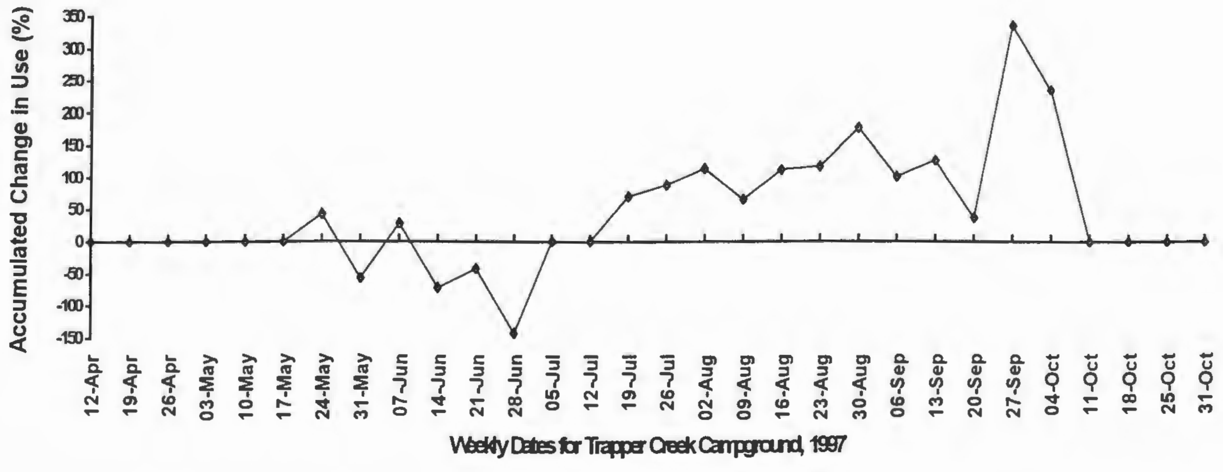
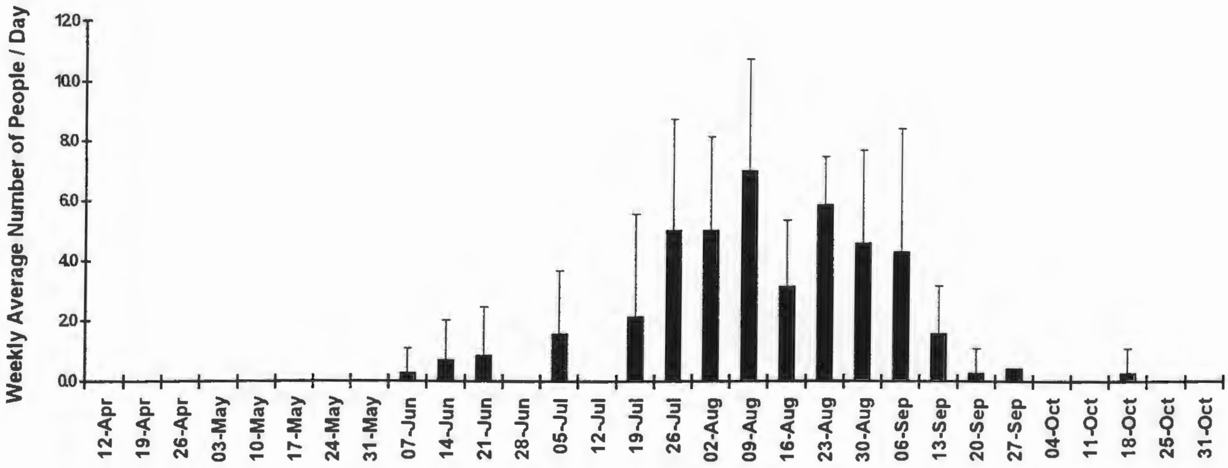
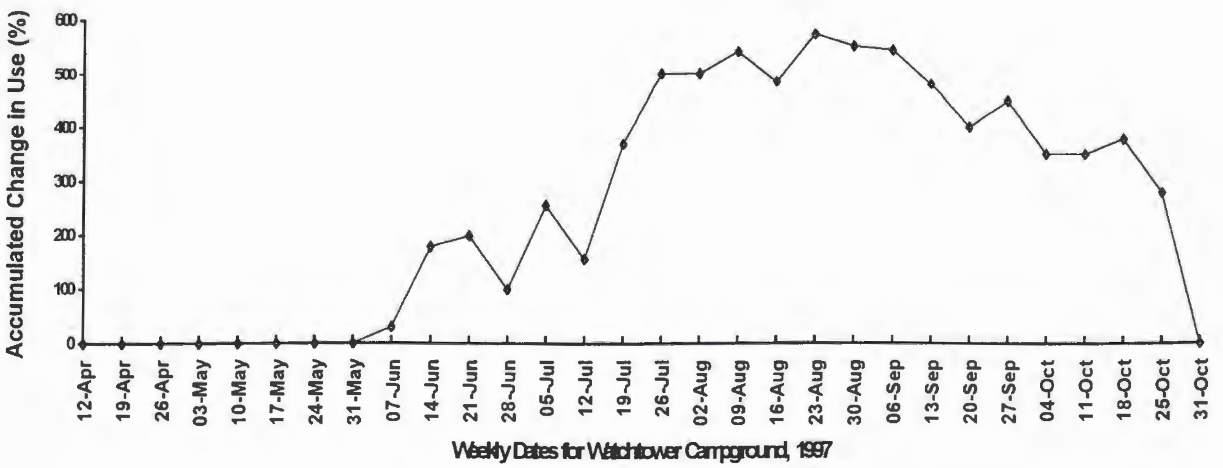

Accumulated Change in Use (%)
350
300
250
200
150
100
50
0
-50
-100
-150
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Trapper Creek Campground, 1997

Fig. E13. The average number of people per night ($\bar{x}$ + SD), averaged on a weekly basis (A), and the change in frequency of use accumulated over the season (B), for Watchtower campground in Jasper National Park. Dates are the end of each weekly period.

A


Weekly Average Number of People / Day
12.0
10.0
8.0
6.0
4.0
2.0
0.0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct

B


Accumulated Change in Use (%)
600
500
400
300
200
100
0
12-Apr
19-Apr
26-Apr
03-May
10-May
17-May
24-May
31-May
07-Jun
14-Jun
21-Jun
28-Jun
05-Jul
12-Jul
19-Jul
26-Jul
02-Aug
09-Aug
16-Aug
23-Aug
30-Aug
06-Sep
13-Sep
20-Sep
27-Sep
04-Oct
11-Oct
18-Oct
25-Oct
31-Oct
Weekly Dates for Watchtower Campground, 1997

APPENDIX F

Monthly amounts of human activity used in the habitat effectiveness model for linear, point, and dispersed (polygon) features in the Maligne Valley, Jasper National Park, from April 1 to October 31, 1997.

Table F1. Monthly amounts of human activity used in the habitat effectiveness model for linear, point, and dispersed (polygon) features in the Maligne Valley, Jasper National Park, from April 1 to October 31, 1997.

April				
LOCATION	ID. #	TYPE	TOTAL	Motorized
8 Pass	1718	line	6	N
Bald Hills - 8 Pass	1721	line	6	N
Bald Hills Road	1731	line	111	N
Beaver Lake - Parking Lot	1910	line	108	N
Beaver Lake Fishing Trail	4122	line	0	N
Big Bend Picnic	3088	line	0	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	4	N
Cornet Trail	1943	line	0	N
Evelyn Creek Trail	1739	line	10	N
Evelyn Creek Trail	1738	line	15	N
Fisherman's Bay Warden	4127	line	0	Y
Fishing Trail	4123	line	0	N
Home Bay Loop	20215	line	0	N
Jacques Lake - Summit	1908	line	0	N
Jeffrey Creek	1755	line	96	N
Lake - Upper Moose Loop	1729	line	101	N
Lake Loop Trail	1775	line	101	N
Lookout Trail	1777	line	10	N
Lorraine Trail	1734	line	101	N
Maligne - Avalanche	1713	line	4	N
Maligne Lake to C.C	4128	line	0	Y
Maligne Lake Duck	4129	line	0	Y
Maligne Lake to Isle	4126	line	0	Y
Maligne Lk. Area Road	2568	line	0	Y
Maligne Pass - Moose Loop	1728	line	105	N
Maligne Pass - Upper Moose	1726	line	105	N
Maligne Pass Trail	1722	line	4	N
Maligne Pass Trail	1724	line	4	N
Maligne Pass Trail	1717	line	4	N
Maligne Pass Trail	1723	line	4	N
Maligne Pass Trail	1719	line	4	N
Maligne River Fishing (West)	4116	line	0	N
Maligne Road	2551	line	500	Y
Maligne Road Trail	1776	line	0	N
Moose Loop Trail	1727	line	101	N
Notch - Tekarra	1765	line	0	N
Old Horse - Mary Vaux	1715	line	4	N
Old Maligne Road	4124	line	0	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	0	N
Opal Hills	1744	line	0	N
Opal Hills	1745	line	0	N
Opal Hills Loop	1746	line	0	N
Road - Surprise Creek	1754	line	0	N
Rockslide Loop	4117	line	0	N
Sewage Lagoon Road	4115	line	0	Y
Signal Mountain Fire Road	1769	line	0	N
Skyline Trail	1741	line	0	N
Skyline Trail	1742	line	96	N
Skyline Trail	1733	line	101	N
Snowbowl - Curator	1756	line	96	N
Spirit Island Trail	4118	line	0	N
Summit - Beaver Lake	1909	line	108	N
Tekarra - Signal Creek	1766	line	0	N
Tekarra-Upper Road	1769	line	0	N
Trapper Creek	1720	line	10	N
Two Valley Gap (Upper)	4121	line	0	N

Two Valley Gap(Lower)	4120	line	0	N
Upper Bald Hills Road	1732	line	111	N
Upper Moose Loop Trail	1725	line	101	N
Warren CK. Trail	4119	line	0	N
Watchtower	1759	line	0	N
Watchtower - Road	1760	line	2	N
Z-Drop Photo Trail	4125	line	0	N
Beaver Lake Cabin	3514	point	0	N
Beaver Shelter	3513	point	110	N
Cornet Creek Campground	3570	point	0	N
Evelyn Creek Campground	3558	point	0	N
Fisher Bay Campground	3569	point	0	N
Henry McLeod Campground	3533	point	0	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	0	N
Little Shovel Campground	3559	point	0	N
Mary Vaux Campground	3562	point	4	N
Old Horse Campground	3553	point	0	N
Samson Ck. Picnic	2103	point	0	N
Schaffer Campground	3554	point	4	N
Scout Cabin / Pit	3080	point	0	N
Shangri-La Cabin	20200	point	48	N
Signal Campground	3567	point	0	N
Snowbowl Campground	3563	point	0	N
Spindly Creek Picnic	20155	point	0	N
Summit Lake Campground	3512	point	0	N
Tekarra Campground	3566	point	0	N
Trapper Ck. Picnic	2101	point	0	N
Trapper Creek Campground	3556	point	0	N
Watchtower Campground	3564	point	0	N
Bald Hills Hike / Ski	20217	polygon	111	N
Beaver Lake Fishing	20201	polygon	0	N
Gravel Pit	4083	polygon	0	N
Maligne - Home Bay to Island	20053	polygon	0	N
Maligne Bridge 1 - 2	4103	polygon	0	N
Maligne Home Bay	20214	polygon	0	N
Maligne Lake Day Use Area	4076	polygon	132	Y
Maligne Lake South	20153	polygon	0	N
Maligne Lake Warden Area	3557	polygon	120	Y
Maligne River	4105	polygon	0	N
Maligne River Below Big Ben	4104	polygon	0	N
Maligne River; Home Bay	4102	polygon	0	N
Medicine Lake Fishing	20194	polygon	0	N
Medicine Lake North	4130	polygon	0	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

May				
LOCATION	ID. #	TYPE	TOTAL	Motorized
8 Pass	1718	line	0	N
Bald Hills - 8 Pass	1721	line	0	N
Bald Hills Road	1731	line	163	N
Beaver Lake - Parking Lot	1910	line	500	N
Beaver Lake Fishing Trail	4122	line	0	N
Big Bend Picnic	3088	line	1	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	3	N
Cornet Trail	1943	line	0	N
Evelyn Creek Trail	1739	line	0	N
Evelyn Creek Trail	1738	line	0	N
Fisherman's Bay Warden	4127	line	0	Y
Fishing Trail	4123	line	0	N
Home Bay Loop	20215	line	2	N
Jacques Lake - Summit	1908	line	50	N
Jeffrey Creek	1755	line	0	N
Lake - Upper Moose Loop	1729	line	101	N
Lake Loop Trail	1775	line	101	N
Lookout Trail	1777	line	0	N
Lorraine Trail	1734	line	4	N
Maligne - Avalanche	1713	line	3	N
Maligne Lake to C.C	4128	line	0	Y
Maligne Lake Duck	4129	line	0	Y
Maligne Lake to Isle	4126	line	0	Y
Maligne Lk. Area Road	2568	line	1	Y
Maligne Pass - Moose Loop	1728	line	150	N
Maligne Pass - Upper Moose	1726	line	3	N
Maligne Pass Trail	1722	line	3	N
Maligne Pass Trail	1724	line	3	N
Maligne Pass Trail	1717	line	3	N
Maligne Pass Trail	1723	line	3	N
Maligne Pass Trail	1719	line	3	N
Maligne River Fishing (West)	4116	line	0	N
Maligne Road	2551	line	13791	Y
Maligne Road Trail	1776	line	0	N
Moose Loop Trail	1727	line	147	N
Notch - Tekarra	1765	line	0	N
Old Horse - Mary Vaux	1715	line	3	N
Old Maligne Road	4124	line	0	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	0	N
Opal Hills	1744	line	0	N
Opal Hills	1745	line	0	N
Opal Hills Loop	1746	line	0	N
Road - Surprise Creek	1754	line	0	N
Rockslide Loop	4117	line	0	N
Sewage Lagoon Road	4115	line	5	Y
Signal Mountain Fire Road	1769	line	4	N
Skyline Trail	1741	line	4	N
Skyline Trail	1742	line	4	N
Skyline Trail	1733	line	4	N
Snowbowl - Curator	1756	line	4	N
Spirit Island Trail	4118	line	0	N
Summit - Beaver Lake	1909	line	101	N
Tekarra - Signal Creek	1766	line	4	N
Tekarra-Upper Road	1768	line	4	N
Trapper Creek	1720	line	0	N
Two Valley Gap (Upper)	4121	line	0	N

Two Valley Gap(Lower)	4120	line	0	N
Upper Bald Hills Road	1732	line	163	N
Upper Moose Loop Trail	1725	line	0	N
Warren CK. Trail	4119	line	0	N
Watchtower	1759	line	0	N
Watchtower - Road	1760	line	94	N
Z-Drop Photo Trail	4125	line	0	N
Beaver Lake Cabin	3514	point	10	N
Beaver Shelter	3513	point	250	N
Cornet Creek Campground	3570	point	0	N
Evelyn Creek Campground	3558	point	0	N
Fisher Bay Campground	3569	point	0	N
Henry McLeod Campground	3533	point	0	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	0	N
Little Shovel Campground	3559	point	4	N
Mary Vaux Campground	3562	point	3	N
Old Horse Campground	3553	point	0	N
Samson Ck. Picnic	2103	point	0	N
Schaffer Campground	3554	point	3	N
Scout Cabin / Pit	3080	point	1	N
Shangri-La Cabin	20200	point	0	N
Signal Campground	3567	point	4	N
Snowbowl Campground	3563	point	0	N
Spindly Creek Picnic	20155	point	0	N
Summit Lake Campground	3512	point	0	N
Tekarra Campground	3566	point	0	N
Trapper Ck. Picnic	2101	point	0	N
Trapper Creek Campground	3556	point	3	N
Watchtower Campground	3564	point	0	N
Bald Hills Hike / Ski	20217	polygon	0	N
Beaver Lake Fishing	20201	polygon	3	N
Gravel Pit	4083	polygon	0	N
Maligne - Home Bay to Island	20053	polygon	0	N
Maligne Bridge 1 - 2	4103	polygon	0	N
Maligne Home Bay	20214	polygon	0	N
Maligne Lake Day Use Area	4076	polygon	13791	Y
Maligne Lake South	20153	polygon	0	N
Maligne Lake Warden Area	3557	polygon	120	Y
Maligne River	4105	polygon	0	N
Maligne River Below Big Ben	4104	polygon	0	N
Maligne River; Home Bay	4102	polygon	0	N
Medicine Lake Fishing	20194	polygon	0	N
Medicine Lake North	4130	polygon	5	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

June				
LOCATION	ID. #	TYPE	TOTAL	Motorize
8 Pass	1718	line	0	N
Bald Hills - 8 Pass	1721	line	0	N
Bald Hills Road	1731	line	629	N
Beaver Lake - Parking Lot	1910	line	1200	N
Beaver Lake Fishing Trail	4122	line	3	N
Big Bend Picnic	3088	line	101	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	2	N
Cornet Trail	1943	line	27	N
Evelyn Creek Trail	1738	line	4	N
Evelyn Creek Trail	1739	line	0	N
Fisherman's Bay Warden	4127	line	26	Y
Fishing Trail	4123	line	0	N
Home Bay Loop	20215	line	13	N
Jacques Lake - Summit	1908	line	848	N
Jeffrey Creek	1755	line	0	N
Lake - Upper Moose Loop	1729	line	1193	N
Lake Loop Trail	1775	line	3229	N
Lookout Trail	1777	line	157	N
Lorraine Trail	1734	line	169	N
Maligne - Avalanche	1713	line	2	N
Maligne Lake Duck	4129	line	6	Y
Maligne Lake to C.C	4128	line	26	Y
Maligne Lake to Isle	4126	line	457	Y
Maligne Lk. Area Road	2568	line	101	Y
Maligne Pass - Moose Loop	1728	line	643	N
Maligne Pass - Upper Moose	1726	line	37	N
Maligne Pass Trail	1717	line	12	N
Maligne Pass Trail	1724	line	35	N
Maligne Pass Trail	1722	line	26	N
Maligne Pass Trail	1723	line	40	N
Maligne Pass Trail	1719	line	26	N
Maligne River Fishing (West) T	4116	line	0	N
Maligne Road	2551	line	28,514	Y
Maligne Road Trail	1776	line	30	N
Moose Loop Trail	1727	line	608	N
Notch - Tekarra	1765	line	19	N
Old Horse - Mary Vaux	1715	line	12	N
Old Maligne Road	4124	line	0	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	0	N
Opal Hills	1744	line	242	N
Opal Hills	1745	line	242	N
Opal Hills Loop	1746	line	968	N
Road - Surprise Creek	1754	line	2	N
Rockslide Loop	4117	line	3	N
Sewage Lagoon Road	4115	line	5	Y
Signal Mountain Fire Road	1769	line	17	N
Skyline Trail	1733	line	149	N
Skyline Trail	1742	line	30	N
Skyline Trail	1741	line	34	N
Snowbowl - Curator	1756	line	18	N
Spirit Island Trail	4118	line	14279	N
Summit - Beaver Lake	1909	line	848	N
Tekarra - Signal Creek	1766	line	13	N
Tekarra-Upper Road	1768	line	17	N
Trapper Creek	1720	line	0	N
Two Valley Gap (Lower)	4120	line	2	N

Two Valley Gap (Upper)	4121	line	2	N
Upper Bald Hills Road	1732	line	629	N
Upper Moose Loop Trail	1725	line	6	N
Warren CK. Trail	4119	line	0	N
Watchtower	1759	line	0	N
Watchtower - Road	1760	line	88	N
Z-Drop Photo Trail	4125	line	0	N
Beaver Lake Cabin	3514	point	101	N
Beaver Shelter	3513	point	374	N
Cornet Creek Campground	3570	point	197	N
Evelyn Creek Campground	3558	point	17	N
Fisher Bay Campground	3569	point	283	N
Henry McLeod Campground	3533	point	4	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	3	N
Little Shovel Campground	3559	point	19	N
Mary Vaux Campground	3562	point	7	N
Old Horse Campground	3553	point	0	N
Samson Ck. Picnic	2103	point	8	N
Schaffer Campground	3554	point	12	N
Scout Cabin / Pit	3080	point	0	N
Shangri-La Cabin	20200	point	0	N
Signal Campground	3567	point	4	N
Snowbowl Campground	3563	point	32	N
Spindly Creek Picnic	20155	point	3	N
Summit Lake Campground	3512	point	0	N
Tekarra Campground	3566	point	18	N
Trapper Ck. Picnic	2101	point	5	N
Trapper Creek Campground	3556	point	15	N
Watchtower Campground	3564	point	13	N
Bald Hills Hike / Ski	20217	polygon	0	N
Beaver Lake Fishing	20201	polygon	30	N
Gravel Pit	4083	polygon	0	N
Maligne - Home Bay to Island	20053	polygon	332	N
Maligne Bridge 1 - 2	4103	polygon	12	N
Maligne Home Bay	20214	polygon	482	N
Maligne Lake Day Use Area	4076	polygon	101	Y
Maligne Lake South	20153	polygon	197	N
Maligne Lake Warden Area	3557	polygon	120	Y
Maligne River	4105	polygon	0	N
Maligne River Below Big Bend	4104	polygon	0	N
Maligne River; Home Bay	4102	polygon	10	N
Medicine Lake Fishing	20194	polygon	0	N
Medicine Lake North	4130	polygon	173	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

July				
LOCATION	ID. #	TYPE	TOTAL	Motorized
8 Pass	1718	line	0	N
Bald Hills - 8 Pass	1721	line	0	N
Bald Hills Road	1731	line	2622	N
Beaver Lake - Parking Lot	1910	line	1655	N
Beaver Lake Fishing Trail	4122	line	2	N
Big Bend Picnic	3088	line	180	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	50	N
Cornet Trail	1943	line	149	N
Evelyn Creek Trail	1739	line	3	N
Evelyn Creek Trail	1738	line	3	N
Fisherman's Bay Warden	4127	line	19	Y
Fishing Trail	4123	line	2	N
Home Bay Loop	20215	line	17	N
Jacques Lake - Summit	1908	line	446	N
Jeffrey Creek	1755	line	0	N
Lake - Upper Moose Loop	1729	line	1193	N
Lake Loop Trail	1775	line	12743	N
Lookout Trail	1777	line	655	N
Lorraine Trail	1734	line	469	N
Maligne - Avalanche	1713	line	50	N
Maligne Lake to C.C	4128	line	19	Y
Maligne Lake Duck	4129	line	4	Y
Maligne Lake to Isle	4126	line	699	Y
Maligne Lk. Area Road	2568	line	101	Y
Maligne Pass - Moose Loop	1728	line	1938	N
Maligne Pass - Upper Moose	1726	line	104	N
Maligne Pass Trail	1722	line	54	N
Maligne Pass Trail	1724	line	104	N
Maligne Pass Trail	1717	line	50	N
Maligne Pass Trail	1723	line	108	N
Maligne Pass Trail	1719	line	58	N
Maligne River Fishing (West)	4116	line	4	N
Maligne Road	2551	line	42497	Y
Maligne Road Trail	1776	line	4	N
Moose Loop Trail	1727	line	1834	N
Notch - Tekarra	1765	line	430	N
Old Horse - Mary Vaux	1715	line	53	N
Old Maligne Road	4124	line	2	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	2	N
Opal Hills	1744	line	342	N
Opal Hills	1745	line	342	N
Opal Hills Loop	1746	line	2739	N
Road - Surprise Creek	1754	line	2	N
Rockslide Loop	4117	line	6	N
Sewage Lagoon Road	4115	line	5	Y
Signal Mountain Fire Road	1769	line	416	N
Skyline Trail	1741	line	557	N
Skyline Trail	1742	line	483	N
Skyline Trail	1733	line	603	N
Snowbowl - Curator	1756	line	457	N
Spirit Island Trail	4118	line	23780	N
Summit - Beaver Lake	1909	line	446	N
Tekarra - Signal Creek	1766	line	422	N
Tekarra-Upper Road	1768	line	416	N
Trapper Creek	1720	line	2	N
Two Valley Gap (Upper)	4121	line	4	N

Two Valley Gap(Lower)	4120	line	4	N
Upper Bald Hills Road	1732	line	2622	N
Upper Moose Loop Trail	1725	line	12	N
Warren CK. Trail	4119	line	6	N
Watchtower	1759	line	40	N
Watchtower - Road	1760	line	307	N
Z-Drop Photo Trail	4125	line	180	N
Beaver Lake Cabin	3514	point	101	N
Beaver Shelter	3513	point	1655	N
Cornet Creek Campground	3570	point	264	N
Evelyn Creek Campground	3558	point	60	N
Fisher Bay Campground	3569	point	329	N
Henry McLeod Campground	3533	point	14	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	10	N
Little Shovel Campground	3559	point	213	N
Mary Vaux Campground	3562	point	42	N
Old Horse Campground	3553	point	0	N
Samson Ck. Picnic	2103	point	10	N
Schaffer Campground	3554	point	34	N
Scout Cabin / Pit	3080	point	0	N
Shangri-La Cabin	20200	point	2	N
Signal Campground	3567	point	113	N
Snowbowl Campground	3563	point	298	N
Spindly Creek Picnic	20155	point	8	N
Summit Lake Campground	3512	point	2	N
Tekarra Campground	3566	point	307	N
Trapper Ck. Picnic	2101	point	15	N
Trapper Creek Campground	3556	point	67	N
Watchtower Campground	3564	point	83	N
Bald Hills Hike / Ski	20217	polygon	0	N
Beaver Lake Fishing	20201	polygon	5	N
Gravel Pit	4083	polygon	0	N
Maligne - Home Bay to Island	20053	polygon	174	N
Maligne Bridge 1 - 2	4103	polygon	347	N
Maligne Home Bay	20214	polygon	598	N
Maligne Lake Day Use Area	4076	polygon	42497	Y
Maligne Lake South	20153	polygon	264	N
Maligne Lake Warden Area	3557	polygon	120	Y
Maligne River	4105	polygon	7	N
Maligne River Below Big Bend	4104	polygon	247	N
Maligne River; Home Bay	4102	polygon	336	N
Medicine Lake Fishing	20194	polygon	1	N
Medicine Lake North	4130	polygon	806	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

August				
LOCATION	ID. #	TYPE	TOTAL	Motorized
8 Pass	1718	line	0	N
Bald Hills - 8 Pass	1721	line	0	N
Bald Hills Road	1731	line	2748	N
Beaver Lake - Parking Lot	1910	line	1778	N
Beaver Lake Fishing Trail	4122	line	2	N
Big Bend Picnic	3088	line	238	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	147	N
Cornet Trail	1943	line	208	N
Evelyn Creek Trail	1739	line	0	N
Evelyn Creek Trail	1738	line	2	N
Fisherman's Bay Warden	4127	line	27	Y
Fishing Trail	4123	line	2	N
Home Bay Loop	20215	line	14	N
Jacques Lake - Summit	1908	line	692	N
Jeffrey Creek	1755	line	8	N
Lake - Upper Moose Loop	1729	line	1169	N
Lake Loop Trail	1775	line	13400	N
Lookout Trail	1777	line	687	N
Lorraine Trail	1734	line	452	N
Maligne - Avalanche	1713	line	146	N
Maligne Lake to C.C	4128	line	23	Y
Maligne Lake Duck	4129	line	0	Y
Maligne Lake to Isle	4126	line	738	Y
Maligne Lk. Area Road	2568	line	101	Y
Maligne Pas Trail	1723	line	212	N
Maligne Pass - Moose Loop	1728	line	1980	N
Maligne Pass - Upper Moose	1726	line	204	N
Maligne Pass Trail	1724	line	204	N
Maligne Pass Trail	1722	line	141	N
Maligne Pass Trail	1717	line	144	N
Maligne Pass Trail	1719	line	148	N
Maligne River Fishing (West)	4116	line	2	N
Maligne Road	2551	line	47035	Y
Maligne Road Trail	1776	line	2	N
Moose Loop Trail	1727	line	1776	N
Notch - Tekarra	1765	line	769	N
Old Horse - Mary Vaux	1715	line	135	N
Old Maligne Road	4124	line	2	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	0	N
Opal Hills	1744	line	990	N
Opal Hills	1745	line	990	N
Opal Hills Loop	1746	line	3690	N
Road - Surprise Creek	1754	line	2	N
Rockslide Loop	4117	line	3	N
Sewage Lagoon Road	4115	line	3	Y
Signal Mountain Fire Road	1769	line	786	N
Skyline Trail	1741	line	876	N
Skyline Trail	1742	line	797	N
Skyline Trail	1733	line	891	N
Snowbowl - Curator	1756	line	803	N
Spirit Island Trail	4118	line	25265	N
Summit - Beaver Lake	1909	line	692	N
Tekarra - Signal Creek	1766	line	778	N
Tekarra - Upper Road	1768	line	786	N
Trapper Creek	1720	line	2	N
Two Valley Gap (Upper)	4121	line	2	N

Two Valley Gap(Lower)	4120	line	2	N
Upper Bald Hills Road	1732	line	2748	N
Upper Moose Loop Trail	1725	line	7	N
Warren CK. Trail	4119	line	0	N
Watchtower	1759	line	46	N
Watchtower - Road	1760	line	173	N
Z-Drop Photo Trail	4125	line	180	N
Beaver Lake Cabin	3514	point	101	N
Beaver Shelter	3513	point	2748	N
Cornet Creek Campground	3570	point	281	N
Evelyn Creek Campground	3558	point	68	N
Fisher Bay Campground	3569	point	335	N
Henry McLeod Campground	3533	point	30	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	35	N
Little Shovel Campground	3559	point	292	N
Mary Vaux Campground	3562	point	77	N
Old Horse Campground	3553	point	22	N
Samson Ck. Picnic	2103	point	2	N
Schaffer Campground	3554	point	101	N
Scout Cabin / Pit	3080	point	15	N
Shangri-La Cabin	20200	point	8	N
Signal Campground	3567	point	206	N
Snowbowl Campground	3563	point	504	N
Spindly Creek Picnic	20155	point	4	N
Summit Lake Campground	3512	point	0	N
Tekarra Campground	3566	point	532	N
Trapper Ck. Picnic	2101	point	10	N
Trapper Creek Campground	3556	point	94	N
Watchtower Campground	3564	point	170	N
Bald Hills Hike / Ski	20217	polygon	0	N
Beaver Lake Fishing	20201	polygon	12	N
Gravel Pit	4083	polygon	0	N
Maligne - Home Bay to Island	20053	polygon	335	N
Maligne Bridge 1 - 2	4103	polygon	155	N
Maligne Home Bay	20214	polygon	384	N
Maligne Lake Day Use Area	4076	polygon	47035	Y
Maligne Lake South	20153	polygon	281	N
Maligne Lake Warden Area	3557	polygon	120	Y
Maligne River	4105	polygon	2	N
Maligne River Below Big Bend	4104	polygon	150	N
Maligne River; Home Bay	4102	polygon	186	N
Medicine Lake Fishing	20194	polygon	36	N
Medicine Lake North	4130	polygon	182	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

September				
LOCATION	ID. #	TYPE	TOTAL	Motorized
8 Pass	1718	line	0	N
Bald Hills - 8 Pass	1721	line	0	N
Bald Hills Road	1731	line	1316	N
Beaver Lake - Parking Lot	1910	line	611	N
Beaver Lake Fishing Trail	4122	line	1	N
Big Bend Picnic	3088	line	9	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	32	N
Cornet Trail	1943	line	65	N
Evelyn Creek Trail	1739	line	0	N
Evelyn Creek Trail	1738	line	1	N
Fisherman's Bay Warden	4127	line	2	Y
Fishing Trail	4123	line	1	N
Home Bay Loop	20215	line	2	N
Jacques Lake - Summit	1908	line	286	N
Jeffrey Creek	1755	line	0	N
Lake - Upper Moose Loop	1729	line	1169	N
Lake Loop Trail	1775	line	8290	N
Lookout Trail	1777	line	329	N
Lorraine Trail	1734	line	245	N
Maligne - Avalanche	1713	line	32	N
Maligne Lake to C.C	4128	line	3	Y
Maligne Lake Duck	4129	line	0	Y
Maligne Lake to Isle	4126	line	582	Y
Maligne Lk. Area Road	2568	line	101	Y
Maligne Pass - Moose Loop	1728	line	1812	N
Maligne Pass - Upper Moose	1726	line	43	N
Maligne Pass Trail	1722	line	37	N
Maligne Pass Trail	1724	line	43	N
Maligne Pass Trail	1717	line	30	N
Maligne Pass Trail	1723	line	43	N
Maligne Pass Trail	1719	line	37	N
Maligne River Fishing (West)	4116	line	1	N
Maligne Road	2551	line	27545	Y
Maligne Road Trail	1776	line	1	N
Moose Loop Trail	1727	line	1769	N
Notch - Tekarra	1765	line	274	N
Old Horse - Mary Vaux	1715	line	30	N
Old Maligne Road	4124	line	1	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	0	N
Opal Hills	1744	line	450	N
Opal Hills	1745	line	450	N
Opal Hills Loop	1746	line	1802	N
Road - Surprise Creek	1754	line	0	N
Rockslide Loop	4117	line	2	N
Sewage Lagoon Road	4115	line	1	Y
Signal Mountain Fire Road	1769	line	298	N
Skyline Trail	1741	line	313	N
Skyline Trail	1742	line	277	N
Skyline Trail	1733	line	357	N
Snowbowl - Curator	1756	line	281	N
Spirit Island Trail	4118	line	19276	N
Summit - Beaver Lake	1909	line	286	N
Tekarra - Signal Creek	1766	line	293	N
Tekarra - Upper Road	1768	line	298	N
Trapper Creek	1720	line	0	N
Two Valley Gap (Upper)	4121	line	7	N

Two Valley Gap(Lower)	4120	line	7	N
Upper Bald Hills Road	1732	line	1316	N
Upper Moose Loop Trail	1725	line	0	N
Warren CK. Trail	4119	line	6	N
Watchtower	1759	line	17	N
Watchtower - Road	1760	line	201	N
Z-Drop Photo Trail	4125	line	2	N
Beaver Lake Cabin	3514	point	23	N
Beaver Shelter	3513	point	1316	N
Cornet Creek Campground	3570	point	72	N
Evelyn Creek Campground	3558	point	8	N
Fisher Bay Campground	3569	point	90	N
Henry McLeod Campground	3533	point	4	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	1	N
Little Shovel Campground	3559	point	76	N
Mary Vaux Campground	3562	point	14	N
Old Horse Campground	3553	point	0	N
Samson Ck. Picnic	2103	point	1	N
Schaffer Campground	3554	point	18	N
Scout Cabin / Pit	3080	point	0	N
Shangri-La Cabin	20200	point	12	N
Signal Campground	3567	point	37	N
Snowbowl Campground	3563	point	200	N
Spindly Creek Picnic	20155	point	1	N
Summit Lake Campground	3512	point	0	N
Tekarra Campground	3566	point	213	N
Trapper Ck. Picnic	2101	point	1	N
Trapper Creek Campground	3556	point	21	N
Watchtower Campground	3564	point	35	N
Bald Hills Hike / Ski	20217	polygon	0	N
Beaver Lake Fishing	20201	polygon	1	N
Gravel Pit	4083	polygon	0	N
Malige River	4105	polygon	4	N
Maligne - Home Bay to Island	20053	polygon	65	N
Maligne Bridge 1 - 2	4103	polygon	2	N
Maligne Home Bay	20214	polygon	185	N
Maligne Lake Day Use Area	4076	polygon	27545	Y
Maligne Lake South	20153	polygon	22	N
Maligne Lake Warden Area	3557	polygon	120	Y
Maligne River Below Big Bend	4104	polygon	2	N
Maligne River; Home Bay	4102	polygon	7	N
Medicine Lake Fishing	20194	polygon	70	N
Medicine Lake North	4130	polygon	16	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

October				
LOCATION	ID. #	TYPE	TOTAL	Motorized
8 Pass	1718	line	0	N
Bald Hills - 8 Pass	1721	line	0	N
Bald Hills Road	1731	line	249	N
Beaver Lake - Parking Lot	1910	line	178	N
Beaver Lake Fishing Trail	4122	line	0	N
Big Bend Picnic	3088	line	2	N
Cornet - Maligne	1945	line	0	N
Cornet - Mary Vaux	1714	line	2	N
Cornet Trail	1943	line	0	N
Evelyn Creek Trail	1739	line	0	N
Evelyn Creek Trail	1738	line	0	N
Fisherman's Bay Warden	4127	line	2	Y
Fishing Trail	4123	line	0	N
Home Bay Loop	20215	line	0	N
Jacques Lake - Summit	1908	line	115	N
Jeffrey Creek	1755	line	0	N
Lake - Upper Moose Loop	1729	line	221	N
Lake Loop Trail	1775	line	1665	N
Lookout Trail	1777	line	62	N
Lorraine Trail	1734	line	35	N
Maligne - Avalanche	1713	line	2	N
Maligne Lake to C.C	4128	line	3	Y
Maligne Lake Duck	4129	line	0	Y
Maligne Lake to Isle	4126	line	104	Y
Maligne Lk. Area Road	2568	line	101	Y
Maligne Pass - Moose Loop	1728	line	377	N
Maligne Pass - Upper Moose	1726	line	2	N
Maligne Pass Trail	1722	line	2	N
Maligne Pass Trail	1724	line	2	N
Maligne Pass Trail	1717	line	2	N
Maligne Pass Trail	1723	line	2	N
Maligne Pass Trail	1719	line	2	N
Maligne River Fishing (West)	4116	line	0	N
Maligne Road	2551	line	9064	Y
Maligne Road Trail	1776	line	1	N
Moose Loop Trail	1727	line	375	N
Notch - Tekarra	1765	line	1	N
Old Horse - Mary Vaux	1715	line	2	N
Old Maligne Road	4124	line	0	N
Opal - North Surprise	1749	line	0	N
Opal - Surprise Lake	1748	line	0	N
Opal Hills	1744	line	70	N
Opal Hills	1745	line	70	N
Opal Hills Loop	1746	line	280	N
Road - Surprise Creek	1754	line	0	N
Rockslide Loop	4117	line	0	N
Sewage Lagoon Road	4115	line	1	Y
Signal Mountain Fire Road	1769	line	4	N
Skyline Trail	1741	line	3	N
Skyline Trail	1742	line	3	N
Skyline Trail	1733	line	7	N
Snowbowl - Curator	1756	line	3	N
Spirit Island Trail	4118	line	2517	N
Summit - Beaver Lake	1909	line	115	N
Tekarra - Signal Creek	1766	line	4	N
Tekarra - Upper Road	1768	line	4	N
Trapper Creek	1720	line	0	N
Two Valley Gap (Upper)	4121	line	0	N

Two Valley Gap(Lower)	4120	line	0	N
Upper Bald Hills Road	1732	line	249	N
Upper Moose Loop Trail	1725	line	0	N
Warren CK. Trail	4119	line	0	N
Watchtower	1759	line	0	N
Watchtower - Road	1760	line	49	N
Z-Drop Photo Trail	4125	line	0	N
Beaver Lake Cabin	3514	point	4	N
Beaver Shelter	3513	point	178	N
Cornet Creek Campground	3570	point	0	N
Evelyn Creek Campground	3558	point	7	N
Fisher Bay Campground	3569	point	16	N
Henry McLeod Campground	3533	point	0	N
Horse C/G - Maligne Pass	3555	point	0	N
Leah Ck. Picnic	2102	point	1	N
Little Shovel Campground	3559	point	0	N
Mary Vaux Campground	3562	point	0	N
Old Horse Campground	3553	point	0	N
Samson Ck. Picnic	2103	point	1	N
Schaffer Campground	3554	point	2	N
Scout Cabin / Pit	3080	point	0	N
Shangri-La Cabin	20200	point	6	N
Signal Campground	3567	point	0	N
Snowbowl Campground	3563	point	0	N
Spindly Creek Picnic	20155	point	1	N
Summit Lake Campground	3512	point	0	N
Tekarra Campground	3566	point	0	N
Trapper Ck. Picnic	2101	point	1	N
Trapper Creek Campground	3556	point	0	N
Watchtower Campground	3564	point	2	N
Bald Hills Hike / Ski	20217	polygon	0	N
Beaver Lake Fishing	20201	polygon	0	N
Gravel Pit	4083	polygon	0	N
Maligne - Home Bay to Island	20053	polygon	3	N
Maligne Bridge 1 - 2	4103	polygon	0	N
Maligne Home Bay	20214	polygon	7	N
Maligne Lake Day Use Area	4076	polygon	9064	Y
Maligne Lake South	20153	polygon	3	N
Maligne Lake Warden Area	3557	polygon	101	Y
Maligne River	4105	polygon	0	N
Maligne River Below Big Bend	4104	polygon	0	N
Maligne River; Home Bay	4102	polygon	0	N
Medicine Lake Fishing	20194	polygon	4	N
Medicine Lake North	4130	polygon	2	N
Medicine Teahouse Pit	4080	polygon	0	N
Pit 28	4081	polygon	0	N

APPENDIX G

Management scenarios for the months of July, August and September to increase habitat effectiveness levels to >80%.

Table G1. Scenarios for the month of July to increase habitat effectiveness for bear management units with habitat effectiveness values ≤80% to values >80%. The original habitat effectiveness values reflect the 1997 human use levels. The resultant habitat effectiveness values were derived after altering use on a particular feature. The data for human use are either specific numbers, if the feature was individually classified, or an estimated minimum value (i.e., < 200) if the feature was made up of several small trail segments.

BMU	Original Habitat Effectiveness Value for July, 1997	Resultant Habitat Effectiveness Value	Action
Lower Maligne	78%	78%	.set Watchtower trail from 307 to zero use
		81%	.set Watchtower trail from 307 to zero use .set northern part of Skyline Trail > 400 to zero use
Middle Maligne	80%	81%	.set Maligne River use from >200 to zero use
		82%	.set Maligne River use from > 200 to zero use .set northern part of Skyline Trail from > 400 to zero use
Upper Maligne	78%	81%	.set Maligne Lake Duck Survey from 4 to zero use .set Maligne River use from > 200 to zero use
		79%	.set Maligne River use from >200 to zero use

Table G2. Scenarios for the month of August to increase habitat effectiveness for bear management units with habitat effectiveness values ≤80% to values >80%. The original habitat effectiveness values reflect the 1997 human use levels. The resultant habitat effectiveness values were calculated after altering use on a particular feature.

BMU	Original Habitat Effectiveness Value for August, 1997	Resultant Habitat Effectiveness Value	Action
Lower Maligne	79%	79%	.set Watchtower trail from 173 to zero use
		81%	.set Watchtower trail from 173 to zero use .set northern part of Skyline Trail from >700 to zero use
		96%	.set Maligne Lake Road from >40,000 to zero use
		79%	.set all point features to zero use
		79%	.set all dispersed (polygon) features to zero use
		100%	.set all linear features to zero use
Middle Maligne	80%	82%	.set Maligne River use from >150 to zero use
		82%	.set Maligne River use from >150 to zero use .set northern part of Skyline Trail from >700 to zero use
		90%	.set Maligne Lake Road from >40,000 to zero use
		81%	.set first reach of Maligne River from 186 to zero use
		80%	.set all point features to zero use
		81%	.set all dispersed (polygon) features to zero use
		95%	.set all linear features to zero use
Upper Maligne	79%	79%	.set Maligne River use from >150 to zero use
		81%	.set Maligne Lake Motorized boat use low and high categories to zero use
		80%	.set Maligne Lake Road from >40,000 to zero use
		79%	.set Maligne Lake Motorized Commercial boat use from high to zero use
		80%	.set first reach of Maligne River from 186 to zero use .set Lorraine Lake trail from 452 to zero use .set Coronet Creek trail from 208 to zero use

	.set first reach of Maligne River from 186 to zero use
81%	.set Lorraine Lake trail from 452 to zero use .set Coronet Creek trail from 208 to zero use .set Opal Hills trail from >990 to zero use
79%	.set all point features to zero
83%	.set all dispersed (polygon) features to zero
84%	.set all linear features to zero

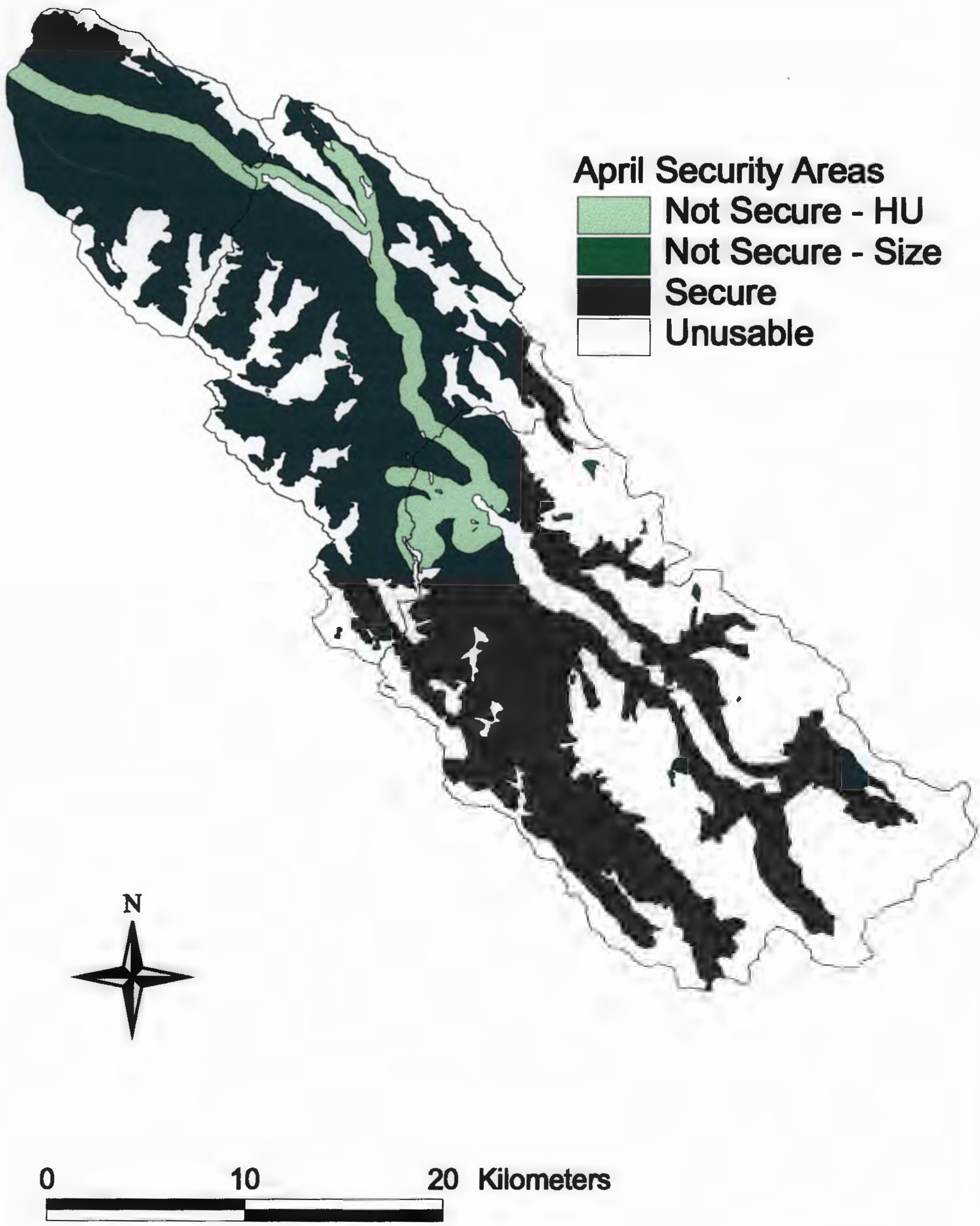
Table G3. Scenarios for the month of September to increase habitat effectiveness for bear management units with habitat effectiveness values ≤80% to values >80%. The original habitat effectiveness values reflect the 1997 human use levels. The resultant habitat effectiveness values were derived after altering use on a particular feature.

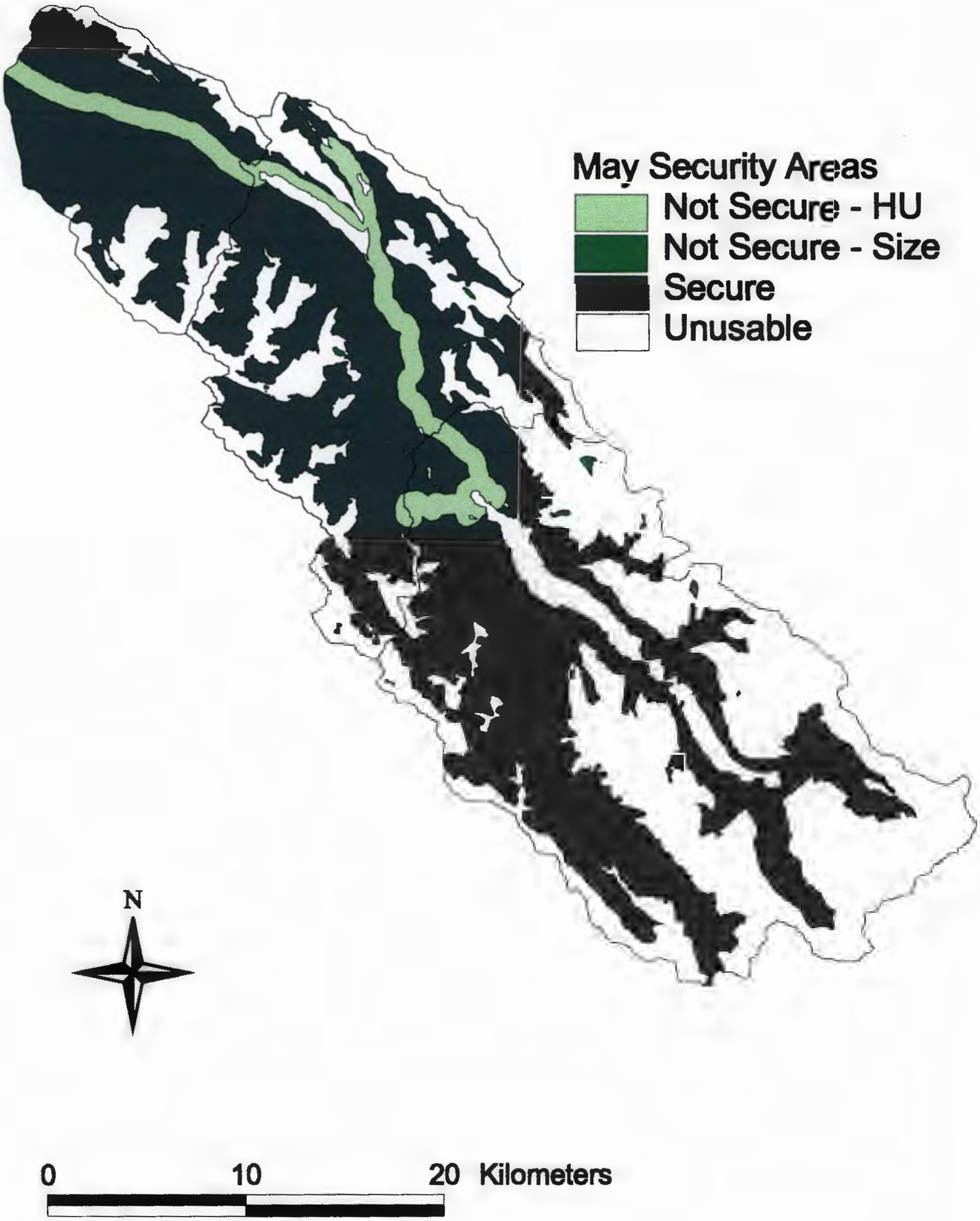
BMU	Original Habitat Effectiveness Value for September, 1997	Resultant Habitat Effectiveness Value	Action
Lower Maligne	79%	82%	.set Watchtower trail to zero use .set northern part of Skyline Trail to zero
Middle Maligne	81%	82%	.set northern part of Skyline Trail to zero

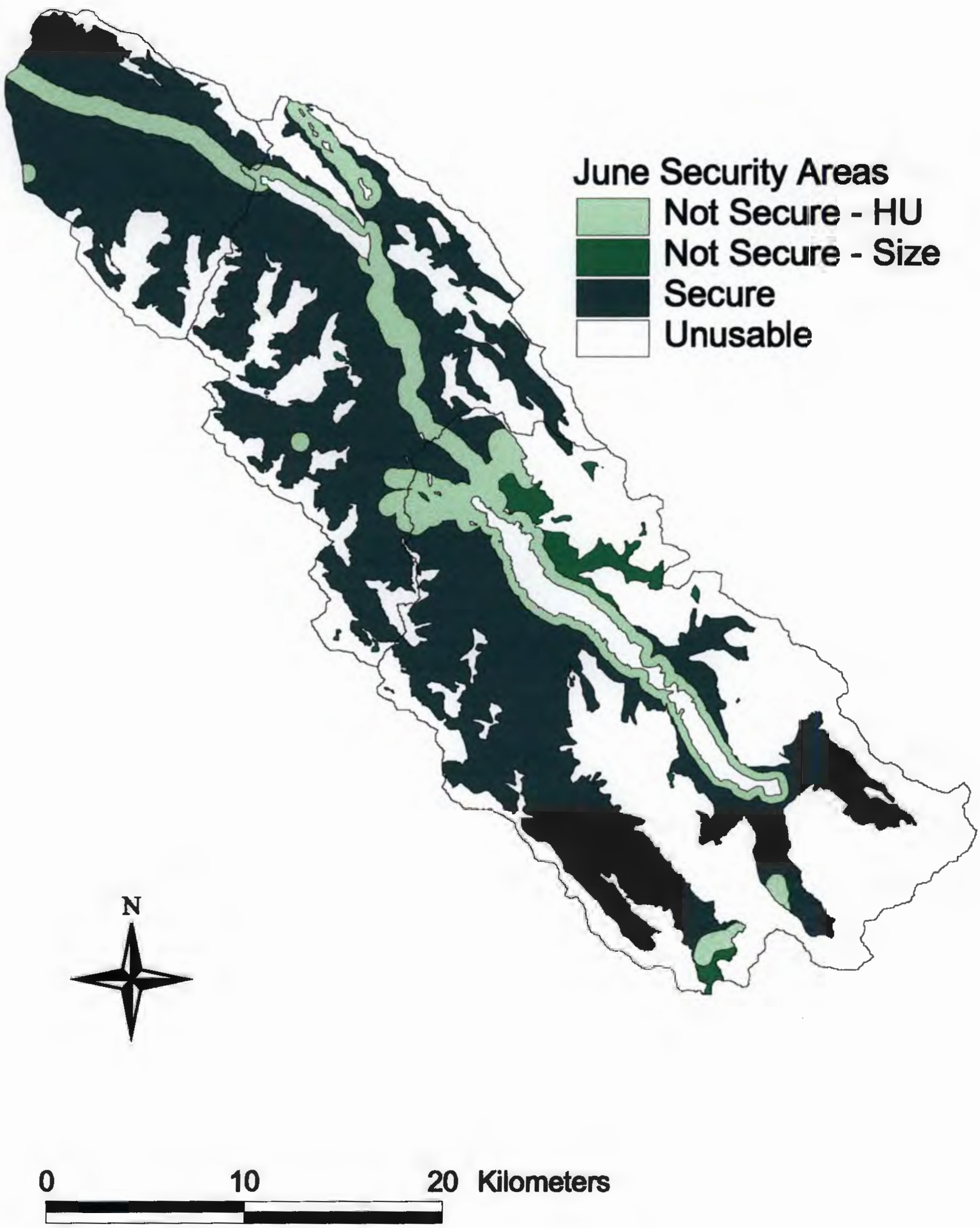
APPENDIX H

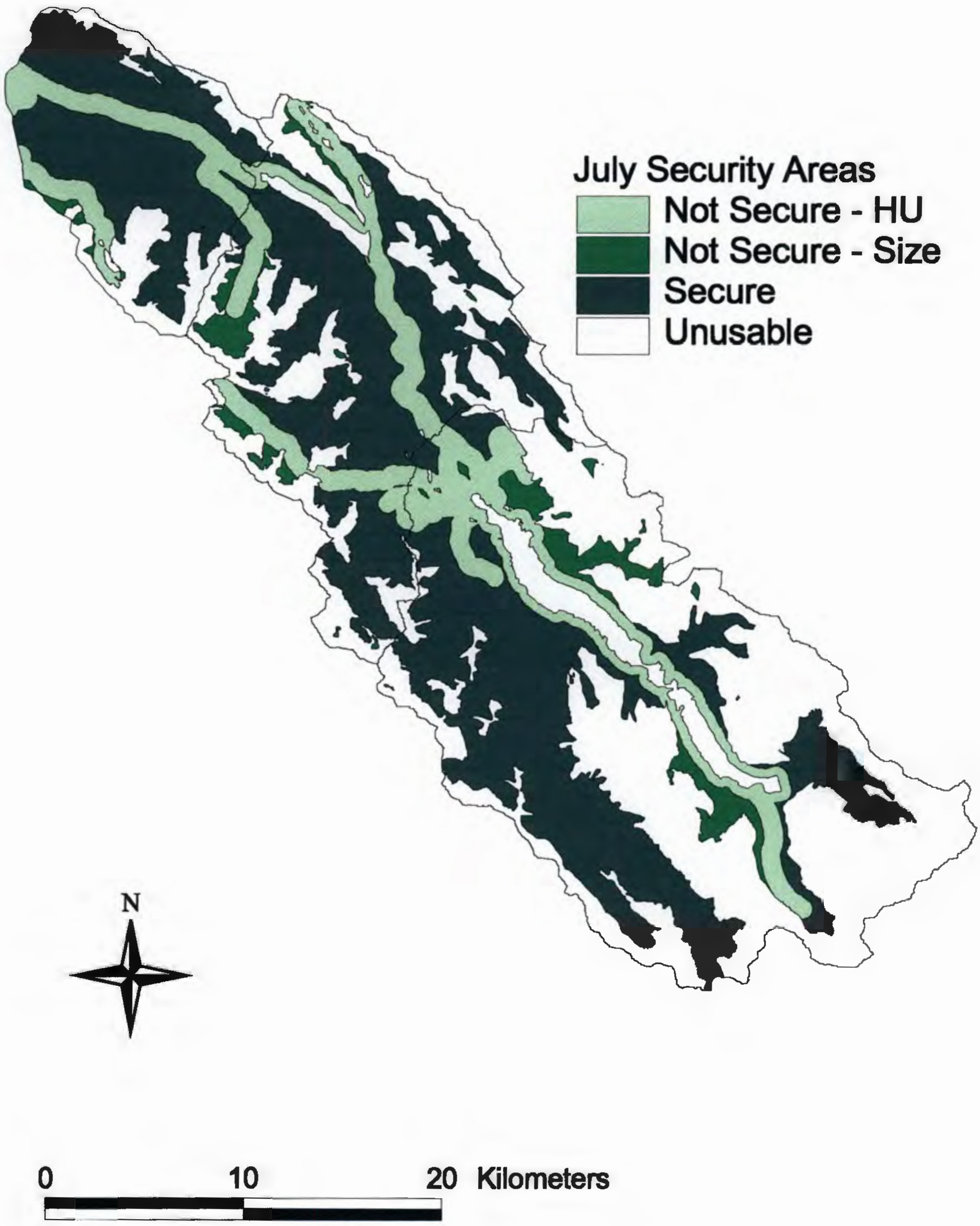
Monthly security area maps for the Maligne Valley,

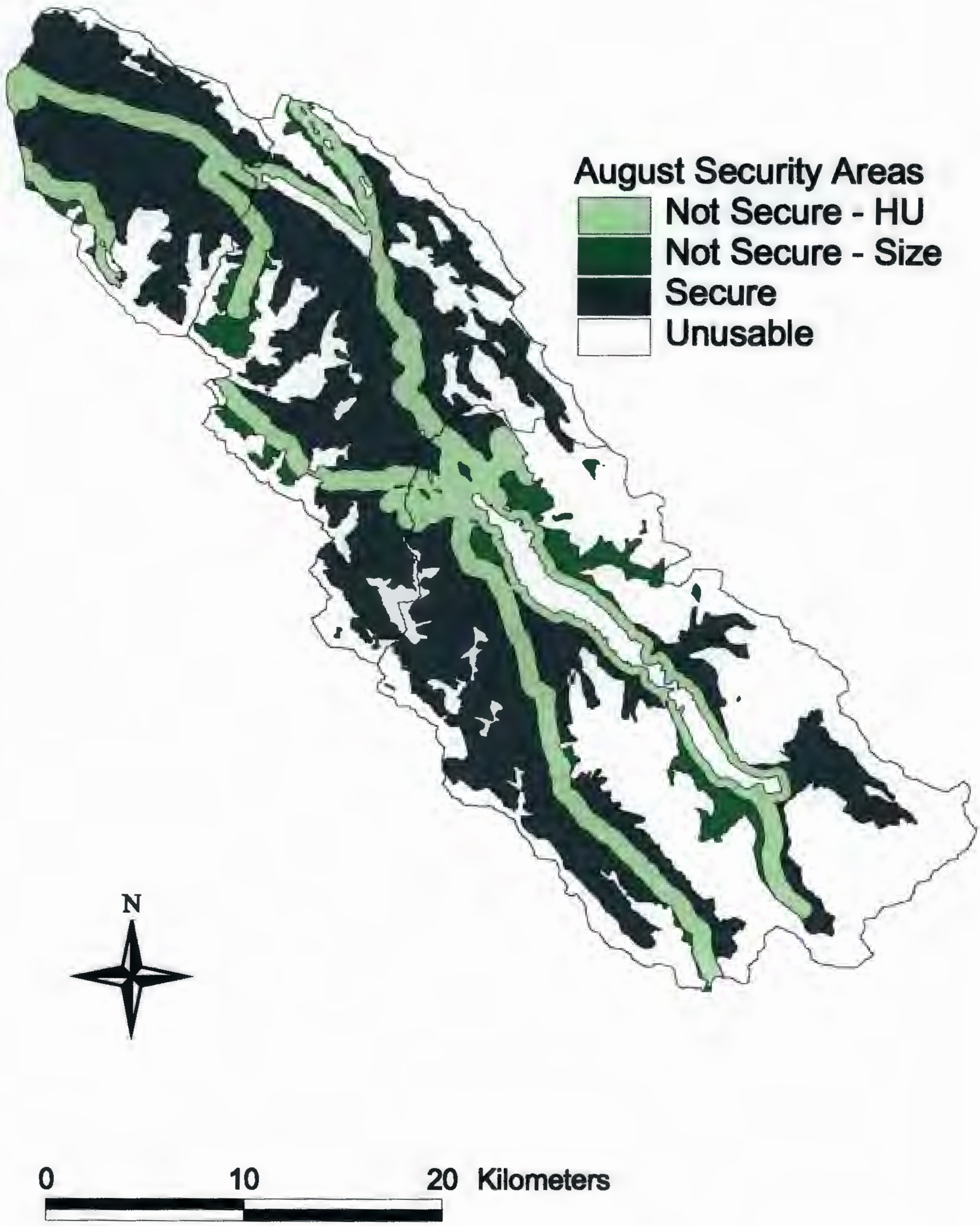
Jasper National Park, from April 1 to October 31, 1997.

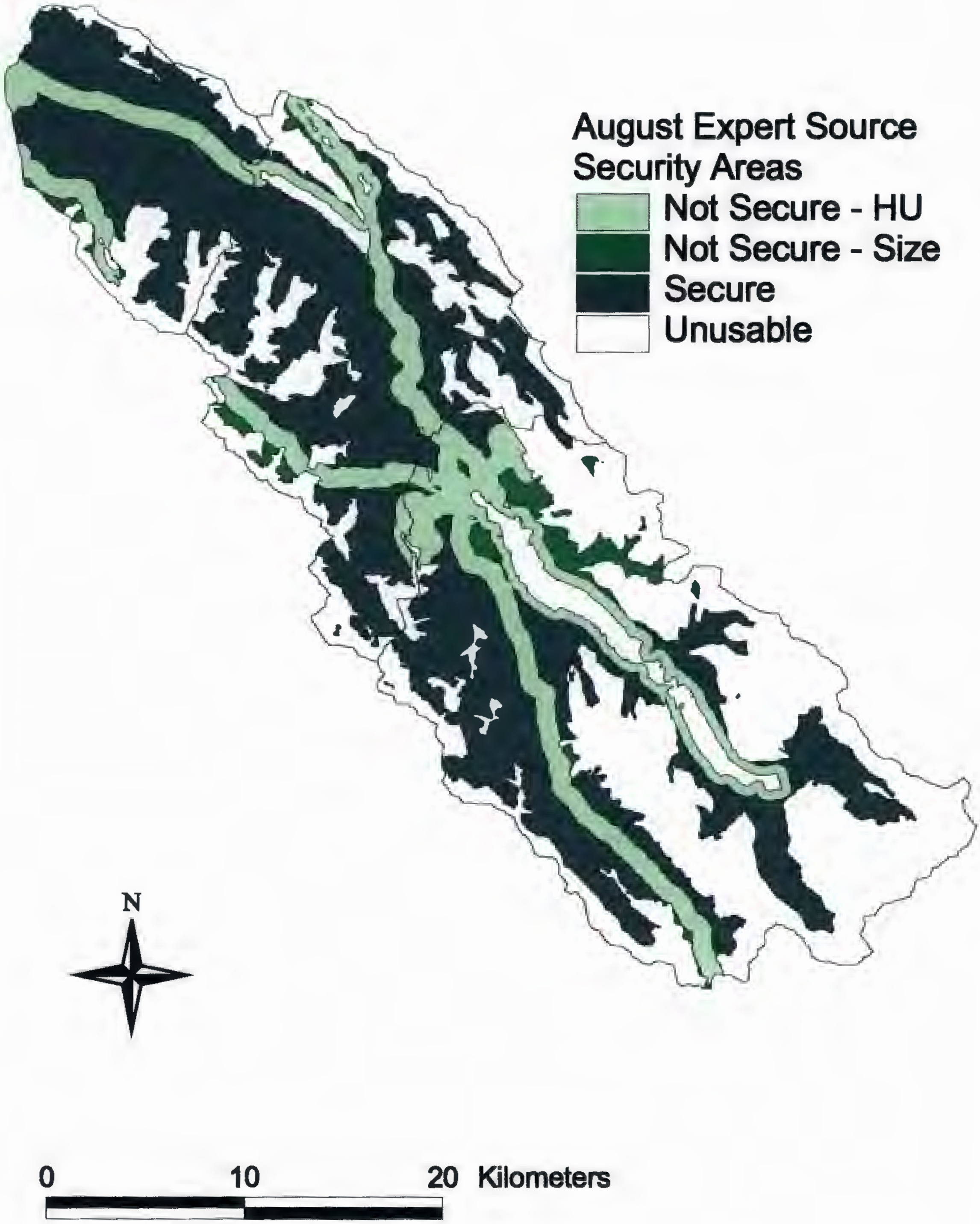

April Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers

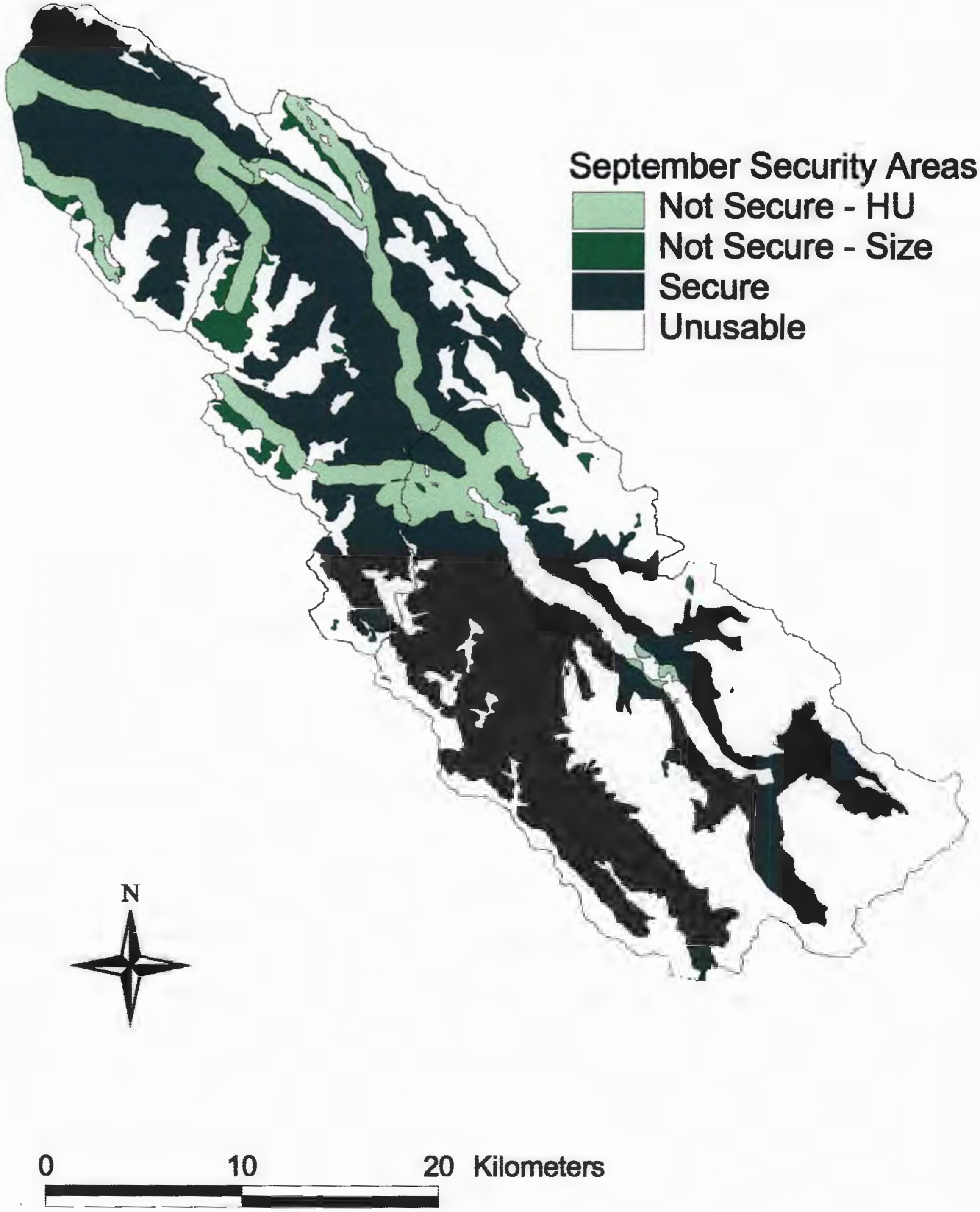

May Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers

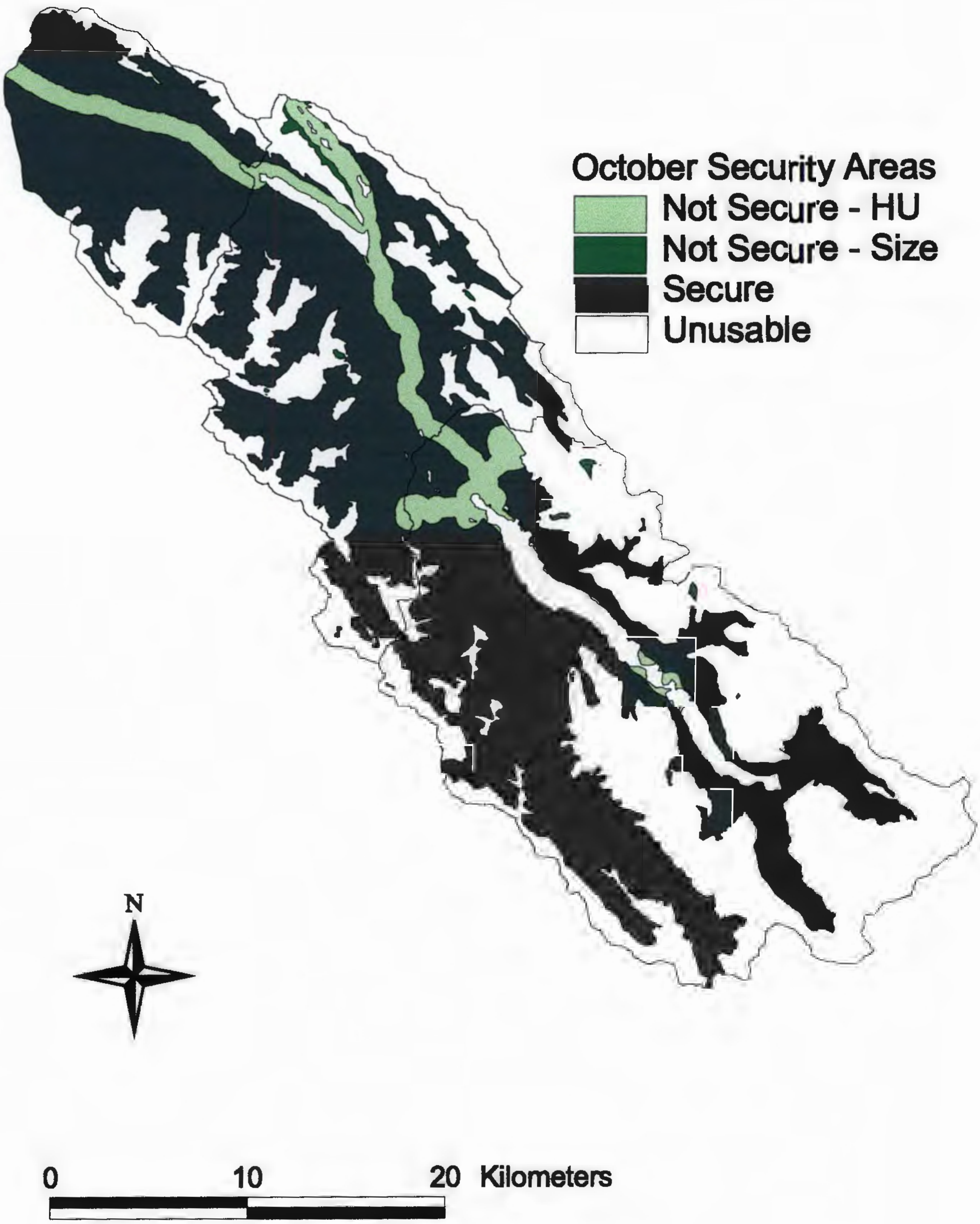

June Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers


July Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers


August Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20
Kilometers


August Expert Source
Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers


September Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers


October Security Areas
Not Secure - HU
Not Secure - Size
Secure
Unusable
N
0
10
20 Kilometers