





Banff National Park State of the Park Report

Resource Conservation Technical Summaries

2008 to 2017

- Condition Monitoring
- Species at Risk
- Active Management and Effectiveness Monitoring
- Operational Programs



Parks Canada Parcs Canada

Canada

Banff National Park State of the Park Report - Resource Conservation Technical Summaries 2008-2017.
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Cat No. R64-552/2019E-PDF
ISBN 978-0-660-30563-9

This report should be cited as:

Hunt, W.A. [Editor]. (2018) Banff National Park State of the Park Report – Resource Conservation Technical Summaries 2008 to 2017. Parks Canada, Unpublished Technical Report.

Cover Photos: Pika collecting alpine vegetation to build a hay pile (top left), smoke plume during a prescribed fire in the North Saskatchewan River valley (top middle), an American dipper searching for aquatic insects on the shoreline of an alpine lake (top right) and free roaming plains bison exploring the alpine after being reintroduced into Banff National Park in 2018 (bottom). (Photo Credits: Bill Hunt/Parks Canada, bison image Karsten Heuer/Parks Canada).

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Introduction

The State of the Park Report (or Assessment) is a key document in Parks Canada's, 10 year, park management planning cycle. The State of the Park Report (SOPR) provides the data needed to develop a scoping document that will provide focus for the upcoming round of public consultations for park management planning to update the Banff National Park Management Plan in 2020. Because a decade of detailed and diverse ecological data must be concisely summarised for the SOPR, we also provide the "Resource Conservation Technical Summaries" document to provide readers with a greater level of detail related to ecological monitoring and active management that has taken place in Banff Park over the past decade.

State of Park Reporting

Currently, state of the Park reporting has been simplified to a very concise summary of data to report on a wide range of measures related to the condition of:

- Built Assets,
- Visitor Experience,
- Aboriginal Relations,
- External Relations,
- Cultural Resources, and
- Ecological Integrity.

The State of the Park report provides information on Ecological Integrity in a few key slides. One slide summarizes a decade of data related to three Ecological Integrity Indicators:

- Forests,
- Tundra/Alpine, and
- Freshwater

The condition and trend for each of the three ecological indicators are derived from an extensive condition monitoring program. For each "Ecological Integrity Indicator" there are 5 separate measures that we report on to derive the overall condition and trend.

Secondly, an appendix slide reports on Species at Risk indicators for the 7 SAR that occurred in Banff National Park in that time:

- Banff Spring Snail,
- Westslope Cutthroat Trout,
- Common Nighthawk,
- Little Brown Myotis,
- Olive-sided Flycatcher,
- Whitebark Pine, and
- Woodland Caribou.

Thirdly, the State of the Park Report includes one slide to report on Key Issues – many of which are identified through not only Condition Measures, but also a Management Effectiveness Monitoring program which rigorously evaluates most of our ecological active management and restoration efforts, to determine their effectiveness and identify future improvements through an adaptive management process.

The purpose of this Technical Summary is to report on the past decade of ecological protection, management, restoration and monitoring. The information provided in this summary is intended to provide more comprehensive data and information that will be used to inform a scoping document to be used in the next round of Park Management Planning. An updated Park Management Plan for BNP is due in 2020.

This State of the Park Report – Resource Conservation Technical Summaries for Banff National Park is divided into 4 main sections:

1 **Condition Monitoring** (CM) – this section reports on the status and trend of 3 Indicators (each with 5 different measures). The goal of this work is to assess the overall condition and trend of the ecological health of Banff National Park over the long-term.

2 **Species at Risk** (SAR) – this section reports on the status and restoration success for 7 species, currently or historically found in Banff National Park, that are federally (under the Species at Risk Act or SARA) listed as either threatened or endangered.

3 **Active Management and Effectiveness Monitoring** (AMEM) – this section reports on monitoring that we have conducted to assess the effectiveness of various active management or ecological restoration efforts such as prescribed fire, dam removal, or restoration of wildlife corridors.

4 **Operational Programs** (OP) – this section provides data on human use trends, and operational demands and these in turn provide insight into interactions with the natural resources of Banff National Park.

This document reports on field work completed in Banff National Park from 2008 to 2017. Although there were many new and exciting developments in 2018 (e.g. Banff Bison), we were unable to update all the material in this document to include those from the 2018 calendar year. We did insert a few recent updates (e.g. changes to species listings under SARA) in an effort to avoid confusion for readers.

Explanation of Parks Canada Field Units

Parks Canada is organized into "field units" each of which oversees the management of one or more National Parks, National Historic Sites, and/or Marine Conservation Areas. The following abbreviations are used throughout the report:



BFU – Banff Field Unit (dark green). Comprises the south half of Banff National Park, Rocky Mountain House National Historic site and the Ya Ha Tinda Ranch.

LLYK – Lake Louise, Yoho, and Kootenay Field Unit. Comprises Yoho and Kootenay National Parks plus the north half of Banff National Park (light green).

BNP – Banff National Park, in Alberta (green).

YNP – Yoho National Park, in British Columbia (yellow).

KNP – Kootenay National Park, in British Columbia (pink).

Acknowledgements

The research, active management, monitoring, and operational programs summarized in this report are the result of a decade of hard work, led by the Parks Canada Resource Conservation teams in the Banff and Lake Louise, Yoho, and Kootenay Field Units. Key contributors include the various program leads (and their actors and predecessors):

Wildlife Ecologists – Jesse Whittington, Dr. Seth Cherry (Alan Dibb, Dr. David Gummer)

Human/Wildlife Conflict Specialists – Blair Fyten, Jon Stuart-Smith, Dan Rafla (Steve Michel, Hal Morrison, Brianna Burley, Saundi Norris)

Bison Project Managers – Karsten Heuer (Brian Low, Saundi Norris)

Aquatics Ecologists – Dr. Mark Taylor, Shelley Humphries (Charlie Pacas)

Species of Special Concern Ecologists – Dr. Bryan MacBeth, Anne Forshner (Jesse Whittington)

Monitoring Ecologists – Derek Petersen (Jesse Whittington)

Fire and Vegetation Ecologists – Jane Park, Jed Cochrane (Ian Pengelley, Rick Kubian, Gregg Walker)

Visitor Safety Program Manager – Brian Webster (Marc Led-widge)

Equine Program Managers – Ginny Crosby and Rick Smith (Cindy Obrigewitsch, Sean Elliot)

Emergency Dispatch Supervisors – Mark Merchant (Lise Gautron)

Resource Conservation Managers – Bill Hunt, Dwight Bourdin (Rick Kubian, Dr. David Gummer, Marc Ledwidge)

It is tremendously important to recognize that these program leads could not have accomplished all of this work without the ongoing support of a very talented team of highly dedicated field staff who work through all kinds of arduous mountain weather to collect data or actively manage and restore ecosystems, and then spend a similar amount of time organizing, analysing and summarizing the mountains of data needed to produce such high quality work. Many of these projects have also been published in peer reviewed scientific journals, public and conference

presentations or proceedings, or in more detailed technical reports. A list of key documents, from the past decade, is appended to this report. We also thank our colleagues in Jasper, Mount Revelstoke, Glacier, and Waterton Lakes National Parks who collaborate with us on many of these projects and programs. Nirmolak Kang and William Greene provided key logistical support in compiling and reviewing the document.

We also want to recognize the Parks Canada team members in the Banff and Lake Louise, Yoho, and Kootenay field units who support the work of Resource Conservation staff – our success would not be possible without the helpful contributions of our Finance, Human Relations, Visitor Experience, External Relations, Heritage Programs, Integrated Land Use Planning, Information Technologies, Highways Operations, and Asset Management team members and of course the leadership of the Field Unit Superintendents. The work summarized in the following 430 pages is truly a team effort.

In addition to work carried out by Parks Canada staff, we benefit from cooperation and collaboration with many Universities, independent researchers, and industrial partners. These include the following: Dr. Tony Clevenger and Dr. Mark Hebblewhite, University of Montana; Dr. Evelyn Merrill, Dr. David Hik, Dr. Scott Neilson, Dr. Rolf Vinebrooke, and Dr. Colleen Cassiday St.Clair, University of Alberta; Dr. Carl Schwarz, Simon Fraser University (now retired); Dr. Sean Rogers, University of Calgary; Dr. Eric (Rick) Taylor, University of British Columbia; Dr. Robert Newbury, Newbury Hydraulics; Dr. Dwayne Lepitzki, Wildlife Systems Research; Dorothy Lindman, Environment and Climate Change Canada; Neil Mochnacz, Fisheries and Oceans Canada; Dr. Mike Demuth, Geological Survey of Canada; Joe Van Humbeck (Ken Roberge) from Canadian Pacific Railway; and Scott Taylor and Aleta Corbett of TransAlta. Additional contributions are highlighted at the end of the individual summaries.

Many of these projects benefit from the support of dedicated teams of volunteers, provided through our Citizen Science program. We thank you for your continued contributions to the stewardship of Banff National Park.

Condition Monitoring

Introduction

Parks Canada's condition monitoring program incorporates nationally standardized indicators that are monitored over many years to provide a measure of ecosystem health. In Banff National Park, we have identified three systems (or what we call "indicators") that we monitor. They are: Forests, Tundra (Alpine) and Freshwater. For each of these indicators, we have five different "measures".

Parks Canada staff monitor these measures in a consistent manner and report back every 10-years, through the 'State of the Park Report" (SOPR) to identify changes in ecosystem health and to inform the Park Management planning process. For each measure we determine the condition (good/green, fair/yellow, or poor/red) and trend (decreasing, stable, or increasing). The condition of each indicator is based on that of the 5 measures and the indicator trend is determined based on the change in that indicator relative to the last assessment period (10 yr).

The park management plan identifies key stressors, and provides goals and objectives for ecosystem maintenance and restoration. We then use "management effectiveness monitoring" (next section) to assess whether or not our management efforts are producing the desired results.

In BNP, YNP, and KNP, our initial Condition Monitoring indicators (begun prior to 2010) included indicators such as biodiversity, connectivity, etc. However, in 2014, these were adjusted to better align with what eventually evolved to be standardized measures across all national parks in Canada. For some measures, the data were quite readily transferable to the new measures, but for others, we are starting anew, and will face challenges in summarizing meaningful trends prior to the 2020 Management Plan review. This is especially true for the Tundra indicator which was entirely new in 2014.

Indicators	Measures
Forest 	Burned Condition Class 
	Non-native Vegetation 
	Terrestrial Birds 
	Multi-species Mammal Occupancy 
	Winter Wildlife Corridors 
Tundra 	Non-native Vegetation 
	Alpine Birds 
	Alpine Extent NR
	Sensitive Alpine Species – Goat 
	Alpine Obligate – Pika 
Freshwater 	Connectivity 
	Amphibian Occupancy NR
	Lake Fish Index 
	Water Quality 
	Stream Fish Occupancy 

Forest Measure: Area Burned Condition Class

Introduction

The Area Burned Condition Class (ABCC) measure is a standardized condition monitoring measure within the Parks Canada Agency National Ecological Integrity Monitoring program for all national parks with fire-dependent vegetation (Parks Canada Agency 2005c, 2007, 2010). This measure is based on the fire cycle concept (Van Wagner 1978, Johnson and Van Wagner 1985) and assesses the degree of departure from historic or reference area burned levels within a park. It is intended to address broadly the following monitoring question: "what is the state of fire as an ecological process in the parks?"



Figure 1. Moose Meadows Prescribed Fire, 2016.

It is important to recognize that decades of fire suppression have moved this ecological condition measure into "poor" condition, and it will take decades of progressive fire management and careful use of prescribed fire to recover from this poor condition. For that reason, we will also report on a "Management Effectiveness Measure" for fire that only assessing trends over the past 20 years (see appropriate MEM section in this report) – as this reflects the relative success of our efforts in meeting intermediate targets (rather than crossing ecological thresholds), since a better understanding of fire's important role in the ecosystem resulted in policy changes in Parks Canada.

- The Area Burned by Condition Class (ABCC) Ecological Integrity measure assesses the degree of **departure** from historic or reference area burned levels within a park.
- ABCC combines area burned by both prescribed fire and wildfire.
- The national target ABCC is to achieve at least 20% of the historic fire cycle in all fire dependent parks (ie. no more than an 80% departure from historic levels), however, in Banff National Park, the Park Management Plan identifies a higher goal of achieving at least 50% of the historic fire cycle.
- Forests do not all burn with the same frequency, so to calculate ABCC we classify forest stands into one of 5 forest types and assign a reference fire cycle (see on next page).

Parks Canada's fire management program's priority is to ensure the safety of people and valued infrastructure.

Monitoring Question

How has the area burned changed over time within Banff National Park when compared to the historic fire cycle?

Metric

% departure from historic fire cycle.

Thresholds

See Table 1.

Table 1. Area burned condition rating and associated area burned departure (ABD) thresholds

Area Burned Condition Class (ABCC)	Area Burned Departure (ABD)
Good	0 - 33%
Fair	34 - 67%
Poor	>68%

Methods

Calculating ABCC for Banff requires a series of steps and calculations in order to obtain a final area burned condition value for the park. The first steps (1-3 below) involve selecting reference fire cycle values for all forested areas in the park based on historic fire regimes. For Banff National Park, the historic fire regime is based on fire history research (Rogeu and Gilbride 1994; Van Wagner 1995). Each year the total area burned in Banff (prescribed fire and wildfire) is calculated by either directly measuring the fire area, using dNBR remote sensing burn severity data (Soveral et al. 2010), or a combination of the two approaches.

Steps for Calculating ABCC for Banff National Park

- **Step 1:** Assemble fire history information for Banff from Rogeau and Gilbride 1994 and Van Wagner 1995)
    - Area burned includes all types of fires (surface, intermittent, crown) and not only stand replacement fires.

- **Step 2:** We developed five Reference Fire Regime Areas (RFRA) for forested regions of Banff. These included: Lower Subalpine, Montane, Old growth, Subalpine (Lodgepole pine) and Upper-subalpine. For each RFRA we established an area (A) in hectares (ha) in GIS.
- **Step 3:** For each RFRA we defined a reference fire cycle (rFC) value (based on fire history research).
- **Step 4:** For each RFRA, we calculated the expected annual area burned (eAAB) following equation 1.

$$eAAB = \frac{A}{rFC} \quad \textbf{[1]}$$

- **Step 5:** For each RFRA, we then calculated expected area burned (**eAB**) and the actual area burned (**aAB**) over the monitoring period (**MP**) following equation 2. The MP is equal to the reference fire cycle (rFC) or the length of the area burned available dataset (whichever is smaller) for the RFRA. Because early fire reports and data from many decades ago was not always reliable; we selected the MP's for Banff based on fire maps or measurements once burned data was reliable.

$$eAB = eAAB \times MP \quad \textbf{[2]}$$

  - aAB = sum of all burned area (wildfires and prescribed fires) during the MP
- **Step 6:** For each RFRA, we calculated an area burned departure (ABD) following equation 3.

$$ABD = \frac{aAB - eAB}{eAB} \times 100 \quad \textbf{[3]}$$

- **Step 7:** For each RFRA, we determined the ABCC by comparing the ABD to the fixed threshold values.
- **Step 8:** We computed a final ABD for Banff National Park following equation 4.

$$ABD_{Final} = \sum_{i=1}^{n} \left[\frac{|ABD_i| \times A_i}{A_t} \right] \quad \textbf{[4]}$$

  - where n represents the number of different RFRAs in the park, and A_i and A_t represent the areas of the individual RFRA and total park, respectively
- **Step 9:** We established a final ABCC condition and trend .

The measure is represented as a percentage departure from the historic fire cycle. If the value is 0%, that means that the park is not departed from the natural fire cycle, while -100% departure indicates that the current fire cycle is double the historic norm.

Results

There is lots of variability among the condition of Banff's forested ecosystems depending on the Reference Fire Regime Area. The lower sub-alpine, upper subalpine and subalpine (lodgepole pine) are in "poor" condition with area burned departure of -87%, -85% and -79 respectively (Table 2). The montane is in "fair" condition with an area departure of -66 and the old growth is in "good" condition with an area departure of -27. The overall condition of forested habitats in Banff National Park, in terms of area burned, is "poor" (Table 2). This overall assessment takes into account the area burned departure and the proportion of Banff composed of each reference fire regime area.

Between 2007 and 2017, the mean number of fires (wild and prescribed) each year in Banff was 12.6 and the mean area burned was 1231.3 ha. Throughout Banff there has been an increase in the number of fires (Figure 2), however, the area burned has been variable due to varying climatic conditions for managed wildfire and prescribed fire (Figure 2 and 3).

Table 2. Illustrates the five difference reference fire regime areas in Banff, their respective reference fire cycle and calculated area burned departure. Condition values for each reference fire regime area and an overall condition for Banff National Park is also illustrated

Reference Fire Regime Area	Reference Fire Cycle (years)	Area Burned Departure (%)	Area Burned Condition Class
Montane	50	-66	FAIR
Subalpine (Lodgepole Pine)	100	-79	POOR
Lower Subalpine	150	-87	POOR
Upper Subalpine	200	-85	POOR
Old Growth	400	-27	GOOD
	Banff Overall	82	POOR

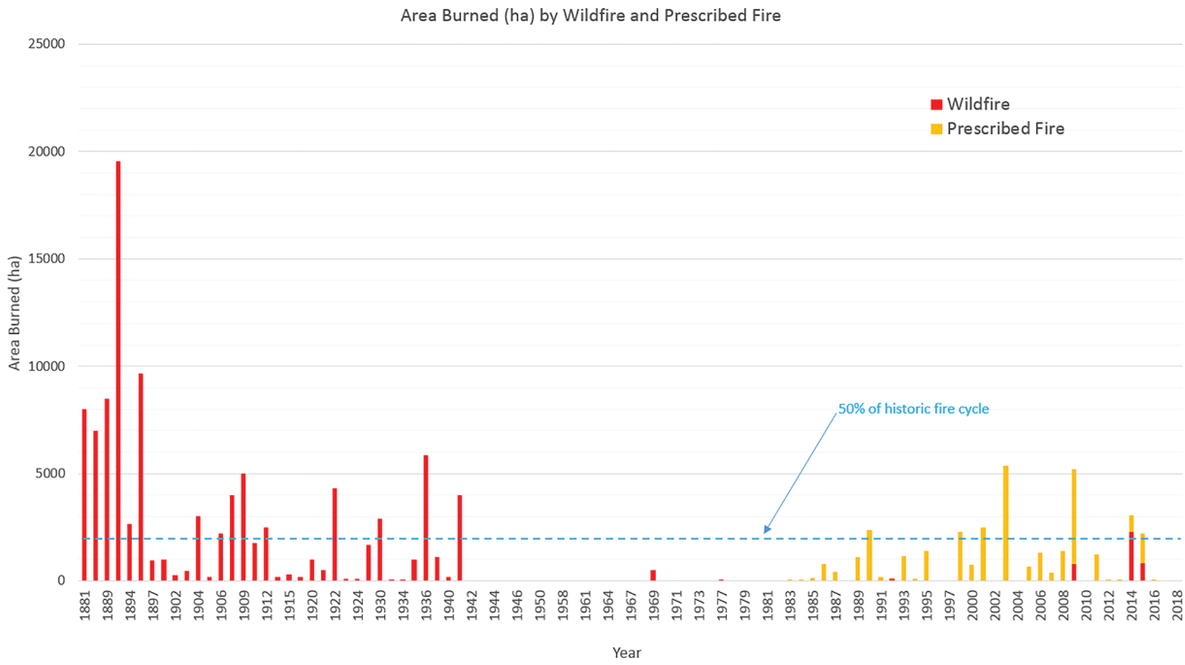


Figure 2. Graphs illustrate the annual number of fires and area burned (ha) in Banff between 2007 and 2017.

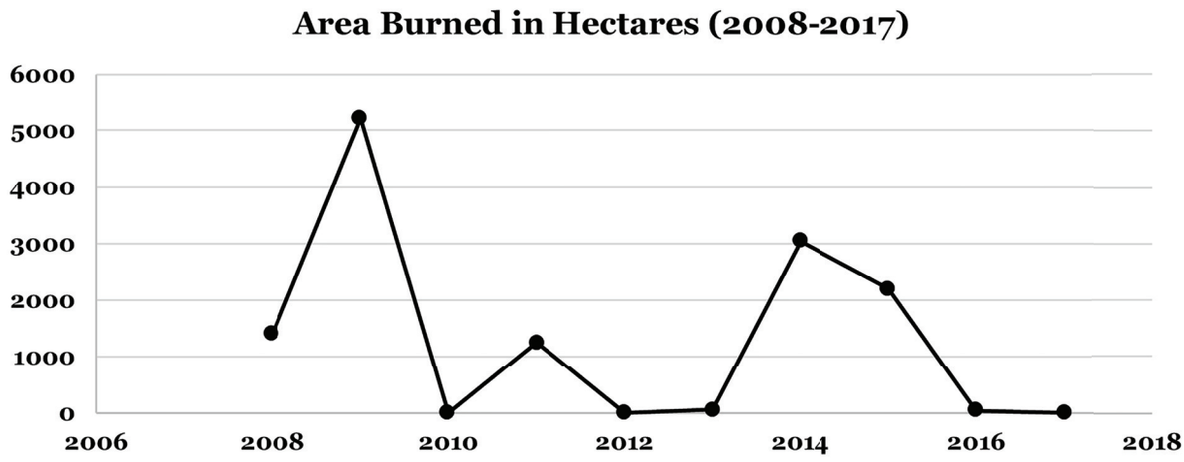


Figure 3. Graph illustrate the annual area burned (ha) in Banff between 2008 and 2017.

Condition and Trend

Condition: POOR
Trend: Stable

Assessment Confidence

Area burned is commonly used to monitor fire effect and there is significant benefits of having a clear, basic measure for park fire management planning and reporting at both the park and national scale. Because of its link to fire history measures (fire cycle, fire return interval) and its effects on ecosystems at a very large scale, area burned departure has become adopted by all National Parks with fire dependant ecosystems. Currently the protocol is complete, however, advances in geomatics technology may change how fire area is calculated in the future.

Discussion

Banff was the first National Park in Canada to conduct a prescribed fire in 1983 and it continues to lead other parks in prescribed fire implementation, however, fires influence on ecosystem maintenance still remains in deficit. In general, the results suggest that the forested ecosystems in Banff are in relatively poor health in terms of area burned by fire. Although more difficult to quantify, areas that have burned by wildfire or prescribed fire illustrate how important fire is for maintaining ecological diversity and integrity. As described within this State of the Park Report, post fire habitats in Banff are critical for restoring/recovering species at risk such as Whitebark pine and the olive sided flycatcher as well as other keystone or iconic species such as grizzly bears, bighorn sheep and elk.

Even though the area burned by condition class is rated 'poor' for Banff, fire management in the last decade has been successful. Since 2007, there have been 17 prescribed fires contributing to over 68% (>9271 Ha) of area burned. Many of these prescribed fires (ex. Sawback, Carrot Creek, Moose Meadows etc) were located in the Bow Valley and consequently were challenging to implement. The geographic extent of these prescribed fires doesn't often contribute to large amounts of "area burned", but because they are strategically located to reduce fuels or create fuel breaks, they reduce the impacts of future wildfires and facilitate the implementation of future prescribed fires.

We suggest caution when interpreting the ABCC trend over the last decade. For comparison, we report the same data, but without partitioning Banff into reference fire regime areas and based entirely on area burned between 2008 and 2017 (SOPR period) (Figure 3) . This approach over a short time period (10 years) can be influenced heavily by a dry year with large amount of area burned, perhaps only one fire. However, examining the area burned over the course of the prescribed fire program (starting in 1983) shows that the prescribed fire program in Banff has positively contributed to the reintroduction of fire back onto the landscape (Figure 4).

While this ABCC "condition measure" is a legacy of decades of fire suppression, that will take many more decades to correct, our "area burned" Management Effectiveness target for Banff National Park was to burn 14,000 ha over the last 10 years (1,400 ha/year) and we have met that active management target (actually slightly under at 13,959 ha). See the Fire Management Program summary under MEM in this report for more details.

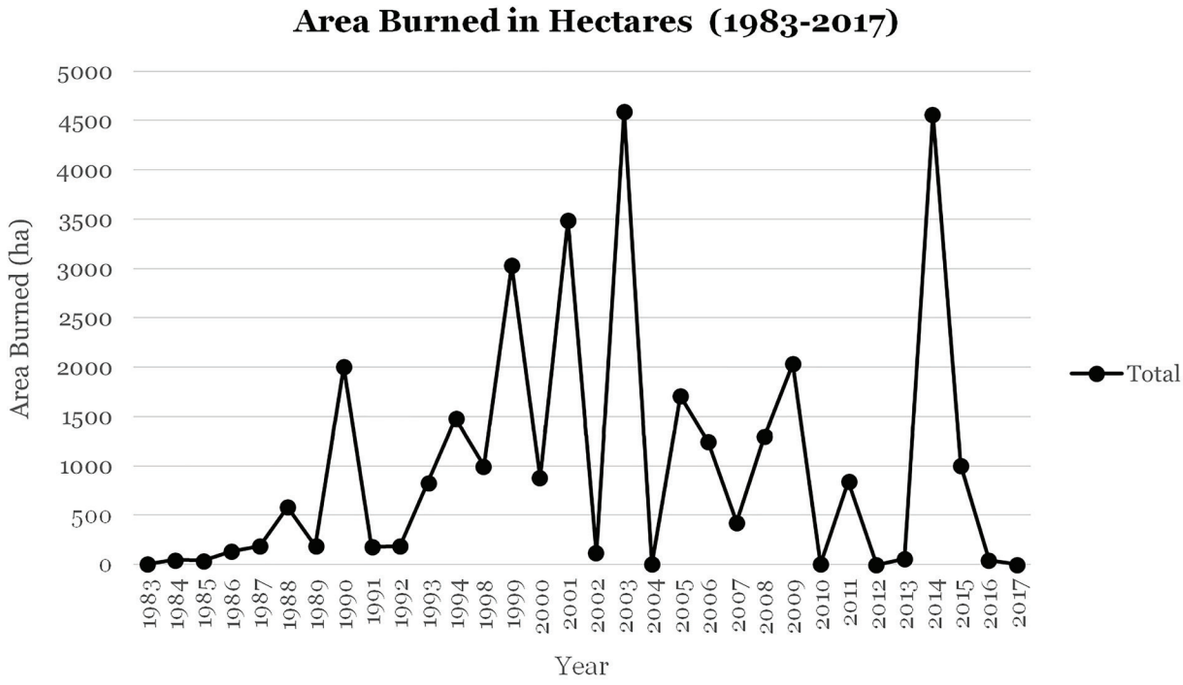


Figure 4. Area burned in hectares since the start of the prescribed fire program in Banff National Park (1983).

Following almost a century of fire exclusion in Banff National Park (White 1985), it has now been 35 years since we first changed our management strategies and began to address the importance of fire for maintaining healthy and functional ecosystems. During the past 35 years, Banff National Park has continued as a world leader in prescribed fire practices, however, the accumulation of fuels, and the homogeneous forest stands that remain after the century of fire exclusion is a constant reminder of the time scale at which these ecosystems operate. If each strategic prescribed fire or fuel break, regardless of its size, is a step towards sustaining healthy forested ecosystems, then Banff National Park is well on its way. One thing that has become apparent in the last 35 years is that restoring healthier ecosystems, following a century of fire suppression, will require a safe, pragmatic and persistent approach.

Acknowledgements/Partners

Fire management in Banff National Park is truly a team effort. We thank the National Fire Management Program for their leadership and guidance not only in fire management, but also in coordinating consistent monitoring and reporting of fire effectiveness. We thank all the staff from other functions of Parks Canada, such as finance, assets, and human resources, who support our delivery of a safe and effective fire program. We also thank our partners in CIFFC (Canadian Interagency Forest Fire Centre) for their support and guidance.

Contact

Jane Park, Fire and Vegetation Ecologist
Banff Field Unit
P: (403) 762-1417
E: *jane.park@pc.gc.ca*

Jed Cochrane, Fire and Vegetation Ecologist
Lake Louise, Yoho, Kootenay Field Unit
P: (250) 347-6161
E: *jed.cochrane@pc.gc.ca*

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Forest Measure: Non-native Vegetation

Introduction

The International Union for Conservation of Nature has identified invasive alien plants (IAP) as the second major threat to biodiversity, after habitat loss (Invasive Species Specialist Group, 2000). Effective IAP control, monitoring and research is important to ensure the maintenance and restoration of ecological integrity in protected areas (Tierney, et al., 2009). The park management plan for Banff National Park identifies maintaining and restoring healthy ecosystems as a primary objective for the park (Parks Canada, 2010). Measuring and monitoring the presence and abundance of IAP in forested ecosystems is important for recognising and addressing the impacts of IAP's on the ecological integrity of Banff National Park. The impact of IAP on ecological integrity is difficult to quantify because it is linked to characteristics of the invading species and the vulnerability of the habitat. To help address this, we divide Banff National Park into three different management zones and rank individual IAP into three classes.



Figure 1. Ecological Management Zones in Banff National Park.

Management Zones

Banff National Park is divided into three IAP Ecological Management Zones reflecting different management objectives (Figure 1) (Parks Canada 2017).

Ecological Preservation Zone (EPZ) includes: alpine habitats, restoration areas and sensitive habitats where the introduction or proliferation of IAP would have significant negative impacts on ecological integrity. The management objective for this zone is to be IAP free.

Enhanced Control Zone (ECZ) includes: backcountry locations, general wilderness park areas and areas near park facilities and infrastructure. The management objective for this zone is timely detection and treatment of IAP colonization to prevent propagation.

Integrated Control Zone (ICZ) includes: roadsides, town-sites, day use areas, the CPR right of way and other front country areas where risk of IAP is high due to high levels of disturbance and associated dispersal pathways. The management objective for this zone is regular, strategic treatment, where effective; with a focus on preventing transmission into adjacent zones.

Each Zone is stratified based on a combination of ArcGIS data, local knowledge from subject area experts, and data from previous inventories. We classified the forested zone based on the Ecological Land Classification (ELC) omitting "alpine" and "rock and ice" (Parks Canada, 2017; Parks Canada, 2016).

Monitoring Question

Is the average IAP percent cover <1% and has it changed by >0.2% during the last 5 years in areas most likely to be colonized within forest ecosystems?

Metric

Mean IAP cover along a line transect.

Thresholds

We used thresholds to assess the resulting weighted mean cover for IAP in forested ecosystems. We established these thresholds before sampling and re-evaluated them after preliminary data collection, analysis, matched field observations and associated ecological impacts

GOOD	<1% mean cover of designated IAP
FAIR	1%-10% mean cover of designated IAP
POOR	>10% mean cover of designated IAP

Methods

Plot Stratification

In 2016, we selected 109 permanent plots (25m transects) in forested ecosystems of Banff National Park; we located 47 plots in the ICZ, 32 in the ECZ and 31 in the EPZ. Within the ICZ, we randomly selected plots without additional stratification. Within both the ECZ and EPZ, we randomly selected plots, however, we stratified the sampling area to be within 10 m of roads and

trails and no more than 5km from vehicle access points. We implemented this stratification to ensure ease of accessibility and to increase the likelihood of capturing IAP infestations in the data, as most IAP are found close to roads, trails or disturbed area (Mortensen, et al., 2009). Each fixed plot consists of a 25m transect that we will re-visit at five year intervals.

We recorded IAP cover at each of the plots, following a line intercept approach. We obtained the total cover for each species by adding the line intercept data. We calculated cover for all IAP by dividing the total cover by the length of the transect (25 m) and multiplying by 100. We calculated mean IAP cover for each Ecological Management Zone. To facilitate plant identification we collected data during peak flowering of most IAP species. We recorded the presence of all IAP in an area; even if they fell outside the plot. For further details please refer to Invasive Alien Plant Condition Class Monitoring Interim Protocol (Parks Canada, 2015).

The impact of IAP differs depending on the Ecological Management Zone and therefore each transect was weighted proportionately as follows:

- EPZ zone: Cover was multiplied by 2
- ECZ zone: Cover was multiplied by 1
- ICZ zone: Cover was multiplied by 0.2

The weight suggests that 1% IAP cover in the EPZ has twice the impact as in the ECZ and 10 times the impact as within the ICZ. We then compared the zone-specific means and the pooled weighted mean to the predefined ecological thresholds for “good,” “fair,” and “poor” condition.

Results

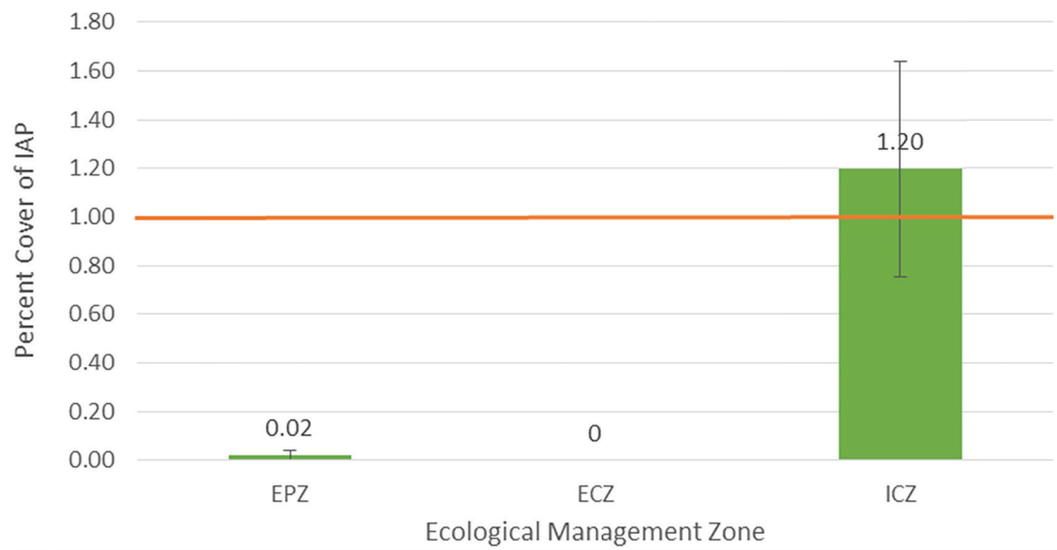


Figure 2. Banff IAP percent cover for each management zone.

As expected, the cover of IAP was low in the EPZ and ECZ but much higher in the ICZ (Figure 3). After weighting, the IAP cover mean was "good" for the EPZ (0.02%) and the ECZ (0%) and above the "fair" threshold for the ICZ (1.2%) (Figure 2). Pooled across all zones, after weighting cover values according to zone, mean IAP cover was 0.28% (Figure 3).

Condition and Trend

Condition: Good
Trend: Not Rated

The mean IAP cover in EPZ and ECZ is less than the target threshold of 1% to indicate "good" condition. In contrast, IAP cover for the ICZ exceed the 1% threshold for "fair". Once weighed to better represent the variation of impact that IAP have in the different management zones, EPZ (0.04 %) and ECZ (0%) remain below the 1% threshold for "good" condition, and ICZ (0.23%) falls below the 1% threshold indicating a "good" condition.

Trends are not yet available since this was the first year of data collection using this protocol. Data collection is taking place on a 5 year cycle. The next round of monitoring will take place in 2021. The next survey will give a comparison and will be used to answer the monitoring question presented in this protocol, giving an indication of how IAP cover is changing over time.

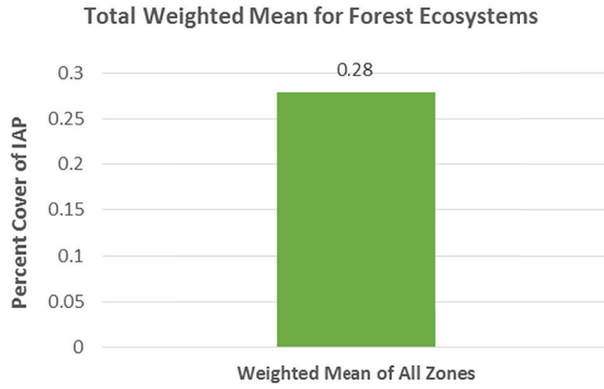


Figure 3. The weighted percent cover for plots found in forest ecosystems, in 2016 is 0.28% indicating "Good EI".

Assessment Confidence

The Forest CCM protocol is new. We are recalculating thresholds and sample sizes to better represent each zone in park.

Discussion

Results of the 2016 survey concludes that IAP are generally present (at variable density) in disturbed, front-country areas in the ICZ but are largely absent from natural (undisturbed) sites in the ECZ and EPZ.

These results will assist in organizing IAP management strategies within ecological management zones by providing quantitative data for each management zone, in addition to providing data for determining the overall condition of the forest ecosystem. The 2016 data confirms the identified pathways of IAP invasion in Banff National Park, which include highways, railways, and other

access roads (Michalsky, 2007). These are all features that are found in the ICZ, which had the highest percentage of IAP cover (1.20%). The IAP percent cover data for the EPZ (0.02%) was not unexpected, as many of the areas classified as EPZ can be found adjacent to the ICZ, which could result in features of the ICZ acting as vectors for IAP in the EPZ. The results in this report will also be used to quantify changes in IAP percent cover with data collected in 2021.

Contact

Brian Yakiwchuk, Resource Management Officer
Banff Field Unit
P: (403) 762-1495
E: *brian.yakiwchuk@pc.gc.ca*

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Forest Measure: Terrestrial Birds

Introduction

Birds are the most diverse group of land vertebrates, and are recognized as a valuable indicator group in forest ecosystems. The highest bird diversity in temperate forest ecosystems in North America is generally supported by diversified forest structures including clearings and old and young stands. The most important threat that forest birds face in North America is habitat loss from the expansion of urban areas and forest management activities, which tend to make forest stands uniform over large areas. The mountain National Parks, where human development is limited, provide important refuges for a wide range of forest bird species and serve as reference sites for assessing the effects of climate change and land use.

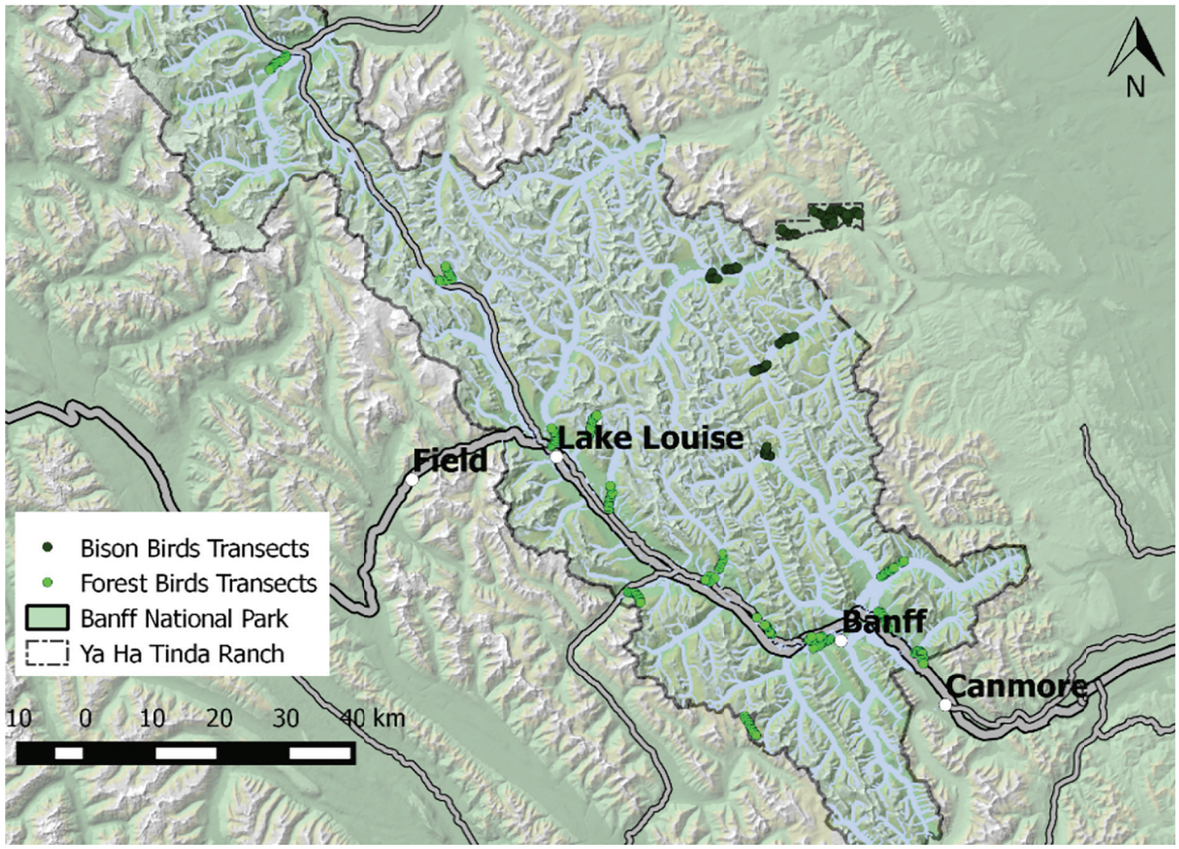


Figure 1. Locations of all forest and bison point count transects in Banff National Park, and Ya Ha Tinda Ranch.

Birds are relatively easy to monitor and show measureable responses to stressors such as habitat loss and fragmentation (Moses et al. 2001), anthropogenic stressors, challenging weather events, and climate change. Monitoring avian population processes provides meaningful information to our ecological monitoring program for numerous reasons: extensive knowledge about avian ecology facilitates the interpretation of the results; birds are highly diverse and provide more insights about biodiversity than any other group of terrestrial vertebrates; birds integrate processes at multiple scales (e.g. local / residents vs. large scale / migrants); niche specialization of certain species can make them sensitive to environmental change; existing data is extensive in many parks; field methods are well known and tested; and strong public interest fosters public en-gagement (Kehler and Samson 2005). Conversely, the migratory nature of many songbirds, can result in uncertainty regarding root causes. When changes are detected – are impacts occurring on breeding ranges or wintering habitats, or both?

In 2007, seven national parks in the western cordillera bioregion (Waterton Lakes, Mount Revelstoke, Glacier, Banff, Yoho, Kootenay and Jasper), implemented songbird monitoring programs to identify bioregional changes in avian abundance and diversity in forest ecosystems.

Monitoring Question

What proportion of native terrestrial bird species and ecological guilds are in decline (>2.5% decrease in detection/year)?

Metrics

1. Percent (%) of bird species declining by ≥2.5%.
2. Percent (%) of forest bird guilds declining by ≥2.5%.

Thresholds

GOOD	<10% of bird species are declining; <25% of bird guilds are declining
FAIR	>10% of bird species are declining; >25% of bird guilds are declining
POOR	>25% of bird species are declining: >50% of bird guilds are declining

	POOR	FAIR	GOOD
Percent of bird species declining	>25%	10-25%	<10%
Percent of bird guilds declining	>50%	25-50%	<25%

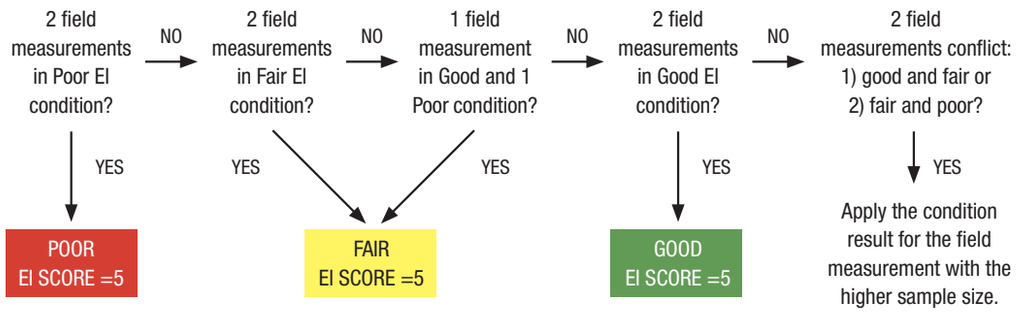


Figure 2. EI Score decision flowchart used to determine measure condition rating.

We measured forest bird thresholds based on the proportion of species or guilds found to be in decline within the montane/sub-alpine ecoregion. A species or guild was in decline if the annual detection rate decreased by more than 2.5% per year. This measure is based on Birds of Conservation Concern (BoCC) and is analogous to measures implemented by the International Union for Conservation of Nature (IUCN 2001) (Eaton et al. 2009).

Methods

Data Collection

We used a standard point count sampling protocol for forest bird monitoring in Banff National Park (BNP). The objective of the point counts is to quantify the relative abundance of avian species in the montane and sub-alpine ecoregions. Relative abundance refers to the frequency of occurrence of a species at the survey point taking in to account its likelihood of being encountered (Bibby et al., 2005, Dunn et al., 2006). We took 10 minute recordings at points located at least 300 m apart along transects. Between 2007 and 2014 we conducted 134 point counts at 17 transects each year. In 2015 and 2016 we added an additional 4 point counts to two of transects. In addition, in 2014, we added 100 additional point count stations at 10 different transects in BNP and at the Ya Ha Tinda ranch, to monitor the impact of bison reintroduction on the landscape; we pooled these transects with our forest transects to provide broader spatial representation. Figure 1 shows the locations of all transects in BNP and at the Ya Ha Tinda Ranch. A specialist in acoustic identification of birds identified all species heard and transcribed the minimum number of individuals at each point count location.

Ecoregions, Indicators and Eco-Communities

We classified each point-count station as "forest" habitat based on the Ecological Land Classification (ELC) and, in some cases, field-based vegetation sampling. We grouped all points that were not classified as "alpine" by the ELC (e.g. "sub-alpine") with the forest ecoregion. We calculated trends for all bird species detected in an ecoregion to obtain the best available representation of the avian eco-community for each indicator. We used ecological guilds (see below) to account for the ecology of bird species in a separate analysis.

Ecological Guilds

Bird species were grouped according to three guild classes.

1. Foraging guild: species based on diet and foraging behaviour. These included bark foragers, granivore-herbivores, granivore-insectivores, insect gleaners, aerial insectivores and omnivores.
2. Habitat guild: species based on the habitat selection behaviour. These included aquatic, forest generalists, grassland-meadows, mature forest, wetland, and habitat generalist.
3. Migratory guild: a bird species must be regularly present within the National Park year-round.

Statistical Analysis

Annual trends – Binomial GLMM. We calculated annual population trends and their 95% confidence intervals for each species using Generalized Linear Mixed Models (GLMM with a logit link). We tested 4 biologically plausible models to assess bird detection/non-detection as a function of year. We modeled year with either a linear or quadratic functions. To account for repeated sampling within sites, we included either transect or point count nested within transect as a random effect term. We used Akaike Information Criterion (AIC) to select the best fit model based on lowest AIC. We assessed model fit by calculating delta AIC, error rates and by plotting binned residuals (Gelman and Hill, 2007). We estimated the overall trend per species using the β coefficients for year from the selected model. We converted β coefficients to annual percent change (R) in bird detection/non detection using the equation $R(\%) = (1 - e^{logic(p)}) \times 100$ for negative trends and $R(\%) = (e^{logic(p)} - 1) \times 100$ for positive trends.

Trend significance. We used 95% confidence intervals of the trend to assess if a species or guild was in decline. If the confidence intervals were below 2.5% decline per year, the species was considered in decline. If confidence intervals were above -2.5%/yr the species/guild was considered stable or increasing. Species/guilds with confidence interval that crossed the threshold level (-2.5%/yr) were considered uncertain. Overall trend estimates were made by calculating the proportion of species/guilds in decline from the total number of species/guilds detected.

Trends by guild. We calculated proportionally weighted average trends by guild to represent the population trend of birds that share similar ecology (function, habitat and resident). We

calculated the weighted trends by summing the product of the model parameters (X_i) by the proportion that each bird species represented within its ecoregion, given by $\Sigma_{i=sp} \frac{n_i}{n_{guild}} \times X_i$. This enables us to account for overrepresentation of bird species with small sample sizes. The percentage of detections that each guild represented in its ecoregion is given by $\varphi_{guild} = \frac{n_{guild}}{n_{comm}} \times 100$, as an indicator of the relative importance of each guild within its guild class. We excluded guilds that represented < 1% of the detections in their ecoregion or where guilds only included a single species. We estimated the number of guilds in decline using the 95% confidence intervals as described above.

Results

- We conducted a total of 962 point-counts in the montane and sub-alpine ecoregion in Banff National Park over the 10-year period (average = 96.2 point-counts/year; Figure 1). We assessed trends for a total of 80 species and 15 guilds (figure 3 & 4).
- Five species or 6% of the total species analysed recorded declines in detection greater than 2.5% per year. These species included the Gray Jay, Hairy Woodpecker, Pine Siskin, Savannah Sparrow and Swainson's Thrush.
- Two of the fourteen guilds (resident, granivore-herbivore) also indicated a decline in detection of more than 2.5% per year. This equated to a decline in 14% of guilds.
- A high proportion of species and guilds had stable or increasing trends. This included 28/80 species (35%) and 8/15 guilds (50%). A number of species recorded increasing trends of over 2.5% per year.
- Trends were uncertain for 59% of species and 33% of guilds.
- Overall the condition of bird species within the montane and sub-montane ecoregions is good for both species and guild sub measures.

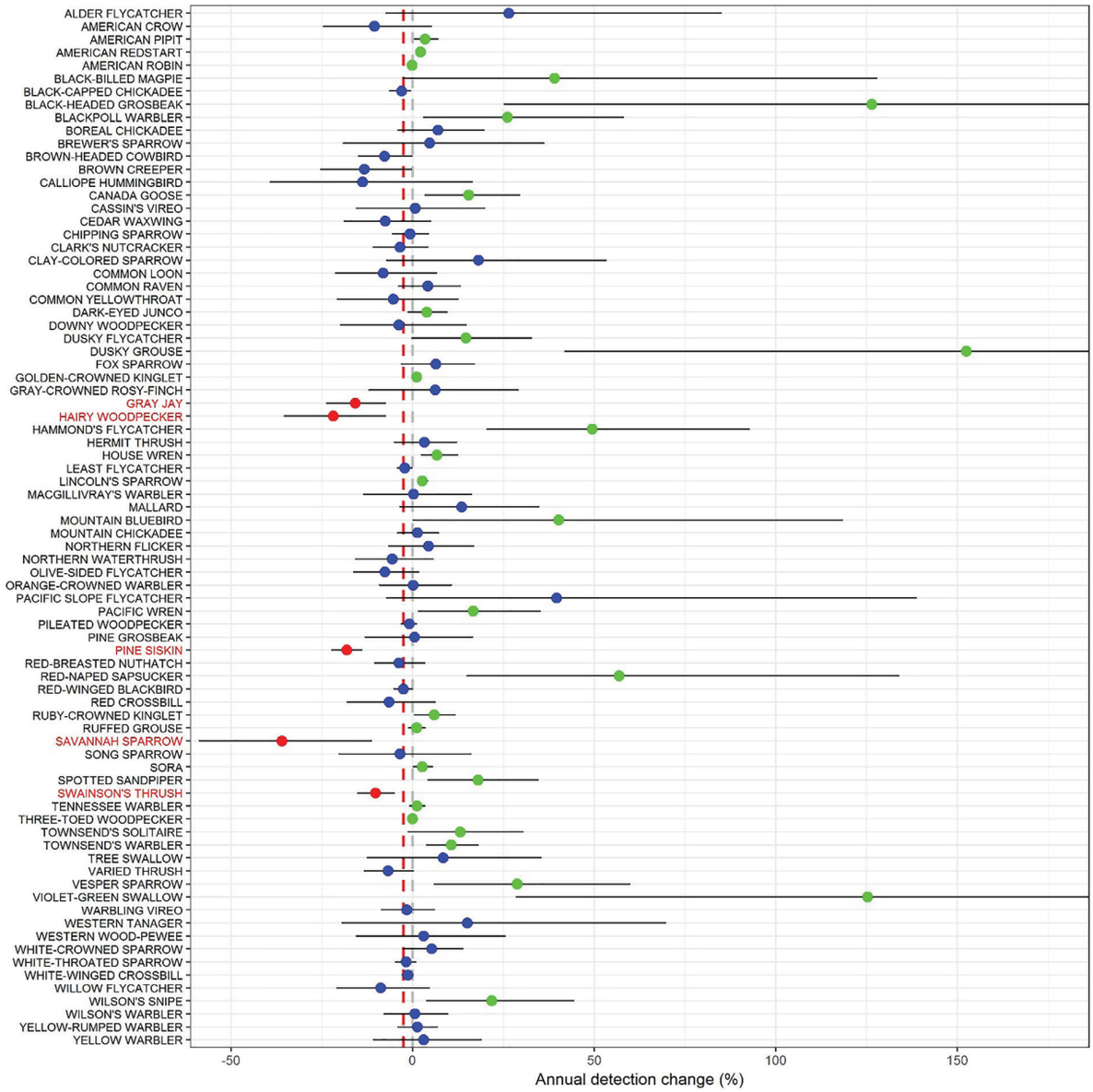


Figure 3. Annual percent change in detection for birds within the montane and sub-montane ecoregion of Banff National Park. Trends and 95% confidence intervals are presented by species. Red dots indicate species with declining trends (-2.5%/yr), blue dots represent species with uncertain trends and green dots represent stable or increasing trends (+2.5%). The gray dotted line represent no change in trend with time (0%) annual change, and red dashed lines signified a decline of 2.5%.

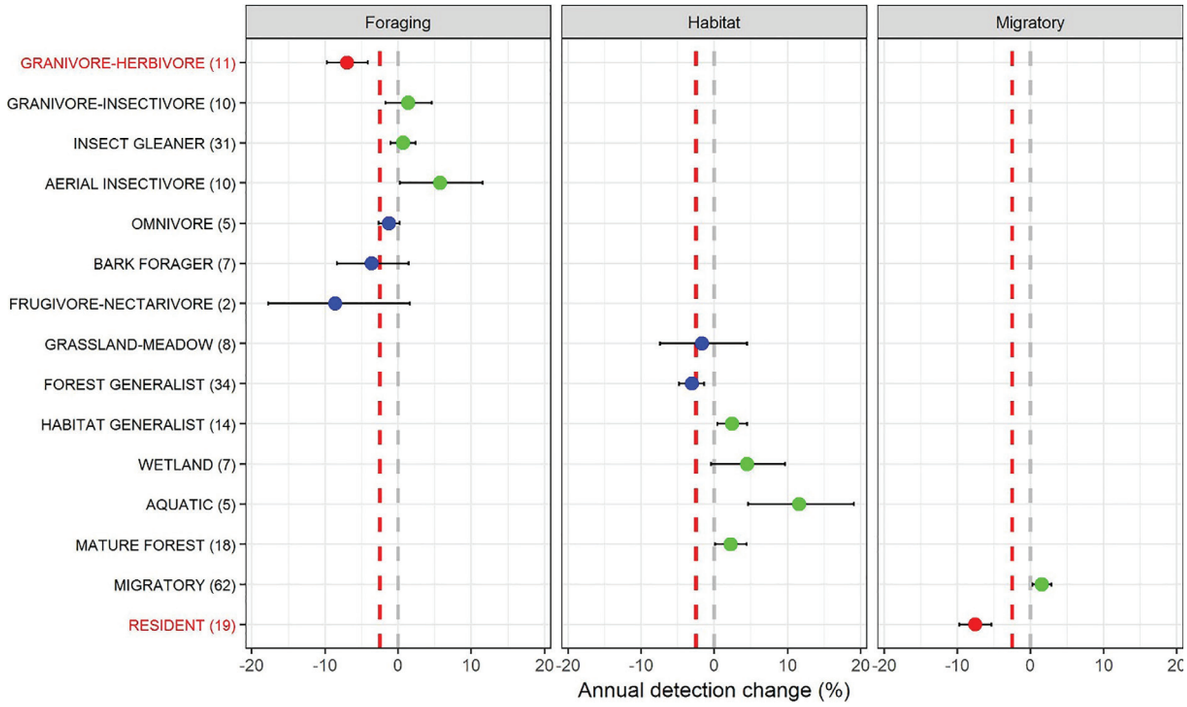


Figure 4. Annual percent change in detection for birds within the montane and sub-montane ecoregion of Banff National Park. Trends and 95% confidence intervals are presented by guild. Red dots indicate guilds with declining trends (-2.5%/yr), blue dots represent guilds with uncertain trends and green dots represent stable or increasing trends (+2.5%). The gray dotted line represent no change in trend with time (0%) annual change, and red dashed lines signified a decline of 2.5%. The number of species within each guild is listed in brackets.

Condition and Trend

Condition: Good
Trend: Undetermined – this is the first analysis based on the current sampling protocol.

Both threshold sub-measures (species and guild)(figure 2) were “good”.

Assessment Confidence

High

We used 95% confidence intervals to incorporate uncertainty into our measure of trends. As seen in Figure 2, wide confidence intervals for many species indicate our detection rates are highly variable over time. This may result from either variability in bird distribution over time, or variability in species detection. For example as we record bird calls only, species which call less frequently may be underrepresented.

Discussion

- Among species showing a significant downward trend, Savannah Sparrows showed the steepest decline (-36%/year). This trend is based on a small sample size of 18 detections. Below treeline, Savannah Sparrows only nest in open grasslands and marshes so there are limited pockets of available habitat for them in BNP and they are likely being detected from meadows or marshes between forest patches and in the sub-alpine. The declines may have occurred at only a few sites, but may still be noteworthy because there are a limited number of sites below treeline in BNP where this species is found. Nonetheless, this is not a typical forest indicator bird. Furthermore, Vesper Sparrows, which occupy similar habitat, showed an increase of comparable magnitude, so it is difficult to speculate about these changes.
- The decline in detection of Gray Jay is in keeping with evidence that suggests that this species may be declining at the southern edge of its range. Gray Jays live in sub-alpine forests and cache food in tree hollows to support breeding in late winter. Stickland and Ouellet (2011) showed warming temperatures led to increasing number of spoilt food caches, resulting in food shortages. This is thought to be as a result of climate change (Strickland and Ouellet, 2011).
- Hairy woodpeckers can be habitat specialists and forage on and underneath bark. The main threat identified for this species is forest fragmentation (Jackson et al. 2002) which may negatively impact available breeding areas (George 2000). Further investigation will be required to determine if the declines we detected are associated with changes in forest structure due to visitor use (i.e. trails), natural disturbances or other yet unidentified causes.
- Pine Siskins showed a decline of approximately 20% per year over a 10 year period. A similar pattern was recorded for this species in Kootenay National Park. This trend may results from changes to winter feeding grounds, as this species is known to vary in irregular patterns which shift from one year to the next. Pine Siskin have been designated as a common species in steep decline in North America by Partners in Flight (Rosenberg et al. 2016). Investigating the causes of decline in these species will inform management planning in the event that decreases in these species continue.
- The ecological guild with the steepest declines were year-round residents and granivore-herbivores. The granivore-herbivore guild is characterized by birds that forage on seeds of grasses, herbs, wildflowers, shrubs and trees, as well as on buds, herbaceous foliage and needles; these include finches, grouse, nutcrackers, doves and some sparrows. We will undertake further investigation of relevant covariates and species-habitat associations in order to determine and prioritize the causes of the declines in these guilds and what if any management response may be appropriate.
- Olive-sided Flycatchers (OSFL) are listed as Threatened in the Species at Risk Act (2002) and although the factors responsible for their decline are unclear, fire suppression is stated as a potential threat in the Recovery Strategy (2015). Fire suppression can negatively influence bird populations because forest fires create heterogeneity in forest structure and regulate natural forest succession processes that some native bird species are adapted to. Through our EI Monitoring program and Multi-species Action Plan, Banff National Park is committed to using prescribed burns and fire management practices to achieve an area burn target

which represents 50% of the historic fire cycle, and active management strategies to create the mosaic of forest ages and structures that OSFL require. The significant decline of this species in BNP over the last 10 years indicates that the distribution and habitat requirements of OSFL should be taken into account in fire, and active management planning in this Park.

- We recommend continuing the bird monitoring program in the forest ecoregion in Banff National Park and analysing the data every 5 years instead of 10 due to the existence of SARA listed species in decline, and for more frequent assessments of Pine Siskin and Varied Thrush.

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Forest Measure: Multi-Species Mammal Occupancy

Introduction



Figure 1. Grizzly bear detected on remote camera, Banff National Park.

Remote cameras are a powerful and efficient tool to non-invasively monitor wildlife populations. Remote cameras can directly monitor changes in abundance of partially marked populations (Whittington et al. 2018; see Grizzly Bear Population). At larger spatial scales, such as the Canadian Rockies, remote cameras have high statistical power to track changes in occupancy (or range) of wildlife communities (Steenweg et al. 2016, Steenweg et al. online early view). Furthermore, remote cameras are a promising tool to monitor changes in global biodiversity (Steenweg et al. 2017). For example, a global analysis of factors affecting carnivore distribution from 12 countries across 5 continents (including Mountain Park data), found that carnivores were more likely to be found in protected areas, further from roads, and in in areas with high prey abundance (Rich et al. *2017*).

Occupancy models are typically used to monitor changes in the spatial distribution or range of wildlife populations. Direct measures of population abudance require that some individuals in the population can be repeatedly identified either by distinct markings, radio-collars, or by DNA. Most mammals along the Canadian Rockies are challenging to identify by distinct markings and DNA surveys are labour-intensive and expensive. Because occupancy is correlated with population abundance, it provides an efficient method for monitoring wildlife communities throughout the Canadian Rockies. Research from the Mountain Parks found that remote cameras have high power to detect changes in occupancy of grizzly bears, grizzly family groups, and most other species with a high cumulative probability of detection (Steenweg et al. 2016, Steenweg et al. online early view). Large mammals have large home ranges that encompass numerous sampling locations, thus the research community suggests that remote camera systems assess probability of use rather than static occupancy (MacKenzie and Royle 2005).

Objectives

- Estimate the occupancy index that tracks the average change in occupancy for six carnivore species: cougar, grizzly bears, lynx, red fox, wolves, and wolverine within the Mountain Parks.
- Estimate changes in occupancy for 14 mammals.
- Compare diurnal activity patterns of wildlife and people.
- Estimate the effects of trail-based human activity on four wary carnivore species.

Monitoring Question

How do the annual occupancy rates of cougar, lynx, grizzly bears, red fox, wolves, and wolverine compare to their base line occupancy rate estimated from 2011 through 2016? More specifically, is the Occupancy Index (average change in occupancy of all species compared to the baseline) greater than threshold values of -0.1 (Good to Fair) and -0.2 (Fair to Poor)?

Metric

Occupancy Index; the average change in occupancy of all species (cougar, lynx, grizzly bears, red fox, wolves, and wolverine) compared to the baseline.

Thresholds

Occupancy Index:

Poor EI	Fair EI	Good EI
< -0.2	-0.1 to -0.2	> -0.1

Methods

Occupancy Analysis

Banff, Kootenay, Yoho, Jasper, and Waterton Lakes National Parks use a systematic framework for distributing remote cameras and pool all data into a central database. Most parks distributed cameras such that they placed at least 1 camera per 10 x 10 km grid cell (5 x 5 km grid cells for Waterton Lakes) and sampled a large proportion of each park. Staff selected sites that occurred at topographic junctions, wildlife trail junctions, rub trees, and in high quality habitat to maximize the probability of detection. Sites were not randomly selected. In addition to this core, long-term monitoring program, project specific cameras set up for management effectiveness monitoring follow similar protocols and were pooled into the analyses.

We used an Occupancy Index to summarize trends of select carnivore species. The Occupancy Index is similar to the Wildlife Picture Index (WPI) that was developed for the Tropical Ecosystem and Assessment and Monitoring Network (TEAM) (Ahumada et al. 2011, Ahumada et al. 2013, Beaudrot et al. 2016). The main difference in methods are that the Wildlife Picture Index assesses proportional rather than absolute changes in occupancy.

We selected data from remote cameras that were active for at least three years and excluded cameras associated with carcass sites and paved roads. We estimated the proportion of sites where each of 14 wildlife species occurred. When a camera detected a species at a site, we were certain the species was present. However, when the camera failed to detect a species, the species could have been truly absent or the species could have been in the area but undetected. The level of uncertainty regarding truly absent versus present-but-undetected depended on the cumulative probability of detection. We estimated detection probability by dividing the camera data into two-week intervals. We classified species as detected or not detected for each interval. Occupancy models integrate sub-models for species distribution (occupancy) and detection probability. We determined annual changes in occupancy rates using single species, multi-year occupancy models with colonization and extinction. We created separate models for summer (May through October) and winter (November through April). Covariates for occupancy included open coniferous forest, deciduous forest, herbaceous and shrub cover, dynamic habitat index based on cumulative NDVI (Hobi et al. 2017), NDVI, distance to road with a decay function, slope, terrain ruggedness, predicted average temperature (Wang et al. 2016), park, and a random effect for location cluster (5 km radius). Covariates for detection probability included trail type, month, park, temperature, and dynamic habitat index. We improved model fit for unexplained variation by adding an observation level random effect for detection probability. We included annual estimated colonization and extinction rates annually. We analyzed the data using Markov chain Monte Carlo (MCMC) techniques. During each MCMC iteration, we extracted the realized annual occupancy estimates for each year and park. For each species, we calculated the difference in occupancy compared to the 5 year baseline (2011-2016). The Occupancy Index was calculated as the average change in occupancy of six species (cougar, lynx, grizzly bears, red fox, wolves, and wolverine) compared to the baseline.

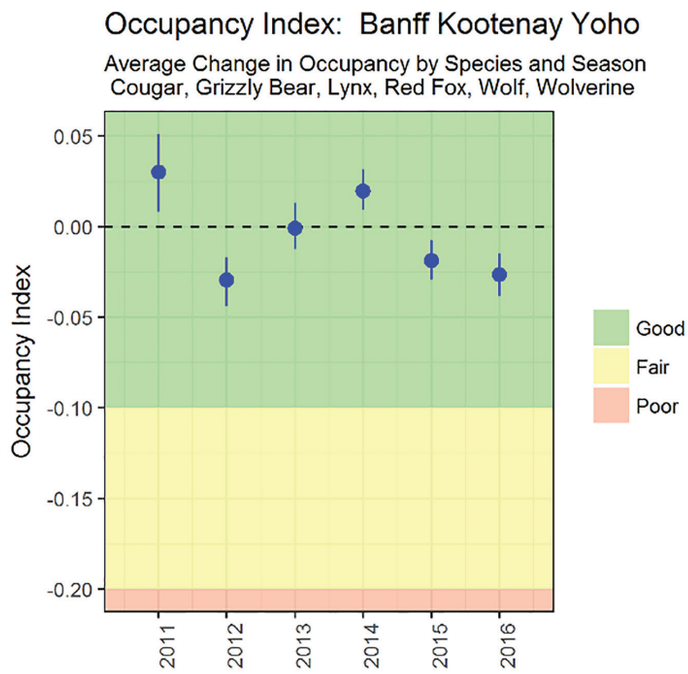


Figure 2. Occupancy Index: average change in occupancy and 95% CI's for cougar, grizzly bears, lynx, red fox, wolves, and wolverine from 2011 through spring 2017.

Diurnal activity patterns

We examined diurnal cycles of wildlife movement activity by determining the von Mises kernel density of detections throughout the day. We calculated estimates of diurnal activity for each species and season.

Effects of Trail-Based Human Activity

We assessed the effects of human activity on wildlife detections for cougar, grizzly bears, lynx, wolf, and wolverine. For each camera sampling day, we summed the number of people that travelled past the camera and determined whether or not we detected each species. Models with the raw data failed to converge because of the large file sizes. Therefore, we divided human use into increments of 10 people per day. For each camera location and level of human use, we tallied the number wildlife detections and number of sample days. We then ran a generalized mixed effects model with a binomial link to determine the effects of dynamic habitat index, terrain ruggedness, average temperature for summer and winter, and people on detection rates. We included a random effect for camera location. We compared models with and without the effects of people using AIC and selected the most parsimonious model.

All human use images captured on remote cameras are managed in accordance with national policies to ensure complete protection of privacy. These data are kept secure by ensuring: cameras are physically locked in the field, camera cards are only handled by Parks Canada staff (not volunteers), and human use images are deleted once classified data is entered in the database.

Results & Discussion

Occupancy Analysis

Condition: Good
Trend: Stable
Confidence: High

Resource conservation staff sampled 794 sites from 2011 to 2017 across Banff, Kootenay, Yoho, Jasper, and Waterton Lakes National Parks resulting in a total of 550,107 sampling days. The number of animals detected included: 612 caribou, 1,486 wolverine, 1,552 grizzly families, 2,132 lynx, 2,443 cougar, 3,099 red fox, 6,354 coyote, 8043 black bear, 8733 moose, 8947 grizzly bears, 22,214 wolves, 25,010 mule deer, 42,629 white-tailed deer, and 46,448 elk.

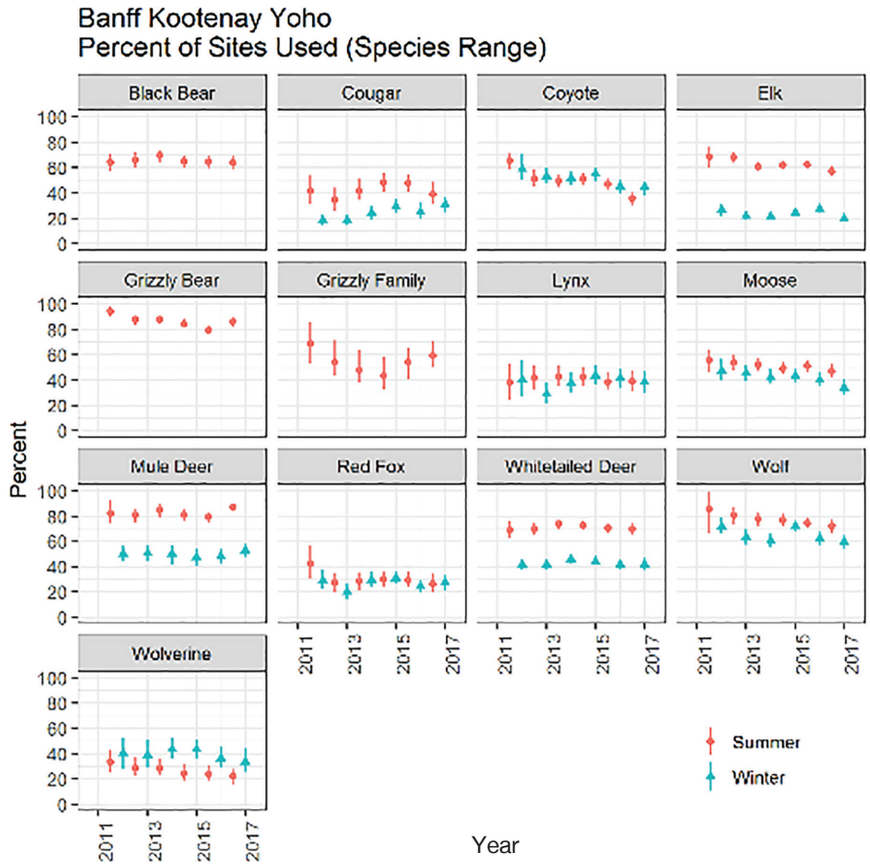


Figure 3. Realized occupancy rates and 95% CI's for wildlife species in Banff, Kootenay, and Yoho National Parks.

We used data from 382 remote cameras that collected at least 3 years of data for the Mountain Parks occupancy analysis. The occupancy index was stable for all parks including Banff, Kootenay, and Yoho suggesting there was minimal change in average occupancy for cougar, grizzly bears, lynx, red fox, wolves, and wolverine (Figure 2). Species specific occupancy models had good overall fit and predictive ability with Bayesian p-values ranging between 0.31 and 0.78. Red fox had the lowest occupancy rates, while grizzly bears had the highest occupancy rates (Figure 3). Occupancy trends for individual species were relatively stable in Banff, Kootenay, and Yoho, although coyote declined slightly. Further analyses are required to understand factors leading to changes in occupancy over time, seasonal migrations, and multi-species interactions.

Diurnal Activity

Bears, bighorn sheep, caribou, wolverine and people were more active during the day compared to the night (Figure 4). Coyotes, elk, lynx, moose, mountain goats, deer, and wolves were active both day and night. Cougar, porcupine, and red fox were more active at night compared to the day. Results represent wildlife movement and may not represent other activities such as feeding when animals may be active but are relatively stationary. Similarly, results were averaged

across cameras and did not examine how animals changed movements to avoid people or other wildlife species.

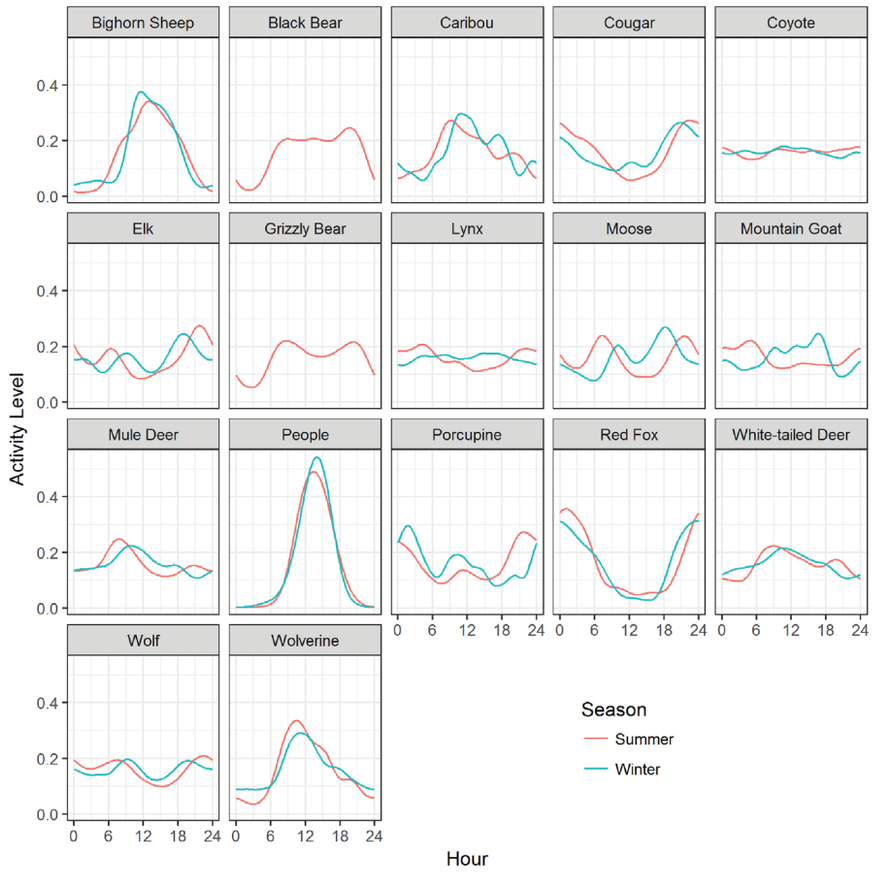


Figure 4. Diurnal activity patterns of wildlife from remote camera detections.

Effects of Trail-Based Human Activity

Daily detection rates for grizzly bears, wolves, and wolverine declined linearly with the number of people per day on trails (Figure 5). The most parsimonious model for lynx included a quadratic term for number of people per day, suggesting that avoidance started around 100 people per day. The analysis included covariates for habitat quality, but did not account for individual variability in behaviour nor increased movements at night to avoid encounters with people (Hebblewhite and Merrill 2008).

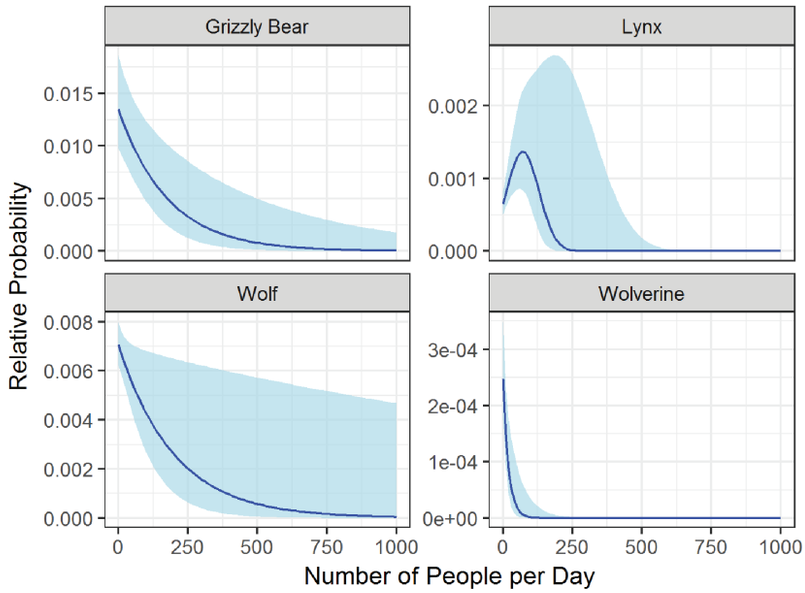


Figure 5. Effects of number of people per day on the relative probability of detections and 95% CI's.

Wolverine had the lowest overall probability of detection and exhibited the strongest negative response to human activity as 95% of the 1548 wolverine detections occurred when there were 1 or fewer people events per day. Wolverine were not detected when there were more than 14 events (39 people) per day. Similarly, GPS collared wolverine in northern Alberta avoided and travelled faster near low-use roads (Scrafford et al. 2018). Wolverine will likely be listed as *Special Concern* under the Canadian Species at Risk. Little is known about wolverine ecology. However, populations are likely affected by deep snow required for denning (Copeland et al. 2010) and thus climate change (McKelvey et al. 2011), habitat fragmentation, trapping, and human activity (Heim et al. 2017).

Summary. Remote cameras provide a powerful, efficient, and non-invasive tool for monitoring wildlife population abundance and distribution. Continued monitoring and collaboration can help understand how underlying factors such as climate change, human activity, habitat quality, invasive species, and inter-specific competition affect wildlife locally, regionally, and globally.

Acknowledgements/Partners

Prepared by Jesse Whittington. Brenda Shepherd, Barb Johnston, & Derek Petersen coordinated data collection. Resource conservation staff from throughout the Mountain Parks collected and classified millions of remote camera images. Robin Steenweg and Mark Hebblewhite from the University of Montana helped develop and strengthen the remote camera monitoring program. Collaboration ecologists from other universities and agencies included John Paczkowski, Jason Fisher, Cole Burton, and Tyler Muhly. The collaboration facilitated large scale analyses of wildlife distributions throughout the Canadian Rockies.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403) 763-8865
E: *jesse.whittington@pc.gc.ca*

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Forest Measure: Winter Wildlife Corridors

Introduction



Figure 1. Cougar kittens detected by remote camera.

Wildlife corridors are an important conservation tool for maintaining landscape connectivity (Marrotte et al. 2017), especially where the combination of rugged topography, water bodies, and human developments fragment wildlife habitat. Wildlife corridors enable wildlife to travel throughout their home range (Panzacchi et al. 2016), which is important for maintaining functional predator-prey processes (Hebblewhite et al. 2005). At a larger scale, creation of corridors enables wildlife dispersal (Benz et al. 2016) and improves genetic connectivity (Marrotte et al. 2017).

Banff National Park (BNP) has been a world leader in corridor conservation (Parks Canada 2010). In the late 1990's, BNP removed or relocated facilities around the periphery of Banff town site (e.g. Cascade Corridor) and reduced human activity in wildlife corridors (e.g. Sulphur corridor closure and seasonal restrictions along the golf course). Wary carnivores quickly responded to these restoration actions and increased their movements around the town site (Duke et al. 2001). Similarly, Jasper National Park in collaboration with Jasper Park Lodge increased wildlife movements and connectivity along the base of Signal Mountain by removing a dilapidated page wire fence, installing sections of carnivore permeable fences, and redirecting human use to other areas (Shepherd and Whittington 2006). The Banff National Park Management plan (Parks Canada 2010) recommends corridor restoration and maintenance by improving habitat quality and minimizing wildlife displacement both within Banff National Park and as part of a large-scale corridor network within the Yellowstone to Yukon region.

Banff National Park has monitored changes in wildlife movements around the town of Banff and more recently around Lake Louise using repeated snow-tracking surveys since 1993. The concurrent development of GPS collars has enabled the evaluation of wildlife movements through corridors during the summer. Here, we summarise how wildlife use of corridors has changed over time.

Objectives

- Measure changes in wildlife use of habitat corridors in winter in the Bow Valley region of Banff National Park.
- Understand factors contributing to wildlife use of corridors.
- Describe summer use of wildlife corridors
- Identify concentrated areas of human-wildlife conflict from wildlife movements into and around the Banff town site.

Monitoring Question: Have carnivore occurrence rates on snow-transects within the Bow Valley changed in the last 5 years?

Metric: Proportion of time wary carnivores are detected on snow transects around the town of Banff, while accounting for snow depth, sampling window, and transect.

Thresholds: We established thresholds based on historic carnivore use and variability on control transects and transects around the Banff town site. Carnivores were detected greater than 40% of the time on reference transects.

Poor EI	Fair EI	Good EI
< -0.2	0.2 to 0.4	> 0.4

Methods

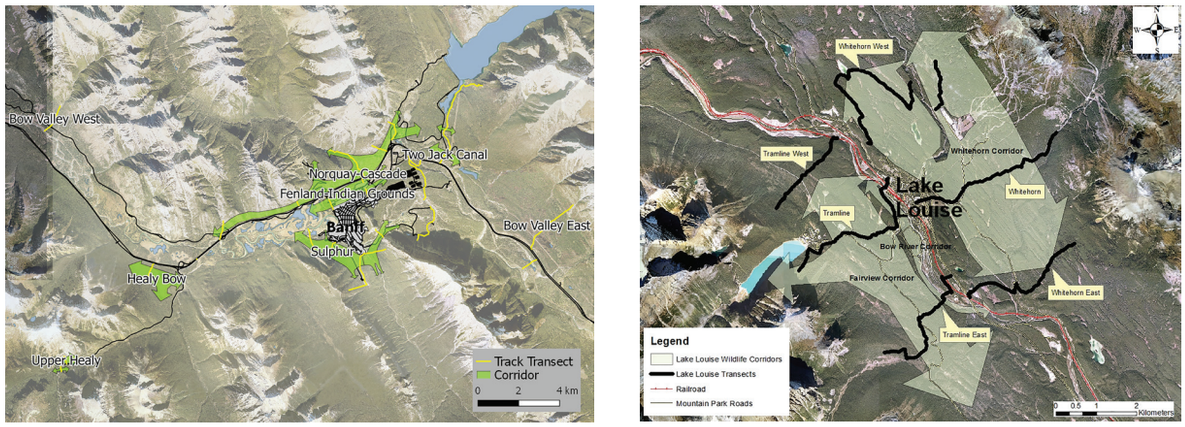


Figure 2. Map of snow-transect routes in wildlife corridors around Banff and Lake Louise. Bow Valley West and East transects provide reference data for expected carnivore use in areas of low human use. Two years of data have been collected in the Lake Louise area, which is insufficient for estimating trends in corridor effectiveness.

We established permanent snow tracking transects to capture wildlife movement through areas bounded by towns, highway fences, cliffs, and water. We surveyed the 25 transects near Banff and more recently 6 transects near Lake Louise (Figure 2) approximately 10 times each winter. Transects near Hillsdale and the Fairholme provided reference areas for expected carnivore use in relatively undisturbed areas east and west of the town of Banff. Staff recorded snow depth and tracks of all wildlife every 100 m. When time allowed, tracks of carnivores were backtracked and mapped using GPS. Twenty-two infrared trail counters monitored human and wildlife use on trails within wildlife corridors. Two motion sensor cameras supplemented snow-tracking data.

We monitored trends in the probability of detecting a wary carnivore (wolf, cougar, wolverine, or lynx) on a transect using a generalized additive mixed effects models with a binomial link. Covariates in the model included the sampling window (log-transformed number of days), a random effect for transect, and a smoothed term for year.

Parks Canada collaborated with Adam Ford (UBC-Okanagan) and Mark Hebblewhite (University of Montana) to determine what factors contribute to corridor effectiveness. The analysis used wolf GPS data to predict habitat quality, patch size, and corridor width and length. We then assessed how corridor use was influenced by habitat quality, topography, width, length, and human activity.

Results

Value: *0.28, 95% CI 0.20 - 0.37*
Condition: *Fair*
Trend: *Stable*
Confidence: *High*

Carnivore use of corridor transects around the town of Banff increased substantially following corridor restoration in the late 1990's (Figure 3). Cougar and wolves were the main carnivores using the corridors. Peak corridor use also coincided with high prey availability and relatively bold wolves. The Fairholme wolf pack at that time was large and some wolves were highly habituated. Corridor use then declined, perhaps associated with changes in wolf pack composition and prey abundance (elk). Carnivore use around Banff has been stable since 2007 with carnivores detected approximately 30% of the time on transects.

We detected carnivores on reference transects near Hillsdale and the Fairholme approximately 50% of the time and always more than 40% of the time (Figure 3). Carnivores used reference transects more than corridors around the town of Banff. Around Banff, the Norquay-Cascade corridor was used more frequently than the Sulphur or Golf Course corridors. The Sunshine corridor (Upper Healy) is the most compromised corridor in the study area and shows no sign of improvement over time.

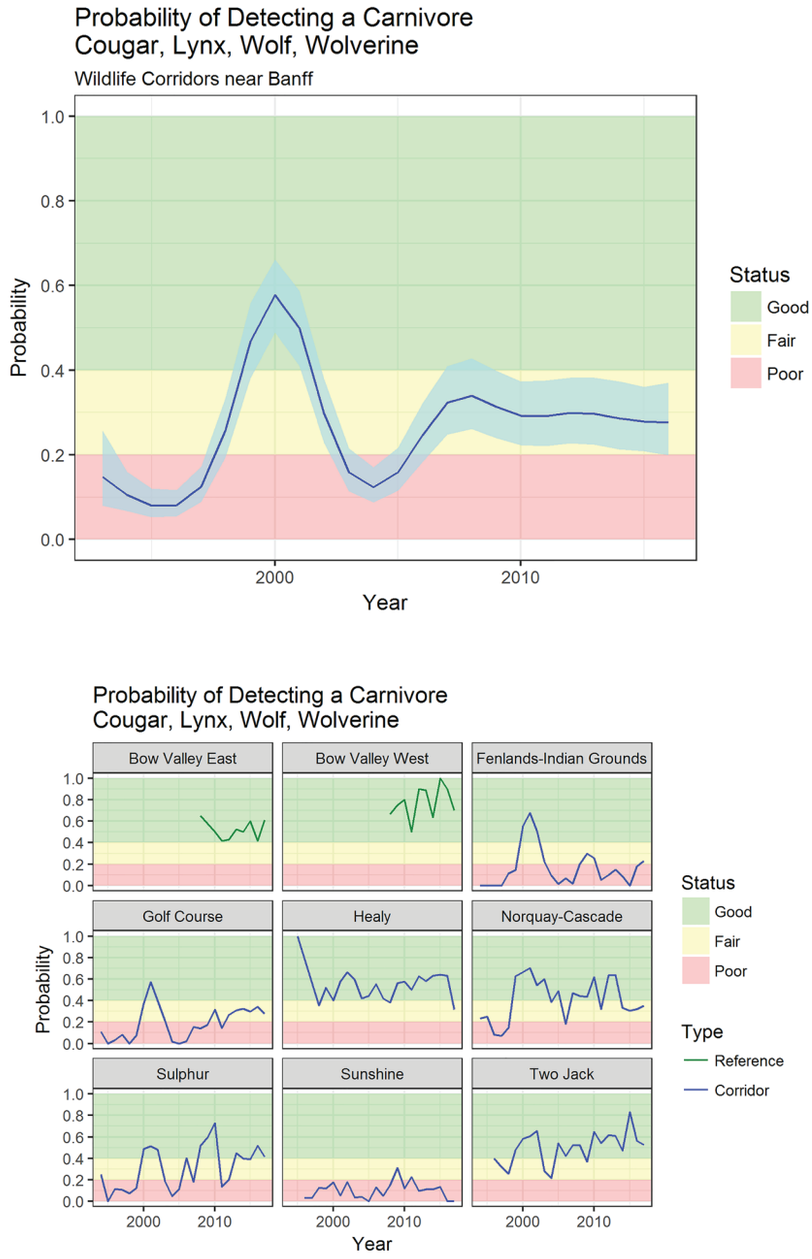


Figure 3. Probability of detecting a wary carnivore with 95% CI's on snow transects around the town of Banff (top) and by region (bottom).

Cougar and wolves were the most commonly detected carnivores (Figure 4), whereas lynx and wolverine were rarely detected. Wolf and cougar use ranged between 10 and 30% over the last ten years and were weakly correlated (correlation = 0.49, p-value = 0.01). After the Bow Valley elk population declined in the 1990's and early 2000's, track indices for elk, deer, and coyotes stabilized at approximately 2 tracks per km per sampling day (Figure 5).

Snow-tracking data show wolf and cougar movement routes around the town of Banff (Figure 6). Pinch points to movement occur along the west end of Mount Rundle, near Middle Springs, the Fenlands-Indian Grounds, and the lower slopes of Mount Norquay and Cascade. Maintaining connectivity through these pinch-points is critical to the maintenance of ecological integrity in the Bow Valley. Adam Ford's preliminary analysis of corridor data collected in the Bow Valley suggests that wolf use of corridors increased with distance to town and distance to trail and decreased with snow-depth and the presence of people. Further analysis of this rich data set could help Parks Canada and other jurisdictions understand the most important factors affecting corridor effectiveness.

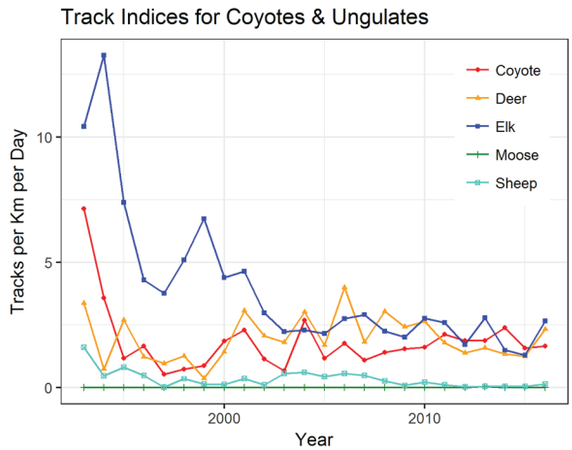


Figure 4. Carnivore detection rates on snow-transects in the lower Bow Valley.

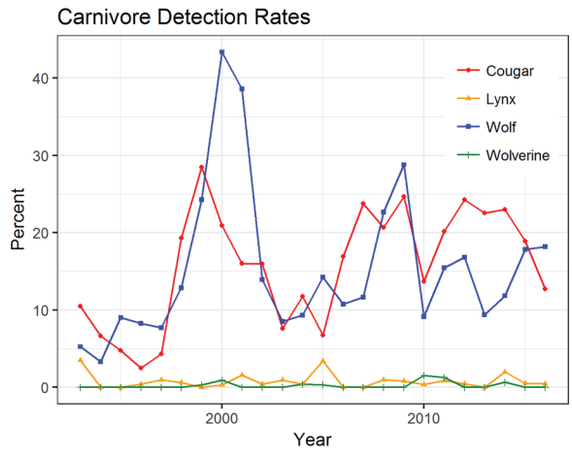


Figure 5. Relative use of corridors by ungulates and coyotes in the lower Bow Valley.

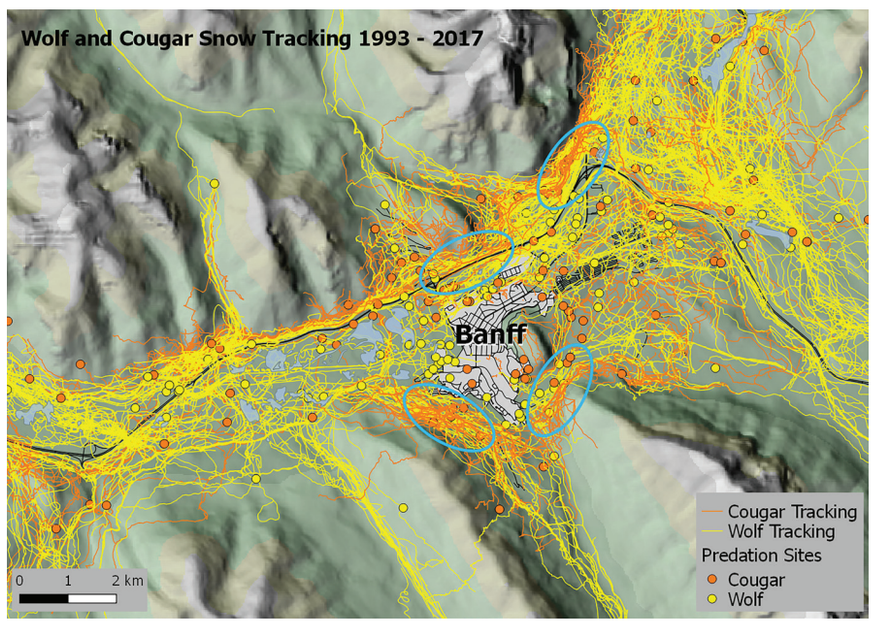


Figure 6. Cougar and wolf snow tracking routes and predation sites around the town of Banff from 1993 through 2017. Blue ellipses indicate areas where carnivore movements are constrained by the combination of human use and topography.

Parks Canada does not have a monitoring framework in place to assess trends in corridor use by wildlife during the summer. While remote cameras could be used, a large number of cameras would be required for adequate statistical power. However, GPS collared grizzly bears and wolves provide a snap shot of how some individual animals travel around Banff (Figure 7). Grizzly bears used the Fenlands-Indian Grounds corridor extensively and usually travelled near the town boundary and between the Industrial Compound and residential areas. They also frequently used an area known as Elk Woods at the eastern edge of Banff. Grizzly bear use of this corridor lead to frequent human-wildlife interactions along this corridor (see below). Wolves frequently used areas east and west of Banff and occasionally used the corridors during summer. They travelled along the northern edge of the Fenlands-Indian Grounds corridor. Many (84%) of the wolf GPS locations near town were collected from the 2016 habituated Bow Valley wolf pack.

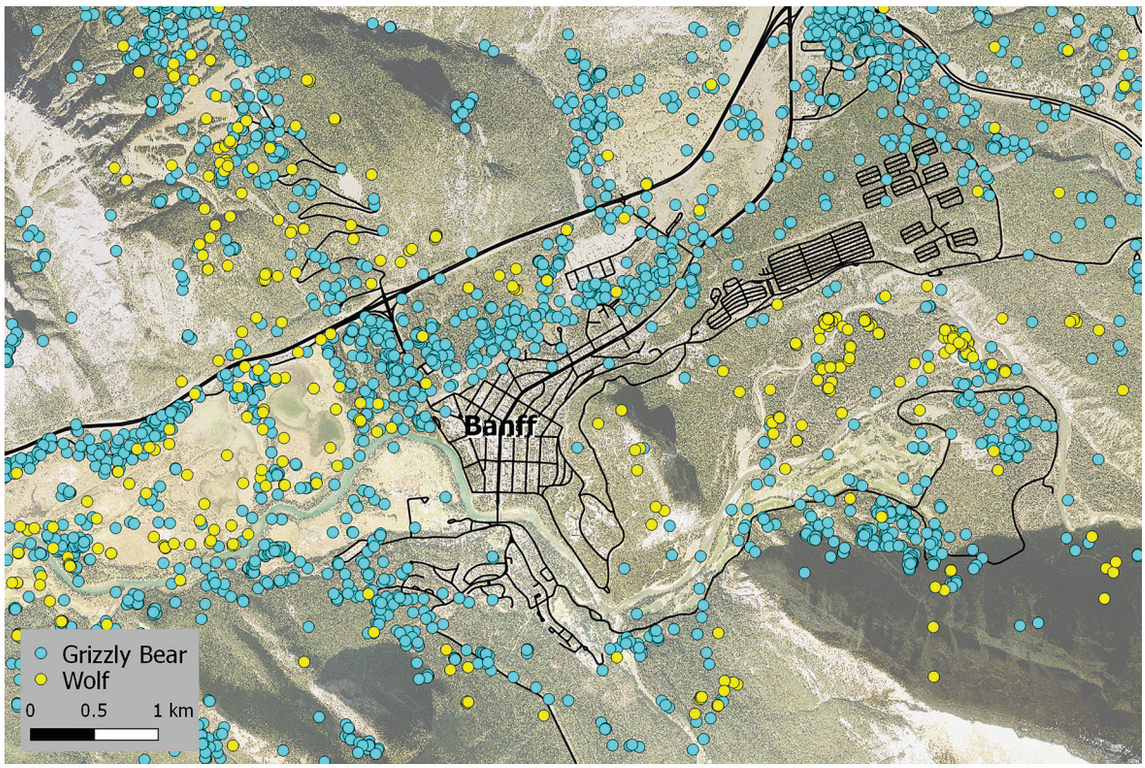


Figure 7. GPS locations of grizzly bears (n = 10) and wolves (n = 4 around the town of Banff during summer (May through September).

Numerous human-wildlife conflict incidents occurred along the town boundary (Figure 8). Many incidents occurred along the Whiskey Creek (north) edge of town and near Middle Springs (southwest). Wildlife incidents in those areas could potentially be reduced by making other wildlife travel routes more attractive. For example, much of the Fenlands-Indian Grounds corridor contains deadfall and debris from the 2013 flood. Movements are thus concentrated close to town. Clearing deadfall and improving travel routes along the northern edge of the corridor and north of the TransCanada Highway could reduce human wildlife conflict.

The Fenlands area is challenging because wildlife must navigate the railway, recreation centre, the new "Welcome to Banff" sign, Fenlands day use area and trails, and the Vermilion Lakes road. Further east, wildlife are constrained between the highway fence and the Town of Banff & Parks Canada maintenance compound – a width of less than 100m. Re-configuring hiking trails and moving, screening and/or consolidating infrastructure, may improve connectivity for wildlife and improve visitor experiences.

South of the Town of Banff, wildlife travelling eastward towards Middle Springs are sometimes funnelled into a dead end habitat patch where they become surrounded by human use on three sides near the Parks Canada administration building. Reducing the attractiveness of this area combined with enhancing wildlife travel routes through the Middle Springs corridor on the south edge of town may reduce human wildlife conflict while improving connectivity.

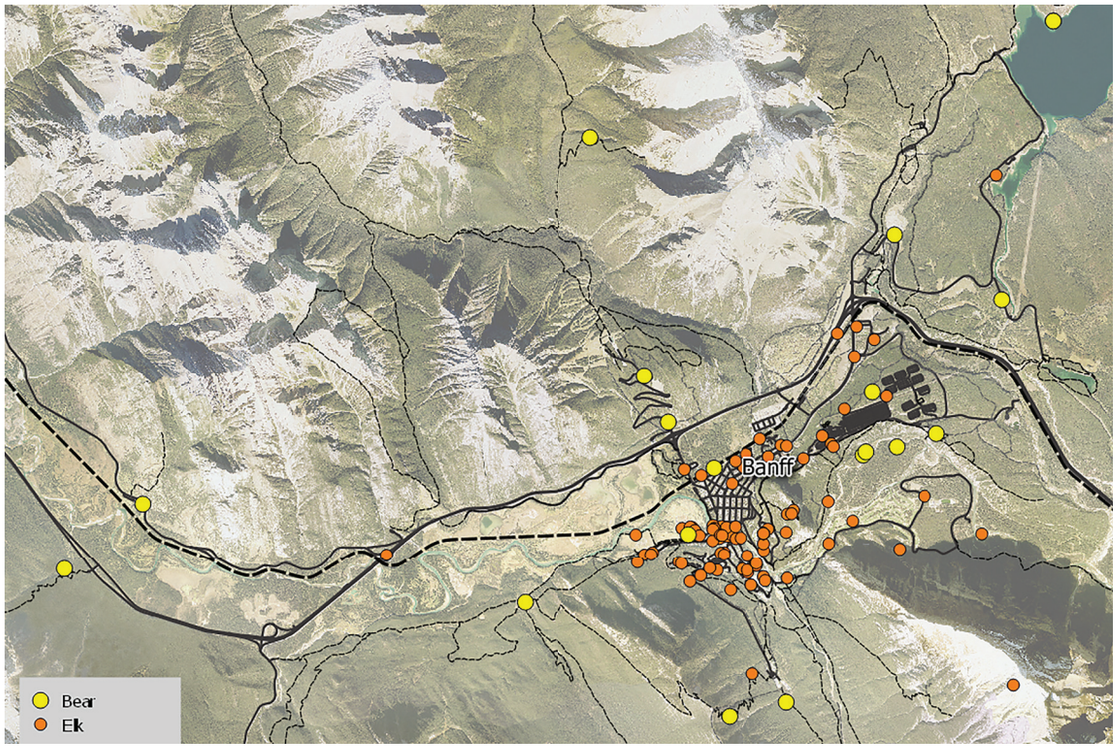


Figure 8. Map showing the location of aggressive elk and bear incidents from 2008 - 2017. Locations are approximate.

Discussion

Wildlife corridors provided important movement routes through areas constrained by topography and human use. However, carnivores crossed wildlife corridors less frequently than reference transects, which suggests that movements through corridors were affected by habitat quality, habitat configuration and size, and levels of human activity. Many key corridors are currently

rated as only “poor” or “fair” for winter use by wary carnivores. Additional management efforts should focus on the Sunshine (upper Healy) and Fenlands-Indian Grounds corridors which are both currently rated as poor. Continued management actions to minimize human activities within wildlife corridors will be essential for continued wildlife use.

Corridor effectiveness and human-wildlife conflicts could be reduced by improving wildlife travel routes through areas further from town, reducing the attractiveness of habitat that leads into residential areas, reconfiguring trails to improve conditions for people and wildlife, and minimizing human use in the Cascade, Fenlands-Indian Grounds, and Golf Course (winter) corridors.

Acknowledgements/Partners

Prepared by Jesse Whittington, Simon Ham, Rhonda Owchar, and Mark Benson. Steve Bertollo, Andrea Kortello, and many other wildlife technicians and Resource Conservation staff conducted track surveys and back-tracked wildlife.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403) 763-8865
E: *jesse.whittington@pc.gc.ca*

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Tundra Measure: Non-native Vegetation

Introduction

Invasive Alien Plants are a serious threat to native ecological communities and considered the second most significant cause of biodiversity loss, after habitat destruction (IUCN, 2011). Invasive alien plants compromise ecosystem function by out-competing native species, altering nutrient cycling, destabilizing soils and reducing forage value (Pimentel et al. 2005, Morishita 1991). The *Banff Park Management Plan* (2010) identifies preventing the spread of invasive plants as a management priority 'Key Action' for sustaining biodiversity.



Figure 1. ACCM transect in an open subalpine meadow near Snow Creek Pass.

Within the *Consolidated Guidelines for EI Monitoring in Canada's National Parks* (2011), Invasive Alien Plants are identified as a stressor of alpine ecosystems. Measuring the overall occurrence frequency of Invasive Alien Plants in the alpine and how conditions change over time is important for understanding how ecological integrity (EI) is affected. Alpine condition class monitoring (ACCM) data collected during the 2017 field season is a baseline for determining the state of Invasive Alien Plants in the park that we will use to monitor future trends in Invasive Alien Plant populations (Figure 1).

We ranked 93 Invasive Alien Plant species in Banff, based on: their ability to invade, the conservation status of the invaded ecosystem, the impact on the invaded ecosystem and the level of management difficulty (Michalsky, 2007). Of these, we prioritised seventy-one for management. This included 12 recognised 'Priority 1' non-native plants that are provincially designated as Prohibited Noxious and, under the *Alberta Weed Control Act,* need to be destroyed. They are often difficult to control once established, easily invade a variety of habitats and are considered the highest stressors of EI. Priority 2 Invasive Alien Plants are typically species that have been provincially designated as Noxious – meaning they must be controlled. These plants may already

be established yet remain a high priority for control. Priority 3 Invasive Alien Plants are considered the lowest priority species for control. They may be impossible to eradicate in the park and are not considered to be significant stressors to EI because of their poor ability to invade undisturbed areas. The ACCM measure attempts to monitor Invasive Alien Plant occurrence frequency against pre-determined thresholds based on priority ranking.

Monitoring Questions

1. What is the mean Invasive Alien Plant occurrence frequency (%) for Priority 1, 2 and 3 species in areas most likely to be colonized by Invasive Alien Plants in the alpine (trails)?
2. Has mean Invasive Alien Plant occurrence frequency (%) changed by >0.2% over the last 5 years in areas most likely to be colonized by Invasive Alien Plants in the alpine (trails)?

Metric

Mean Invasive Alien Plant occurrence frequency (%) by presence or absence along a belt transect.

Thresholds

We developed weighted thresholds to account for the priority differences between Invasive Alien Plant species and their ecological impacts. A chart showing the weighted thresholds by species priority and condition determination can be found in Table 1. We will use these thresholds until ongoing data collection informs a more biologically appropriate or statistically significant value.

Table 1. Pre-determined thresholds for Invasive Alien Plants Frequency.

	Thresholds
Priority 1 Species	0% =0 Points >0.01%-<.50% = 3 Points >.50% = 5 Points
Priority 2 Species	<1% =0 Points >1%-<2.5% = 3 Points >2.5% = 5 Points
Priority 3 Species	<2.5% =0 Points >2.5%-<10% = 3 Points >10% = 5 Points

Condition Determination

We pooled total points to assess the overall condition of Invasive Alien Plants in the Alpine ecosystem.

GOOD	<5 points
FAIR	5-9 points
POOR	≥10 points

Methods

We first defined alpine habitats based upon Ecological Land Classification (ELC) and Vegetation Resources Inventory (VRI) data. Within the alpine, we randomly selected ACCM plots using GIS software. We established and monitored thirty plots as part of the first year of data collection.

For the plots, we established 250 m belt transects for 2 m on both sides of alpine trails, excluding rock and ice (500m total length). We divided transects into 5 m subplots and observed presence or absence of Invasive Alien Plants. Additionally, we recorded the species, number of plants, phenology, and distribution for Invasive Alien Plants in each section.

We calculated total Invasive Alien Plant occurrence frequency (%)for each plot and summarised mean Invasive Alien Plant frequency (%)across all plots. We assessed mean Invasive Alien Plants frequency (%) for each species' priority ranking against their respective thresholds to determine alpine condition.

Results

We did not find any Priority 1 or 2 Invasive Alien Plants in ACCM transects for 2017. We observed a total of 51 Priority 3 Invasive Alien Plant occurrences (mean frequency = 1.7%, σ= 5.28, CI= 0.06) (Table 2 and 3). As the mean Invasive Alien Plant occurrence of Priority 3 species was <2.5% it scored 0 points in 2017. Priority 3 species found in the 2017 ACCM transects included common dandelion (*Taraxacum officinale*) and red clover (*Trifolium pratense*).

Table 2. Total Invasive Alien Plant occurrence frequency % by transect. Each transect was 250 m long on both sides of alpine trails (500m total) and consisted of 100 five metre subplots.

Total IAP Frequency (%) per Transect																														
Plot#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Priority 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Priority 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Priority 3	0	0	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	4	0	0	24	0	18	0	0

Table 3. Showing the mean total Invasive Alien Plant occurrence frequency **%**.

Plot#	Mean Total IAP Frequency (5)
Priority 1	0
Priority 2	0
Priority 3	1.7

Condition and Trend

Condition: Good (total points= 0)
Trend: Not available. Data collection is taking place on a 5 year cycle. The next round will take place in 2022.

Assessment Confidence

The ACCM protocol is new. Data shows a large variance due to two transects that were observed to have a high frequency (%) of low priority Invasive Alien Plants compared to the rest of the transects (Plot # 26= 24% and Plot # 28= 18%) . Weighting the thresholds by Invasive Alien Plant priority helped provide a more accurate representation of Invasive Alien Plant condition. As this was the first year implementing the ACCM protocol, no trend is available.

Discussion

The approach of using weighted threshold classes is important for determining the overall condition of the Invasive Alien Plants measure because it allows for recognition of the differing levels of significance and ecological impact between species within each of the 'priority' groupings, and results in an overall condition assessment which not only considers level of occurrence but also level of stress that the species represents to the alpine ecosystem. We will continue to evaluate these thresholds as more data are collected.

This monitoring allows managers to effectively assess Invasive Alien Plants condition in the alpine and respond strategically by allocating resources to priority areas by considering specific stressors and their level of threat to ecological integrity.

Contact

Brian Yakiwchuk, Resource Management Officer
Banff Field Unit
P: (403) 762-1495
E: *brian.yakiwchuk@pc.gc.ca*

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CONDITION (NO TREND):

Tundra Measure: Alpine Birds

Introduction

Organisms found in alpine systems often have specialized life histories (Martin 2012) and may be particularly sensitive to changes in climate and habitat. For example, alpine bird species that are specialized to breed in extreme conditions (cold, wind, frost) may be outcompeted by more generalist species in warmer or more stable conditions. Vegetation zones and habitat types may shift due to climate change (Garamvölgyi and Hufnagel 2013, Song et al. 2013), and species-specific shifts in the elevation ranges of birds may occur as a result. This change in relative species abundance and community composition may have cascading ecological consequences. For example, declines in groups of birds (guilds) that occupy a similar ecological niche could inhibit ecosystem function by reducing seed dispersal and pest control. For these reasons, alpine systems are an important indicator of ecological integrity in the Mountain National Parks.

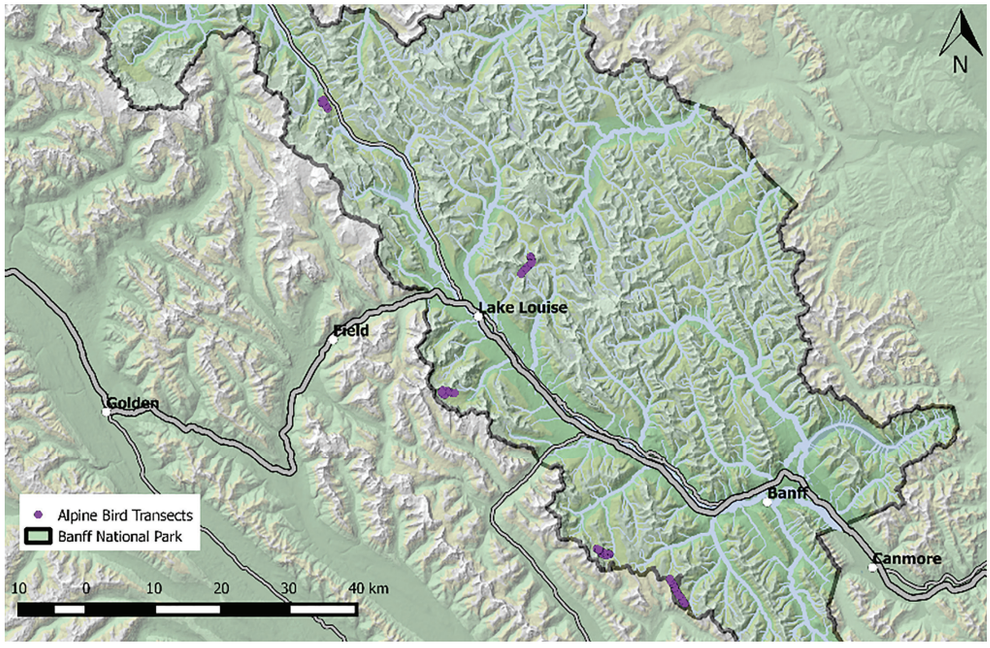


Figure 1. Locations of alpine bird monitoring transects in Banff National Park

Birds are relatively easy to monitor and show measureable responses to stressors such as habitat loss and fragmentation (Moses et al. 2001), anthropogenic stressors, challenging weather events, and climate change. In 2007, the Mountain National Parks initiated forest bird monitoring as a

measure of Ecological Integrity for numerous reasons: extensive knowledge about avian ecology facilitates the interpretation of the results; birds are highly diverse and provide more insights about biodiversity than any other group of terrestrial vertebrates; birds integrate processes at multiple scales (e.g. local / residents vs. large scale / migrants); niche specialization of certain species can make them sensitive to environmental change; existing data is extensive in many parks; field methods are well known and tested; and strong public interest fosters public engagement (Kehler and Samson 2005). Conversely, the migratory nature of many songbirds, can result in uncertainty regarding root causes. When changes are detected are impacts occurring on breeding ranges or wintering habitats, or both?

In 2015, we incorporated alpine bird monitoring into the condition monitoring program for Banff, Yoho and Kootenay National Parks, as part of a suite of measures informing the health of the Tundra indicator. The goal of this monitoring is to identify bioregional changes in avian diversity and abundance in alpine ecosystems.

Monitoring Question

What proportion of native terrestrial bird species and ecological guilds are in decline (>2.5% decrease in detection/year)?

Metrics

1. Percent (%) of bird species declining by ≥2.5% within the alpine ecoregion.
2. Percent (%) of bird guilds declining by ≥2.5% within the alpine ecoregion.

Thresholds

GOOD	<10% of bird species are declining; <25% of bird guilds are declining
FAIR	>10% of bird species are declining; >25% of bird guilds are declining
POOR	>25% of bird species are declining: >50% of bird guilds are declining

We measured alpine bird thresholds based on the proportion of species or guilds found to be in decline within the alpine ecoregion. A species or guild was in decline if the annual detection rate decreased by more than 2.5% per year. This measure is based on Birds of Conservation Concern (BoCC) and is analogous to measures implemented by the International Union for Conservation of Nature (IUCN 2017) (Eaton et al. 2009).

	POOR	FAIR	GOOD
Percent of bird species declining	>25%	10-25%	<10%
Percent of bird guilds declining	>50%	25-50%	<25%

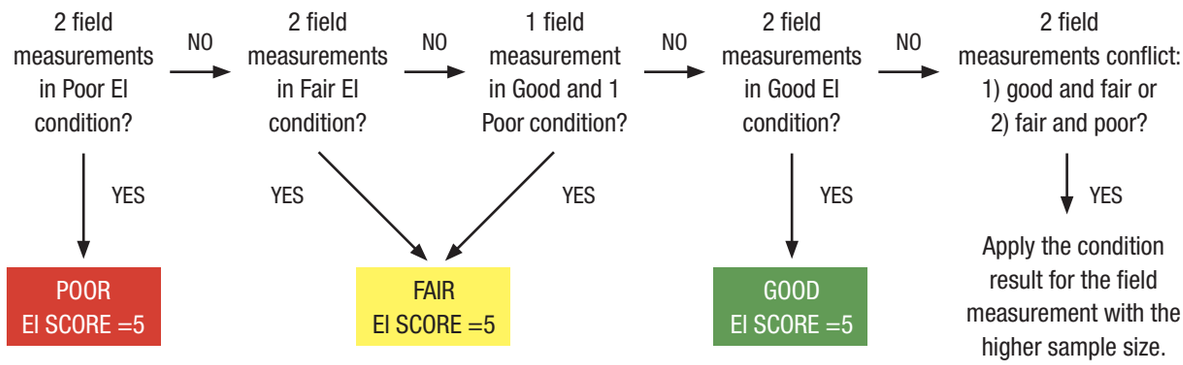


Figure 2. EI Score decision flowchart used to determine the measure condition rating.

Methods

We used a standard point count sampling protocol for alpine terrestrial bird monitoring in Banff National Park. The objective of the point counts is to quantify the relative abundance of avian species in the alpine ecoregion. Relative abundance refers to the frequency of occurrence of a species at the survey point taking in to account its likelihood of being encountered (Bibby et al., 2005, Dunn et al., 2006). Between 2007 and 2014 we monitored 9 point count stations at 3 transects. In 2015 and 2016, we conducted point counts at 51 stations across 5 transects (Figure 1). We conducted a ten minute acoustic recording at each sample station during the spring breeding season. A specialist in acoustic identification of birds identified all species heard and transcribed the minimum number of individuals at each point count location.

Ecoregions, indicators and eco-communities

We classified point-count stations as "alpine" habitat based on the Ecological Land Classification (ELC) ecoregions and, in some cases, field-based vegetation sampling. We calculated trends for all bird species detected in this ecoregion to obtain the best available representation of the avian ecological community for each indicator. We used ecological guilds (see below) to account for the ecology of bird species in a separate analysis.

Ecological guilds

We grouped bird species according to three guild classes.

1. Foraging guild: groups species based on diet and foraging behaviour. These included bark foragers, granivore-herbivores, granivore-insectivores, insect gleaners, aerial insectivores and omnivores.
2. Habitat guild: groups species based on the habitat selection behaviour. These included aquatic, forest generalists, grassland-meadows, mature forest, wetland, and habitat generalist.
3. Migratory guild: to be considered resident, a bird species must be regularly present within the National Park year-round.

Statistical analysis

Annual trends – Binomial GLMM. We calculated annual population trends and their 95% confidence intervals for each species using Generalized Linear Mixed Models (GLMM with a logit link). We tested 4 biologically plausible models to assess bird detection/non-detection as a function of year. We modeled year with either linear or quadratic functions. To account for repeated sampling within sites, we included either transect or point count nested within transect as a random effect term. We used Akaike Information Criterion (AIC) to select the best fit model based on lowest AIC. We assessed model fit by calculating delta AIC, error rates and by plotting binned residuals (Gelman and Hill, 2007). We estimated the overall trend per species using the β coefficients for year from the selected model. We converted β coefficients to annual percent change (R) in bird detection/non detection using the equation $R(\%) = (1 - e^{logic(p)}) \times 100$ for negative trends and $R(\%) = (e^{logic(p)} - 1) \times 100$ for positive trends.

Trend significance. We used 95% confidence intervals of the trend to assess if a species or guild was in decline. If the confidence intervals were below 2.5% decline per year, the species was considered in decline. If confidence intervals were above -2.5%/yr the species/guild was considered stable or increasing. Species/guilds with confidence intervals that crossed the threshold level (-2.5%/yr) were uncertain. We made overall trend estimates by calculating the proportion of species/guilds in decline from the total number of species/guilds detected.

Trends by guild. We calculated proportionally weighted average trends by guild to represent the population trend of birds that share similar ecology (function, habitat and resident). We calculated the weighted trends by summing the product of the model parameters (Xi) by the proportion that each bird species represented within its ecoregion, given by (X_i) by $\Sigma_{i=sp} \frac{n_i}{n_{guild}} \times X_i$. This enables us to account for overrepresentation of bird species with small sample sizes. The percentage of detections that each guild represented in its ecoregion is given by $\varphi_{guild} = \frac{n_{guild}}{n_{comm}} = 100$, as an indicator of the relative importance of each guild within its guild class. We excluded guilds that represented < 1% of the detections in their ecoregion or where guilds only included a single species. We estimated the number of guilds in decline using the 95% confidence intervals as described above.

Results

- We conducted a total of 121 alpine point-counts in Banff National Park over the 10-year period (average = 12.1 point-counts/year) and assessed 12 species and 9 guild trends.
- No species or guilds recorded a declining trend (>2.5 % per year) (Figure 3 & 4). Of the 12 species, 6 were uncertain and 6 were stable/increasing. Similarly, of the 9 guilds recorded, 5 were found to be stable/increasing and 4 uncertain. This indicates the alpine bird measure for Banff National park is in "good" condition.
- Due to wide confidence intervals, we could not determine with certainty the individual trends for 50% of species and 50% guilds.
- Two species; the Yellow-Rumped Warbler and Pine Siskin, were predicted to decline at a rate >2.5% /year, however due to the wide confidence intervals we cannot say with certainty if these species are in decline.
- Of the guilds assessed, three (insect gleaners, granivore-insectivores and migratory) showed positive trends within increases in detection over time.

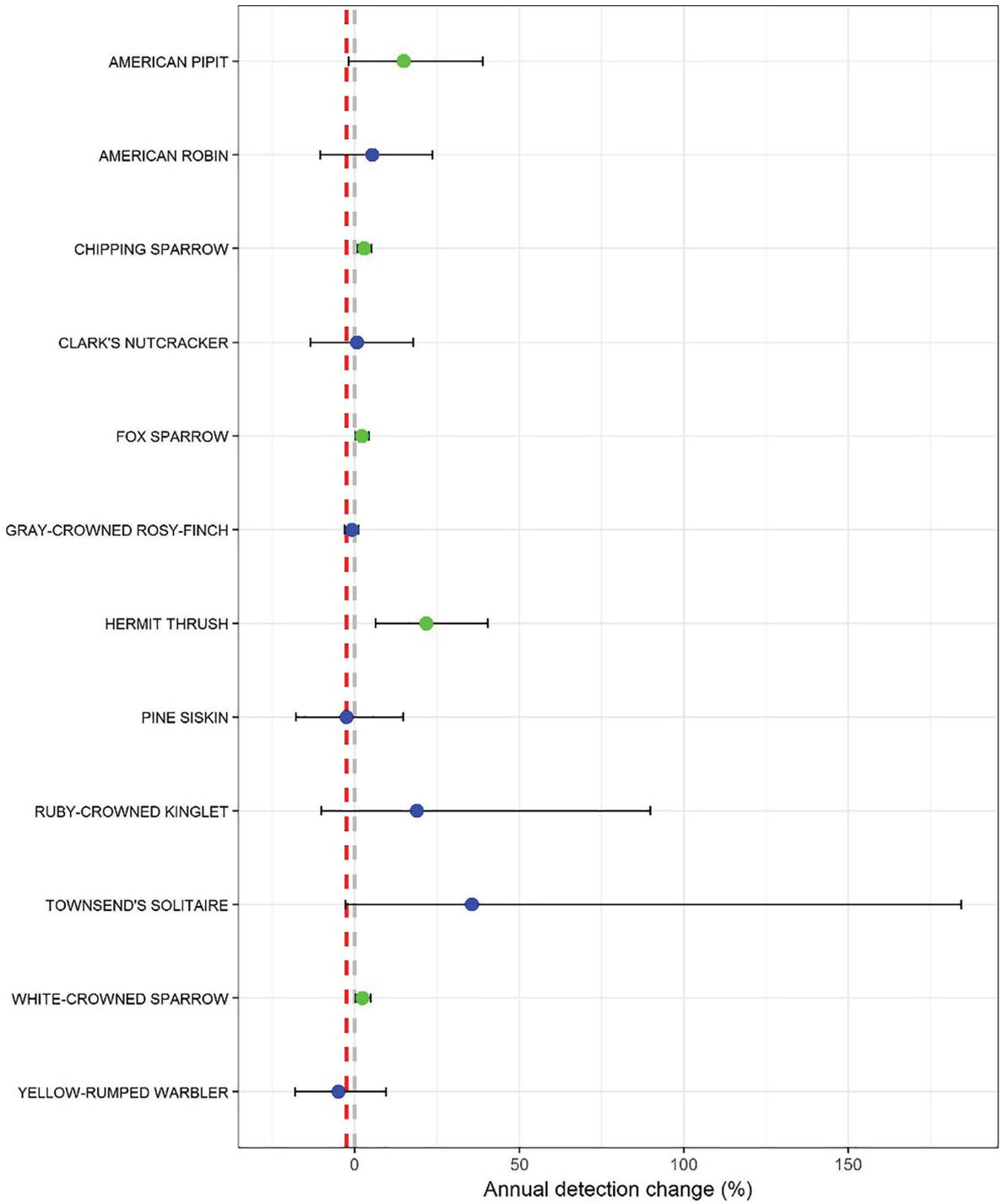


Figure 3. Annual percent change in detection for birds within the alpine ecoregion of Banff National Park. Trends and 95% confidence intervals are presented by species. Red dots indicate species with declining trends (-2.5%/yr), blue dots represent species or guilds with uncertain trends and green dots represent stable or increasing trends (+2.5%). The gray dotted line represent no change in trend with time (0%) annual change, and red dashed lines signified a decline of 2.5%.

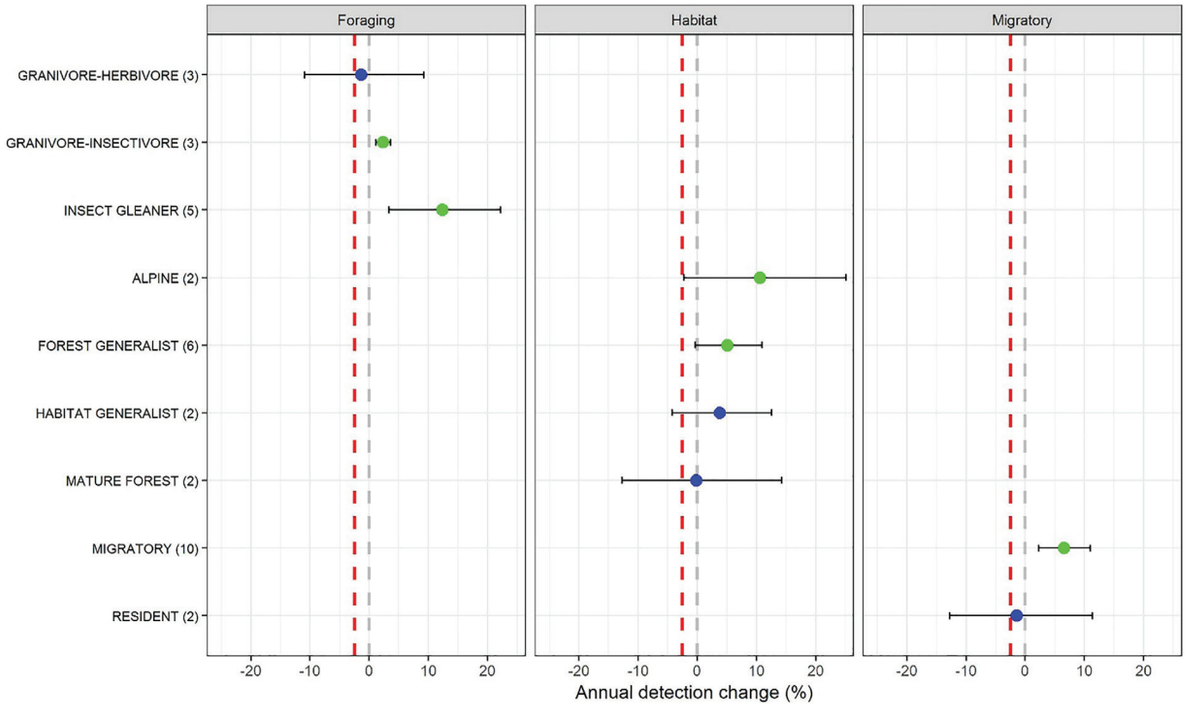


Figure 4. Annual percent change in detection for birds within the alpine ecoregion of Banff National Park. Trends and 95% confidence intervals are presented by guilds. Red dots indicate guilds with declining trends (-2.5%/yr), blue dots represent guilds with uncertain trends and green dots represent stable or increasing trends (+2.5%). The gray dotted line represent no change in trend with time (0%) annual change, and red dashed lines signified a decline of 2.5%. The number of species within each guild is listed in brackets.

Condition and Trend

Condition: Good
Trend: Undetermined – this is the first analysis based on the current sampling protocol

Both threshold sub-measures (species and guild) (figure 2) were “good”.

Assessment Confidence

High

We used 95% confidence intervals to incorporate uncertainty into our measure of trends. As seen in Figure 2, wide confidence intervals for many species indicate our detection rates are highly variable over time. This may result from either variability in bird distribution over time, or variability in species detection. For example as we record bird calls only, species which call less frequently may be underrepresented.

Discussion

- The abundance of each monitored bird population and bird guild was stable (no significant decrease greater than 2.5%) over the 10-year period in the alpine in Banff National Park.
- A number of species showed stable or increasing trends. For example increases in alpine specialist species such as the American pipit indicating that for the sites included in these analyses, there is suitable alpine habitat for this species. Similar trends were recorded in alpine ecoregions of adjoining national parks (e.g. Kootenay National Park).
- These analyses were limited by the small number of species and guilds for which a reliable trend could be calculated. Species with smaller sample size were inadequately represented in the analysis, because they were less common or have lower detection probability. Given the wide confidence intervals, we are limited in providing more detailed trends, although this is likely to improve with additional years of data.
- In addition to transects added in 2015, we will be adding three to five new alpine transects in 2018 to increase sampling effort and spatial representation in the alpine. This will enable us to more definitively determine the status and trends of alpine avian detectability in Banff National Park.

Contact

Derek Petersen, Ecological Integrity Monitoring Coordinator
Lake Louise, Yoho and Kootenay and Banff Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Tundra Measure: Alpine Extent

Introduction

The alpine ecozone is the area above treeline and includes both vegetated and non-vegetated landscapes. This ecozone is characterised by harsh conditions including huge temperature variations over space (i.e. aspect) and time (i.e. day and night and season). Consequently the vegetated ecosystems within this zone contain highly endemic species and are sensitive to temperature change (Nagy and Grabherr 2009).



Figure 1. Treeline extent shown in images at Panther Mountain (station 197) in 2009 (above) and 1918 (below). Images courtesy of Mountain Legacy Project.

Climate change can have a serious impact on ecosystems, especially at northern latitudes where processes resemble the higher elevation habitats in the mountains. If predicted temperature and weather pattern changes occur, the resulting elevation shift in vegetation zones will provide good insight to assess spatial extent and health of alpine ecosystems.

Through the use of projects such as the Mountain Legacy project (*http://mountainlegacy.ca/*), we can see large scale changes in vegetation over the course of the last century (Figure 1). A comparison on photo points collected in the early 1900's with those collected in 2000's highlights on a broad scale, changes in vegetation patterns such as treeline (Figure 1.). While these comparisons provide a coarse indication of change, more detailed analysis using remote sensing and aerial photos would provide a higher resolution method to measure these changes on a finer scale.

Geographic Information Systems (GIS) technology can be used to detect land cover change by measuring densities of faster growing shrubs as well as changes in the extent and configuration of the alpine meadow zone. Long term monitoring of this nature is important to assess gradual and subtle changes in vegetation which occur over long periods of time (Luckman and Kavanagh 1998, 2000, Kavanagh 2000).

Commencing in 2016, we have identified long term alpine extent monitoring as one of five measures to assess and detect change over time in the ecological health of alpine ecosystems. In this context Alpine Extent is defined as the vegetated shrub and meadow zone between treed areas at lower elevations and non-vegetated (bare ground) at higher elevations. For Banff National Park (BNP), because high resolution air photos exist for 2014 (baseline year), we will re-assess alpine extent in 2019 and 2024 to detect change in land cover type and extent.

Monitoring Question

What is the change in area in alpine extent (pixels of combined vegetated shrub and meadow zone) over a 10 year period in Banff National Park?

Metric

Alpine extent will measure the change in total area of pixels (of combined vegetated shrub and meadow zones) in each of the study sites.

Thresholds

Due to the preliminary nature of this measure, we have not yet determined thresholds. We are currently using a combination of scientific research, discussions with experts in remote sensing, and other pilot projects within Parks Canada (Jasper Alpine Extent) to develop scientifically rigorous thresholds appropriate to Banff National Park.

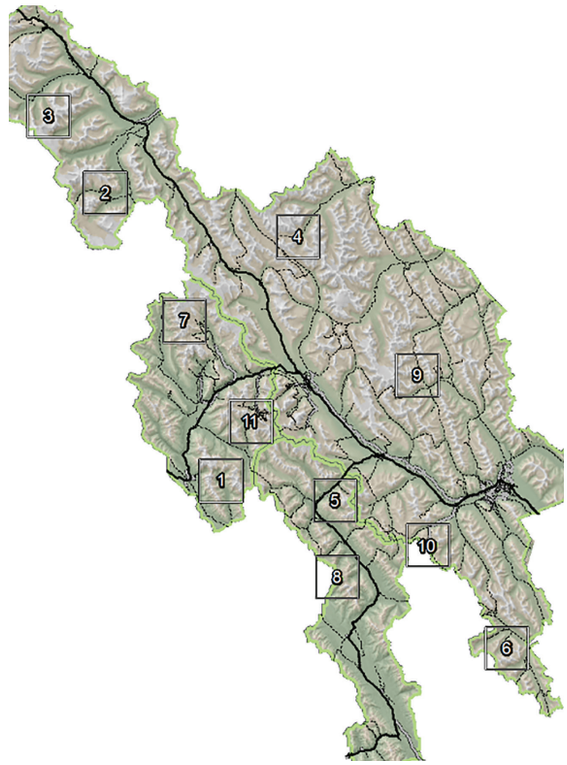


Figure 2. Alpine Extent sample sites for Banff, Yoho and Kootenay National Parks.

Thresholds will be based on comparing high resolution imagery over 10 year periods to capture the magnitude of change in alpine extent across six study sites in BNP.

Thresholds will focus on the change in area (reduction or expansion) of the alpine extent.

GOOD	+/- 1 standard deviation change from mean baseline area of alpine ecozone
FAIR	+/- 2 standard deviation change from mean baseline area of alpine ecozone
POOR	+/- 3 standard deviation change from mean baseline area of alpine ecozone

Methods

Overview: We will use high resolution air photos or remote sensed images to assess changes in alpine extent (shrub and meadow zones) and adjoining land cover types (tree line and bare ground) for selected alpine study sites. Every ten years, alpine regions will be re-evaluated regarding their land cover composition and compared with the previous extent. From this measure we will have an understanding of alpine extent and the rate of change within and surrounding the alpine region.

Site Selection: Six representative study areas (10km x 10km) were selected within Banff National Park (Figure 1.). Potential sites were identified using GIS software with the 1:50,000 scale Ecological Land Classification spatial data. We identified areas which contained large contiguous patches of alpine vegetation and southern facing aspects (SW and SE). Selecting regions with south facing slopes minimises the influence of shadow on imagery and ensures effective image classification comparisons into the future. Using ArcMap analysis toolset, we then used a focal statistic analysis to identify which of these areas has the highest density of alpine regions while ensuring the amount of permanent snow and ice is not covering a significant area. We then selected study sites as far apart as possible to minimise spatial auto-correlation. One site location (Sunshine Ski Resort) was selected to maximise resource efficiency as it is currently the location of a complementary human use monitoring program.

Imagery Acquisition: In 2014, Banff National Park acquired detailed ortho-rectified air photo imagery (4 band) for the entire park. This will provide the baseline for alpine extent on which future imagery will be compared. We will restrict future images to those captured between late July and September to detect the peak greenness of the vegetation. We will only use images when accurate comparisons are possible: ie. few clouds, low smoke, and minimum shadows.

Baseline Alpine Extent Calculations: We are currently developing methods to estimate the most accurate measures of alpine extent. In 2017 we conducted a pilot project using the 2014 air images for Banff National Park. We used PCI Geomatica software to classify areas based on 1) vegetation type (Normalized Difference Vegetation Index NDVI) and 2) common spectral themes (unsupervised classification). Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). NDVI is a standardized way to measure healthy vegetation. We conducted classification using *Unsupervised classification* in which the algorithm classifies classes (or clusters) in a multiband image without the analyst's intervention. This prevents variation introduced by the individual conducting the analysis.

Preliminary results of these pilot projects suggest more refinement or specific criteria and guidelines may be required to accurately identify the four classes of interest (tree, shrub, meadow, bare ground) within the images. Once refined, we will use this method to classify images for all sites within Banff, Yoho and Kootenay and to calculate the baseline alpine extent.

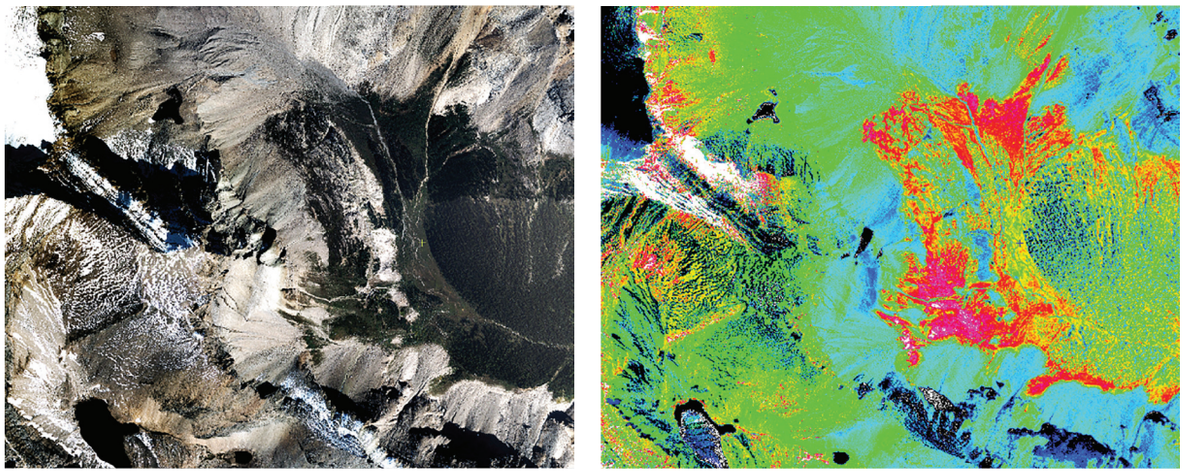


Figure 3. A sample satellite imagery (left) location taken in 2014 with corresponding NDVI (right) calculations for the pilot project to classify baseline alpine extent.

Measurement of change in Alpine extent

Every ten years, we will acquire high resolution imagery or air photos to enable comparisons between the reference or baseline alpine extent. We will compare future satellite images to the 2014 baseline using the Change Vector Analysis in PCI Geomatica. We will use NDVI values to identify "changed" pixels compared to the reference image and these pixels will be relabelled to one of four classes (tree, shrub, meadow, bare ground). The results will provide a detailed breakdown in the total number and area of pixels for which the land cover type has changed. While trees and bare ground land cover types are not classed as alpine region, we will measure them to provide an understanding of the migration of the shrub/meadow zone.

On ground field methods: On-ground field measurements have been proposed as a means to ground truth the results obtained from imagery. Potential methods include, on-ground GPS point locations to mark boundaries between tree line, shrubs, meadow line and bare rock.

Results

Condition and Trend

The condition and trend of the Alpine Extent indicator is Not Rated. An assessment will not be available until 2019 for Banff National Park. Shorter time scale analysis will be undertaken if and when quality imagery becomes available as a result of other projects.

Assessment Confidence

The protocol is in final draft form.

Discussion

Despite the early stages of this program, the alpine extent measure provides an effective way to monitor gradual or subtle changes occurring over long periods of time. The alpine ecozone is an important life zone for many species of vegetation and wildlife and has a demonstrated sensitivity to climate change related impacts. It will be important to monitor changes so we will be able to predict impacts to the key biodiversity elements that rely upon alpine zone. This understanding of the scope and scale of change will be important, even though it is unknown whether there will be any effective ways to mitigate such change.

The methods employed for this measure will continue to be sensitive to improvements in remote sensing and GIS technologies and will adapt as necessary to capitalize upon these improvements.

Acknowledgements/Partners

Olivier Berard – Parks Canada

Dr. Philippe Henry - Univ. of Northern BC, Jasper National Park.

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Tundra Measure: Sensitive Species – Mountain Goats

Introduction

Mountain goats are unique among the mountain park ungulates for their late age at first reproduction (3-4 years), little capacity for producing twin young, and generally poor potential to compensate for increased adult mortality from any cause (Mountain Goat Management Team, 2010). Banff, Yoho and Kootenay National Parks are currently discussing how to best undertake long-term monitoring in order to assess mountain goat temporal and spatial trends.

Until a broader monitoring strategy is defined, we continue with annual aerial surveys in the Lake Louise area in Banff National Park. The objectives of these surveys, initiated in 2002, are to estimate relative abundance and determine current distribution patterns. The Lake Louise area has been selected in order to develop an understanding of how transportation corridors, human use, and wildlife habitat management may affect goat populations over time.

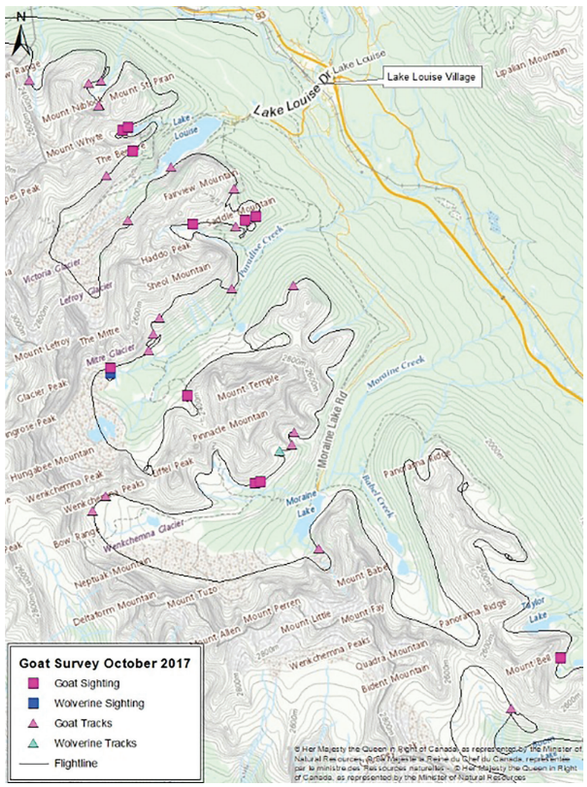


Figure 1. Wildlife observations (sightings and sign) from October 2017 Lake Louise area mountain goat aerial survey.

Monitoring Question

Is mountain goat relative abundance and distribution changing in the Lake Louise area over time?

Metric

The metric is based on a 3 year moving window average of the number of goats observed on the Bow-LL Transect.

Thresholds

GOOD	Within 1SD (standard deviation) around the mean of 10 consecutive three year moving window averages
FAIR	Within 2SD (standard deviation) around the mean of 10 consecutive three year moving window averages
POOR	> 2SD (standard deviation) around the mean of 10 consecutive three year moving window averages

Methods

Every fall, researchers conduct a helicopter survey along an established transect of the Bow Range in the Lake Louise area of Banff National Park (Bow-LL transect) to determine the distribution and abundance of goats (Figure 1). The Bow-LL transect runs from just northwest of Lake Louise, near Ross Lake, to just south east of Taylor Lake. These surveys have been conducted annually since 2006, with two additional surveys conducted in 2002 and 2003. Methods used are outlined in Protocols for Lake Louise and Slate Range Mountain Goat Aerial Surveys (Wrazej, 2016). The transect elevation is set at approximately 7,500 ft (2,286m). Researchers count all the goats they observe and determine their locations using a Garmin GPS. To address annual variation in survey routes, we used ESRI ArcGIS 10.4 to define a survey area polygon that encompassed all areas consistently surveyed each year. We only analyse the observations found within this polygon to ensure that annual comparisons are reflective of a similar survey effort. We used a three year moving window average to determine a long-term condition rating representative of trends in the relative abundance of goat observations. To determine the current condition of the measure, we compared the most recent three year moving average to upper and lower thresholds based on the first 10 consecutive years (2006 – 2015) of aerial goat survey data. We set the upper threshold at one standard deviation below the mean of these 10 years and the lower threshold at two standard deviations below the mean (Parks Canada Agency, 2011). We determined the trend in the goat condition rating by comparing the current condition to the status of the previous measure assessment (Parks Canada Agency, 2011).

Results

We collected 14 years of mountain goat aerial survey data from the Bow-LL transect (Figure 2). We determined the upper threshold value to be 20.7 and the lower threshold was 11.7. The goat observation moving window average fell below the upper threshold but above the lower threshold in 2015 and has remained there through to 2017 (Figure 3). Based on the moving window calculation, the 3 year average for 2017 is 14 and therefore rated in 'fair' condition. The trend in the number of goats observed in the Lake Louise area has been generally declining since 2006.

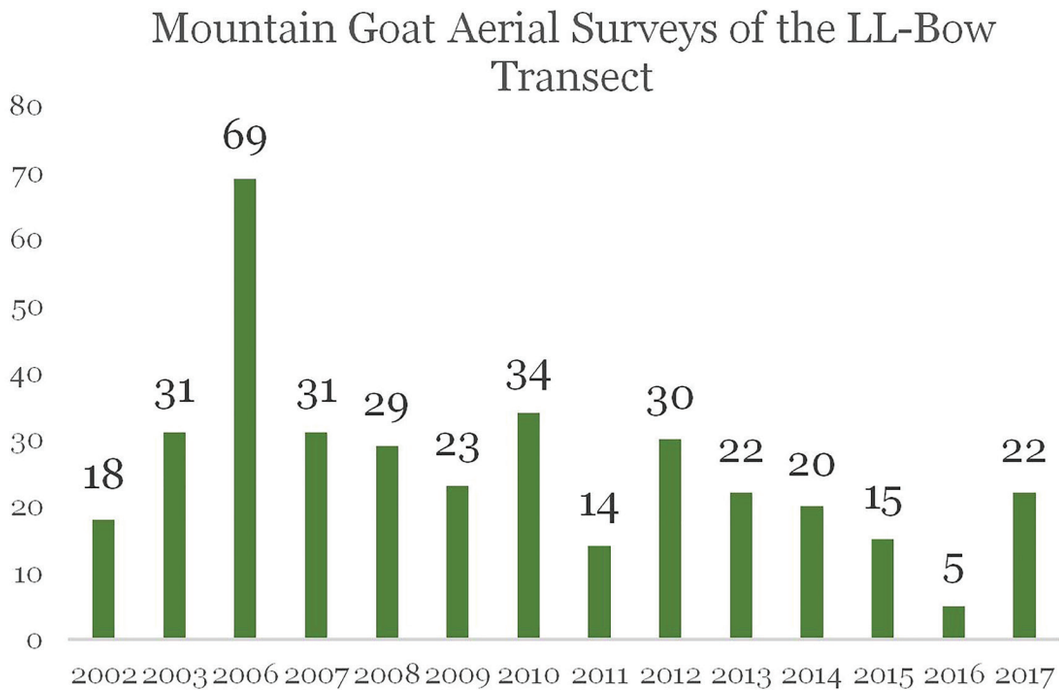


Figure 2. Lake Louise Mountain Goat Aerial Survey Total count/year.

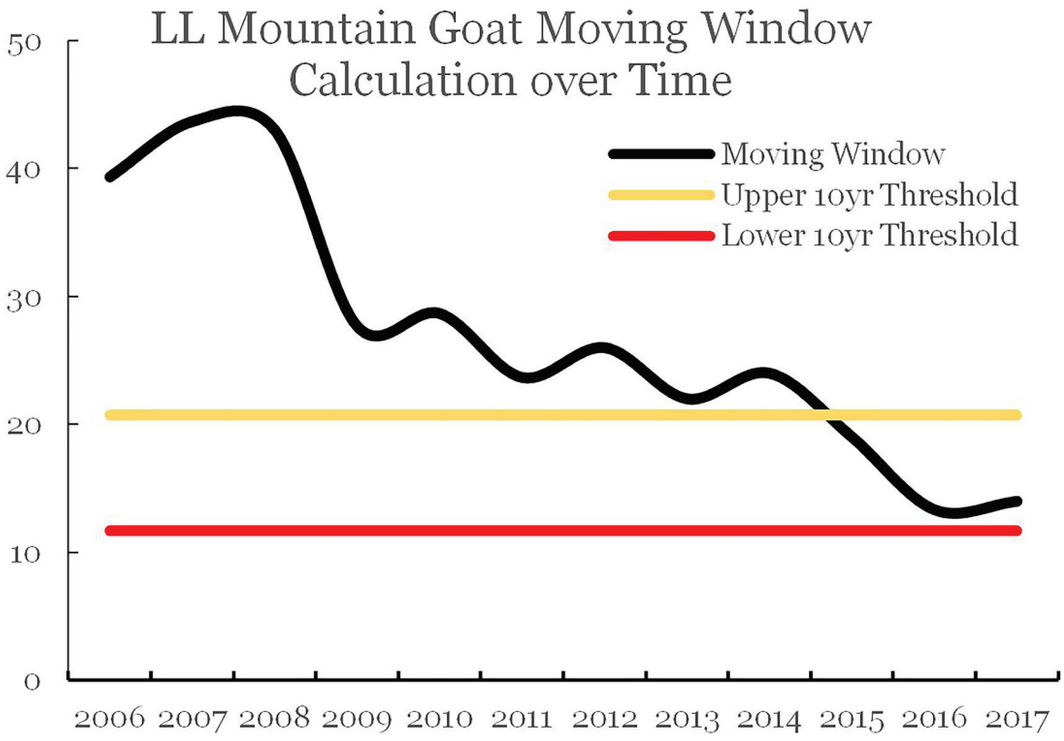


Figure 3. Lake Louise Mountain Goat Moving Window Calculation over Time. Threshold based on data from 2006-2015.

Condition and Trend

Condition: Fair
Trend: Stable

Assessment Confidence

The state of protocol development for the 'Sensitive Large Mammal Species – Goats' measure is *In Progress*. These surveys were initiated in 2002 to monitor goat numbers in an area of high human use - the Lake Louise area. Additional factors may affect consistency, and therefore variability in long-term survey data, such as survey conditions (e.g, snowpack, lighting etc.), surveyor experience and seasonal timing of the survey (early fall to early winter). Another potential reason for variability in the long-term survey data is that the survey area is not a closed or isolated unit, as it bisects goat habitat within the Bow Mountain Range, therefore goats may move in and out of the transect area between years.

This measure may not be representative of goat population status in other areas of Banff, Yoho, and Kootenay National Parks due to the high amount of human use in the Lake Louise region and possibly differences in relative mountain goat habitat suitability. To spatially broaden the measure to include all of Banff, Yoho, and Kootenay, we have mapped goat sub-population management units (PMUs) and goat survey units (GSUs) throughout the Lake Louise, Yoho, and Kootenay field unit. These units are more isolated (i.e. natural barriers such as major river valleys, may limit movement of goats between units so surveys can be better compared over time). Between 2015 - 2017, we have surveyed most of these GSU's, using more robust survey methods established by the province of BC (see RISC 2002, Poole 2015). We will use these data and protocols to collect long-term observations and improve the Sensitive Large Mammal Species – Goats measure in future years. Parks Canada will continue to report on the trend of goats in the Lake Louise area but will also assess temporal and spatial trends in goat populations throughout Yoho and Kootenay and the remainder of Banff National Park.

Discussion

Based on the annual surveys, goat use of the Lake Louise area appears to have declined since the early 2000s; however, in recent years the declining trend has stabilized. Because this survey transect is not closed to goat movement and goats could move to the 'back side' of the Bow Range, into the Tokumm valley in Kootenay or the Lake O'Hara valley in Yoho, it is difficult be certain if population numbers are declining or distribution has changed over time. According to Park Ecological Land Classifications (Achuff et al., 1984, Holroyd et al., 1983 and Wallis et al., 1996) 78% of summer goat habitat and 80% of winter goat habitat that is rated as high in the Bow Range was found on the 'front-side' (Lake Louise side). In the 2015 Yoho survey, we counted three goats on the 'back side' of the Lake Louise transect in the Lake O'Hara area and on the 2016 Kootenay goat aerial survey of the Tokumm Valley, we observed seven goats on the 'back side' of the Bow Range. In 2003, a landscape altering fire completely transformed the

Tokumm Valley and may result in the creation of more suitable habitat for goats. Taylor et al. (2006) found that mountain goats used burned areas more than expected, 20 – 40 years after a fire. Landscape changes that result in alterations to habitat suitability highlight the need to survey larger, closed survey units with reduced probability of animal movement across survey unit boundaries.

The Lake Louise area is one of Banff National Park's most popular visitor attractions and hosts millions of people every year. Many of Lake Louise's day hikes access mountain goat habitat. In addition, helicopter traffic, used for Parks operations such as servicing outlying accommodations, wildfire patrols and visitor safety incidents, is notable in this area, particularly in summer. The goat habitat in this area is ideal with varied alpine terrain such as broken cliffs, open steep meadows (Holroyd et al. 1983) and a potential lick at the base of the Paradise Valley. The degree to which relatively high human presence influences mountain goat habitat use, distribution, and overall population health is uncertain at this time; however, this may be an important focus for future research initiatives given the perceived long-term decline in relative goat abundance on the Bow-LL transect.

The declining trend of goat relative abundance in the Lake Louise area appears to have stabilized in recent years. In order to fully understand and appropriately manage mountain goat populations, robust survey techniques must be employed, including surveys of complete (closed) goat survey units. The effect of high human use on goat behaviour and distribution must also be better understood. To meet these goals, a more extensive and robust mountain goat condition monitoring measure will be developed for Banff, Yoho, and Kootenay that uses larger PMUs dispersed across a gradient of human use levels and goat habitat suitability.

Contact

Seth Cherry, Wildlife Ecologist
Lake Louise, Yoho and Kootenay Field Unit
P: (250) 347-6158
E: *seth.cherry@pc.gc.ca*

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Tundra Measure: Alpine Obligate - Pika

Introduction

American pika (*Ochotona princeps*) are small mammals of the Lagomorpha Order (rabbits and hares) and because they live along the interface between talus slopes and meadows in alpine and subalpine environments, are sometimes referred to as "rock rabbits". They are an IUCN Red-Listed species, currently with a status of *Least Concern*. There have been recent documented declines in this species in the US (Beever et al., 2016; Smith, Andrew T. & Nagy, 2015), but little is known about their status in Canada. Declines in the US are attributed to a variety of abiotic and biotic factors including warmer summer temperatures, decreases in summer precipitation and associated vegetation changes, and decreases in maximum snowpack (Wilkening et al. 2011, Beever et al. 2013); as well as earlier spring snowmelt (Morrison et al. 2004). Pika are sensitive to environmental changes due to their low thermal tolerance and because they do not hibernate (Smith and Weston 1990), but collect and dry vegetation ("hay piles") for their winter food supply (Figure 1). As such, this species is a good indicator of the health and condition of the alpine ecosystem.



Figure 1. Pika collecting vegetation for winter food supply (photo: W. Hunt)

This measure reflects monitoring of Pika populations within Banff National Park. Implementation of the same protocol within Yoho and Kootenay National Parks allows data from all three parks to contribute to a greater sample size and range of climatic and environmental conditions, increasing the power to detect trends in occupancy changes. We chose to survey for active pika hay piles as a simple means of quantifying occupancy, which is an efficient and cost effective way of determining the status of populations with high rates of detection, such as pika.

Monitoring Question

Has the proportion of pika occupancy (averaged at all monitoring locations) decreased by greater than 30% or greater than 50% over a ten year interval?

Metric

Annual % change in pika occupancy.

Thresholds

GOOD	Less than 30% decline in pika occupancy over 10 years
FAIR	Greater than 30% decline in pika occupancy over 10 years
POOR	Greater than 50% decline in pika occupancy over 10 years

We used thresholds derived from the International Union for Conservation of Nature (IUCN) criteria at which species' global populations are listed for *vulnerable* (≥30% population decline over 10 years) or *endangered* (≥50% population decline over 10 years) (IUCN 2017).

We calculated annual threshold changes via the formula (C. Schwartz, pers. comm.)

$$Y = (1 + X)^{1/(Z-1)} - 1$$

Where:
X = proportion of threshold change over 10 years monitoring (e.g. 0.5 inserted for 50%) and
Z = number of years of monitoring data.

The resulting conversions for 7 years of monitoring in BNP:

1. 30% decline/10 yrs = 3.0% decline annually
2. 50% decline/10 yrs = 4.6% decline annually

Methods

The approach for monitoring pika populations is based on repeat presence-absence surveys of hay piles within pika home-ranges ("sites"). We chose monitoring locations (talus patches) to represent east-west gradients and a range of elevations, such that regional and elevation dependent climatic conditions are represented in the monitoring network. We surveyed locations annually between mid-August and mid-September. We documented each site as having either active or inactive hay piles, and noted any pika sightings or auditory calls.

Monitoring began in 2011 in the Banff Field Unit (BFU), with additional locations added in 2015 and 2016 in BNP, YNP and KNP (Table 1). Currently, we monitor 656 sites at twenty locations, annually. Elevation of the locations range from 1814- 2314m.

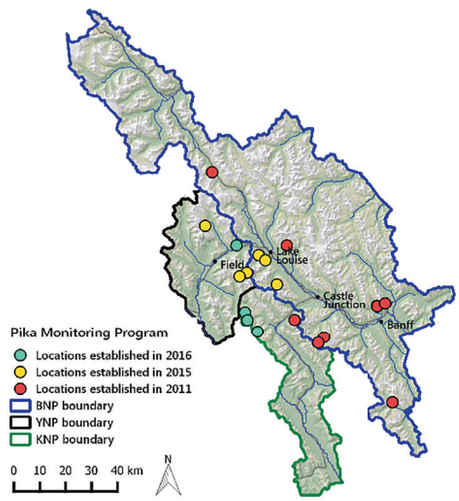


Figure 2. Pika monitoring locations in BNP, YNP and KNP.

Table 1. Pika monitoring locations and site characteristics in BNP, KNP and YNP.

Location	Park	Year Estab.	# of Sites	Elev (m)	Slope (°)	Aspect
Bow Summit	Banff	2011	30	2314	18	N
Brvant Shelter	Banff	2011	45	1843	5	S
Cascade Amphitheater N	Banff	2011	65	2132	9	S
Cascade Amphitheater S	Banff	2011	31	2192	26	E
C-Level Cirque	Banff	2011	38	1963	16	SE
Egypt Talus	Banff	2011	31	2103	18	W
Egypt Wliistling Pass	Banff	2011	51	2275	16	SE
Simpson Pass Rockband	Banff	2011	34	2213	22	NW
Wolverine	Banff	2011	56	2308	21	SW
Consolation	Banff	2015	32	2015	17	SE
Lake Agnes	Banff	2015	32	2161	14	SE
Saddle Pass	Banff	2015	35	2291	19	E
Stanley Glacier •*	Kootenav	2011	32	1968	21	W
Helmet Falls	Kootenay	2016	17	1814	15	SE
Wolverine Pass	Kootenav	2016	15	2230	16	E
Goodsir Pass	Kootenav	2016	10	2237	7	SW
Iceline	Yoho	2015	33	2149	17	SE
Lake Oesa	Yoho	2015	23	2213	15	S
McArthur	Yoho	2015	35	2180	21	W^
Paget Lookout	Yoho	2016	11	2279	26	SW^

Beginning in 2013, we placed temperature loggers within talus interstitial space near hay piles at ten locations to monitor the micro-refugia temperatures. We collected temperature data for two years at ten locations (Aug 2013 to July 2014, and Aug 2015 to July 2016), and added three locations in 2016, and 7 more locations in 2017. We will use these data in future analyses, along with additional covariate data such as elevation, aspect and climate, to investigate the determining factors leading to changes in pika occupancy.

We used locations with seven years of data to determine occupancy trends for pika. We calculated occupancy as the ratio of occupied to unoccupied sites at each location (from ~30-65 individual pika sites). Pika detection rates are typically high (>90%).

We used a generalized linear mixed modeling approach to determine the population trend over seven years using a logit link and binomial distribution. We use year as a fixed effect, and location and year as random effects. This enabled us to estimate the average rate of change in pika occupancy over time, while accounting for variation within locations and within years. We

tested several candidate models, and chose the resulting best fit model according to the most favorable AIC (Akaike information criteria):

Best model = glmer (active2~year2 +(1 + year2|location)

We calculated the annual percent change in occupancy using the slope of the modeled relationship. This model enabled estimation of the rate of change for all locations, and for each location. We calculated standard error and 95% confidence intervals for the rates of change for all locations and each location separately.

Locations established in 2015 and 2016 do not yet have enough data to establish baseline occupancy, so the current measure is based on bioregional data analysis from the BNP and KNP locations with sufficiently long datasets. Future analyses will include more recently established locations as the data become available.

Results

We calculated percent pika occupancy, as a ratio of occupied and unoccupied sites at each location, for seven years (2011-2017) at ten locations in BNP and KNP, three years (2015-2017) at six locations in BNP, YNP and KNP and two years (2016-2017) at four locations in YNP and KNP (Figure 2). We found substantial annual variation in the occupancy at each location, which is characteristic of small mammals.

Condition and Trend

Condition: Good
Trend: Stable

We based condition and trend data on 10 locations with seven years of data. We will add the additional locations to the analyses in future years once sufficient data has been collected.

The annual rate of change in pika occupancy for the locations with seven years of data was an annual increase of 1% per year, with the 95% confidence interval indicating a range from -11% to +13% change per year. The overall rate of change indicates that the population is currently stable and not exhibiting concerning levels of decline over time (Figure 3 - top), while the large range in the 95% confidence interval (Figure 3 - bottom) is likely a result of the large natural annual variability in pika populations. Additional years of monitoring will increase confidence in the trend metric.

We based the condition and trend of the pika measure on data aggregated from multiple locations; therefore, threshold occupancy changes at specific locations (i.e. sub-measure variability) may not be evident within the overall measure. The overall trend is stable, with most locations showing neutral or positive occupancy trend (Figures 2, 3 (bottom); however, there are three locations ('Bow Summit', 'Bryant Shelter' and 'Wolverine') in which the average rate of change

(Figure 3, bottom) indicate population declines greater than the 3% per year threshold. These locations represents the lowest elevation (Bryant Shelter – 1843m) and highest elevations (Bow Summit – 2314m, Wolverine – 2308m) in the monitoring network. There are three additional locations in which the lower bounds of the 95% confidence intervals cross either one or both of the 3% or 5% per year thresholds.

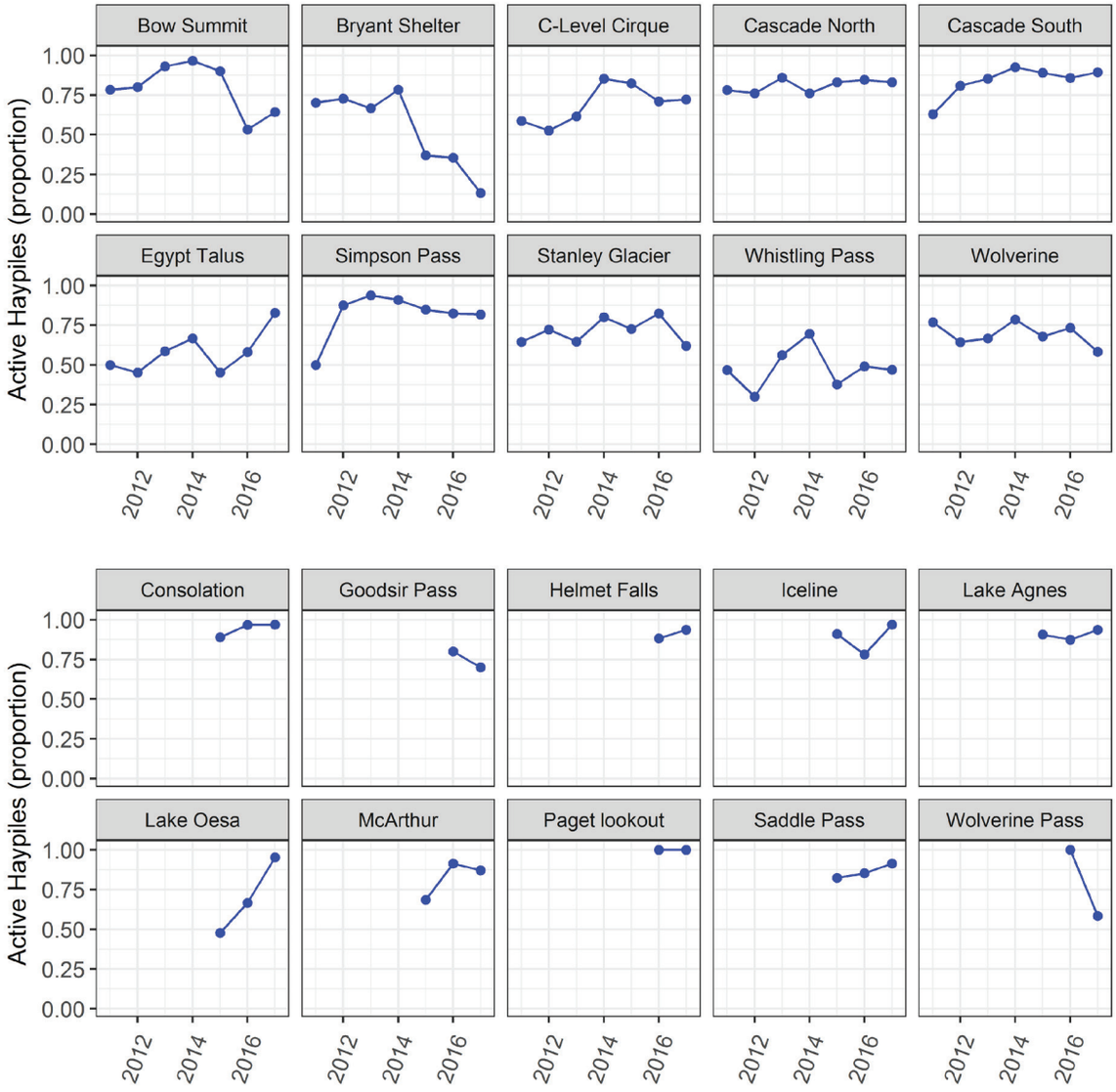


Figure 3. Pika occupancy from (top) 2011-2017 for ten locations in BNP and KNP, and (bottom) 2015(16)-2017 for ten locations in BNP, KNP and YNP.

To assess pika condition status and incorporate uncertainty into the trend measurements, we used a coarse "Bayesian posterior belief" calculation. This calculation relates uncertainty estimates (95% confidence intervals) to threshold levels to assess the % belief in the state of the trend condition (C. Schwartz, pers. comm.). The formula is as follows; $Y = \{\sum_{p1} + {}_{p2} \ldots\}/n * 100$ where,

Y= % belief for the threshold of interest; *p*= posterior belief score for each location (denoted by the subscript) such that *p*=1 if the 95% confidence interval (CI) is fully beyond the threshold of interest, *p*=0.5 if the 95% CIs encompasses both sides of the threshold of interest, and p=0 if the 95% CI does not cross the threshold; *n*= the total number of locations. Using the above calculation the resulting Bayesian posterior belief (%) for each threshold state (condition) was as follows:

Good: 65% belief
Fair: 35% belief
Poor: 30% belief

Covariate data provides insight into important attributes that affect pika persistence. Pika use talus' interstitial space as micro-refugia from summer warm temperatures and winter cold temperatures, thus temperatures measured in these talus micro-refugia spaces provide information on environmental conditions the pika are experiencing. Temperature data recorded from August 2015 to July 2016 at select locations (Figure 4) showed strong diurnal temperatures during spring, summer and fall months, but were dampened during winter months once insulating snowpack accumulated at most locations.

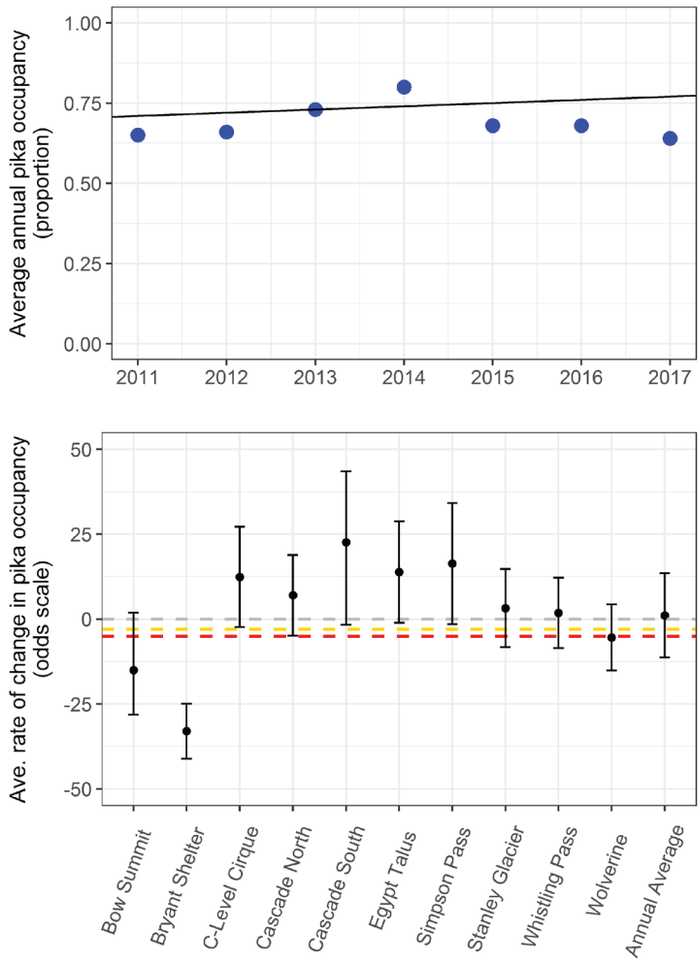


Figure 4. (Top) Average annual pika occupancy (proportion of active to non-active haypile sites) for all locations with seven years of data, with GLMM modeled seven year trend-line; (Bottom) Average rate of change in pika location, derived from the GLMM model, for ten locations with seven years of data, along with the 95% confidence intervals, and average annual rate of change for all locations (far right). The yellow and red dashed lines indicate the 3%/year and 5%/year thresholds, respectively.

Research in the US (Beever et al. 2010) has used temperatures thresholds (summer temperature > 25°C, and winter temperatures <-5°C) as a guideline for when pika may experience thermal stress. In this study, talus temperatures rarely increase above 25°C (Figure 4) suggesting that warm summer temperature may not be a stressor at these locations. Snow cover in winter months can provide effective insulation against cold temperatures, resulting in less energy expenditure by pika, relative to ambient winter air temperatures. If sufficient insulation is present, temperature loggers will show a narrow range in daily temperatures (less than 2°C

variation). Bow summit, C-Level Cirque, Egypt Talus and Whistling Pass data all indicate effective insulating snow cover; however, Bryant Shelter and Stanley Glacier data both show a large range in temperatures (large daily amplitude in Figure 5), as well mean temperatures well below -5°C. These data are preliminary, and are a sample of talus micro-refugia temperatures, that are likely variable across talus slopes. With additional years of data collection, this information will be used in conjunction with other covariate data to form hypotheses on the factors driving pika population changes.

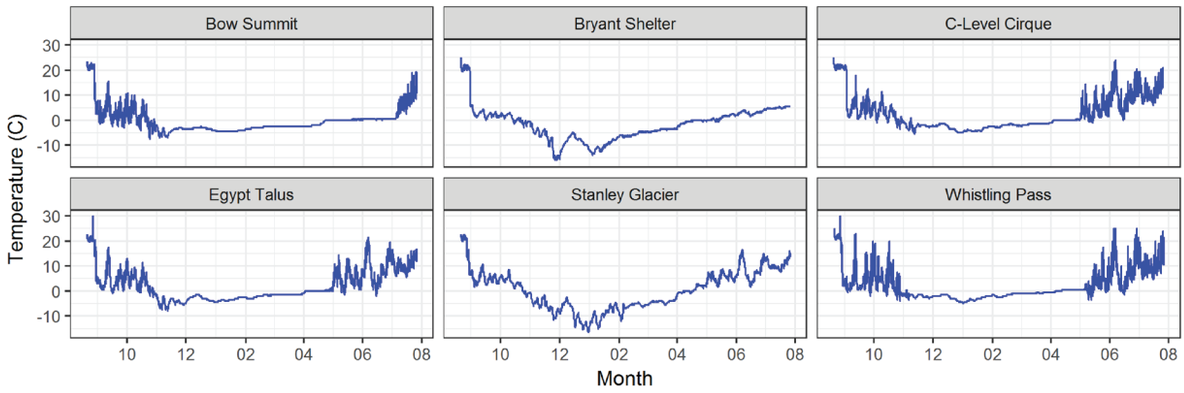


Figure 5. Time series of temperature measured in talus interstitial space at select pika monitoring locations from August 2015 to July 2016.

Assessment Confidence

There are several challenges with data collection that affect the precision of population estimates and the power to detect trends over time. These include:

1. Difficulty in defining the boundary between individual pika sites (home ranges) with closely adjacent or overlapping boundaries
2. Thoroughness of detection of hay piles (especially in large blocky talus)
3. Inconsistent observations between observers
4. Inaccurate GPS signal resulting in inaccuracies in locating sites

Actions for improving these challenges include: sites with overlapping boundaries will be consolidated to single sites for future surveys; additional observer training will reduce errors from (2) and (3) above, and annual repeat surveys will help to quantify the magnitude of these errors. In future years all sites will be marked with a physical marker (e.g. cairn or tree tag) to aid in re-location.

The Pika Monitoring Protocol is Complete, but may undergo revisions if upcoming internal and external reviews suggest design improvements. Issues we are investigating in reviews include (1) the inability of the method to detect shifting pika home ranges (due to spatially 'fixed' sites)

and (2) an insufficient number of monitoring locations for determining the driving variables of any population changes with statistical robustness.

Discussion

The overall pika condition and trend is 'good' and 'stable', with a posterior belief confidence in this measure of 65%. Defining occupancy trends in small mammals with large natural occupancy variability is challenging. However, long term data collection will help to offset this variability and allow for better detection of significant population trends.

Declining occupancy at three locations within the monitoring network suggests smaller scale (location level) trends may be occurring within the greater landscape population trends. Identifying changes within specific sub-populations (locations) could act as an early alert to overall population trends (E. Beever, USGS pika biologist, personal comm.). Therefore, we will consider adding a location-level threshold on top of our existing park-level thresholds. In addition, the biotic and abiotic factors that may be driving landscape and location-level population trends are currently unknown for this area. Therefore, we will also consider monitoring attributes known to be important to pika populations, so that if changes do occur in pika occupancy (at both location and landscape scales), we may better understand the drivers.

Acknowledgements/Partners

Citizen science volunteers have been a key component of this project since the outset, by providing field assistance to Resource Conservation Staff in completing these surveys. In addition, the Bow Valley Naturalists also collected pika observations from the public as part of their High Elevation Localized Species (HELS) monitoring initiative (website. *http://bowvalleynaturalists.org /page21/page21.html)*. We would also like to thank Dr. David Hik, Univ. of Alberta, Dr. Philippe Henry of Univ. of Northern BC, Dr. Erik Beever of US Geological Survey, and the PC staff at Mount Revelstoke and Glacier National Park for their support and collaboration.

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Freshwater Measure: Stream Connectivity

Introduction

The aquatic connectivity measure is a stressor based monitoring measure. Parks Canada aquatics specialists developed this measure in Jasper National Park as a pilot in 2005 and we adopted it for Banff National Park (BNP) in 2007. Here we report on changes that have occurred in the last decade. Streams and rivers function as nature's pathways for both aquatic and terrestrial organisms – this movement supports critical behaviours (e.g. foraging, reproduction) and life history stages, (e.g. spawning, over-wintering), allows animals to move in response to change or disturbance events (e.g. flood, climate change) and maintains genetic diversity. In addition to maintaining connectivity for various organisms, well-designed crossing structures also allow movement of alluvial materials (sediment/gravel) and minimize impacts to the natural processes of alluvial fan development and stream meandering. This natural process is often severely constrained by undersized bridges and culverts resulting in loss of biodiversity and significant capital costs following natural flood events. Restoring and maintaining aquatic connectivity is critical to the maintenance of ecological integrity in Banff National Park.

In 2006 and 2007, we completed a park wide inventory of road stream crossings (Taylor and Helms 2008). At each road stream crossing we photographed the structure (primarily culverts) and recorded a series of channel and culvert measurements to characterize passage for fish and other wildlife.

Monitoring Question

Which road-stream crossings within Banff National Park are barriers to the movement of aquatic organisms, primarily fish?

Metric

In 2006 and 2007 we assessed all BNP road-stream crossing structures that had flowing water to evaluate them for fish passage and established a database to track changes over time.

We classified each crossing structure into: full barrier, partial barrier or no barrier by evaluating each crossing structure for the following characteristics: velocity barrier, insufficient depth, outfall drop, debris barrier, inlet drop, orifice flows, bottom raised above substrate, screened, ice barrier and flow contraction/turbulence. Table 1 provides a brief summary of each barrier type; more detailed methods and results are in Taylor and Helms (2008).

Table 1. Road-stream crossing barrier criteria.

Barrier Type	Criteria
No Barrier	A crossing was considered no barrier to fish passage if all of the following criteria were met: 1. Hang Height = 0 m 2. Velocity ≤ 0.5 m/s 3. Water depth ≥ 0.15 m
Full Barrier	A crossing was considered a full barrier if any of the following criteria were met: 4. Hang height > 0.6 m 5. Velocity > 0.7 m/s 6. Water depth = 0 m
Partial Barrier	A crossing was considered a partial barrier if any of the following criteria were met: 7. Hang height > 0 m and ≤ 0.6 m 8. Velocity > 0.5 m/s and ≤ 0.7 m/s 9. Water Depth > 0 and < 0.15 m

The following excerpt from Taylor and Helms (2008) provides additional context:

"Outfall drops > 0.6 m were considered full barriers to fish passage as defined by Love and Firor (2001) and cited in the barrier classification criteria used by the Foothills Model Forest (Wilson et al., 2003). The criteria for this rational is in consideration of juvenile salmonids and based on the leaping capabilities of individual species and life stages. For example, adult cutthroat and rainbow trout are capable of jumping 1.5 m, while juveniles (50 mm) are only capable of jumping 0.3 m (Whyte et al, 1977).

A partial barrier was assigned to any crossing structure with and outfall drop > 0 m and ≤ 0.6 m as this height range is well within the jumping abilities of adult salmonids, but not necessarily all juveniles (Love and Firor, 2001).

The outfall depth criterion is intended to be conservative to ensure species such as sculpin can pass through the crossing structure. For example, a very small outfall drop may be within the range that any trout species can leap. However, the capabilities of sculpin to leap are not well understood. It was assumed that sculpin would have difficulties with an outfall drop of any size, therefore, a culvert with even the smallest outfall drops were assigned as partial barriers.

For velocity to be considered a barrier, it must exceed the swimming capabilities of the target species and life stages of fish. A range of criteria to delineate velocity barriers exists in the literature. For example, Chestnut (2002) considers velocity readings < 0.4 m/s accessible to 50 mm juvenile rainbow trout. Chilibeck et al., (1993) is less conservative and states that average water velocity in a culvert should not exceed 0.9 m/s for culverts greater than 24.4 meters in length. A full barrier to fish passage is assigned to a crossing structure with a velocity > 0.7 m/s. This is based on the swimming capabilities of some salmonids such as rainbow and cutthroat trout and is consistent with the British

Columbia Ministry of Environment (MOE) culvert inspection procedures (Parker, 2000). Given that juvenile fish have limited swimming capability 0.5 m/s will be the upper limits of passage for many juvenile species (Parker, 2000). Therefore, in accordance with the B.C MOE culvert inspection procedures, partial barrier status is assigned to crossings that have velocities > 0.5 m/s and and ≤ 0.7 m/s

Insufficient depth was used as a rational when the water level in the crossing structure was < 0.15 m. This value is based on the minimum water depth needed for adult resident trout (Votapka, 1991) and is consistent with the B.C MOE culvert inspection procedures (Parker, 2000).

Specific criteria for all other barrier rationales (debris barrier, inlet drop, orifice flows, bottom raised above substrate, screened, ice barrier and flow contraction/turbulance) were not used, as these rationales are not as easily quantifiable. For example, in the literature there are no specific criteria to determine barrier thresholds for inlet drops. Furthermore, debris barriers are hard to quantify by measurement. Therefore, the investigator is to use his/her best judgment to determine if a road-stream crossing is a partial, full or no barrier due to one of these aforementioned rationales. These rationales usually occur in combination with one of the more common phenomenon of velocity, insufficient depth and hang height."

Thresholds

GOOD	> 80% of road-stream crossings can pass all life stages and species of fish year round
FAIR	60%-80% of road-stream crossings can pass all life stages and species of fish year round
POOR	<60% of crossings can pass all life stages and species of fish year round

Methods

A comprehensive survey was completed in 2006 and 2007. Since that time we replaced several culverts as part of the Trans-Canada Highway Twinning. In addition major changes occurred at some road stream crossings as a result of flooding in 2012 and 2013 (Figure 1). Therefore we also revisited key locations affected by flooding.

It was our intention to re-measure culverts based on the original criteria in 2006 – however with the emergence of whirling disease in 2016 we modified our approach



Figure 1. Noyes Creek flooded across highway 93N in June 2013 after the culvert was overwhelmed with water and debris.

to discontinue in-stream measurements unless a visual inspection proves inconclusive. Whirling disease can easily be transferred on wet equipment and many of the original measurements were made in the wetted stream channel including hang height, water depth at outlet, depth of stain, riffle crest, and upstream and downstream water velocity. This modified approach the reduced risk of spreading whirling disease and minimized labour and equipment costs, as none of the culverts in BNP required further assessment, beyond a visual inspection in 2017, to assess for fish passage.

Results

Table 2, below shows the road stream crossings that were changed since 2007. We replaced fifteen culverts. Two previously existing bridges, one over Moraine Creek and one over the Bow River, were substantially upgraded by moving the bridge abutments back to increase channel width while also increasing the bridge deck height. Three culverts were removed and replaced with wider multispecies underpasses with the stream running through it (Fig 2). One culvert on Highway 93N (55.4 – Noyes Creek) was a full barrier to fish movement prior to 2013 flooding and emergency repairs – however the downstream channel work filled-in the hang height and full passage has been restored.

The culvert name includes the road it is located on, the number indicates the distance in kilometers from a zero point – for the Trans-Canada Highway it was the Banff East Gate. It should be noted that some culverts included below were not evaluated in 2006-07. Several locations were unsafe to visit due to high water (Paradise Creek, Bath Creek) or active highway construction.

Table 2. Road stream crossings modified in Banff National Park between 2007 and 2017.

Culvert Number	Watercourse Name	2006 Barrier Status	2017 Barrier Status	Comments on change to crossing
TCH_53.4	Unnamed	Full	No	Culvert upgraded
TCH_54.2	Unnamed	Full	No	Culvert upgraded
TCH_55.9	Taylor Ck	Full	No	Culvert upgraded
TCH_57.3	Unnamed	Full	No	Culvert upgraded – upstream stream reconstruction gravel pit
TCH_58.9	Unnamed	Full	Partial	Culvert upgraded - reset to high water mark only as experiment
TCH_60.0	Unnamed	Full	No	Culvert upgraded
TCH_60.02	Unnamed	Not Assessed	No	Culvert upgraded
TCH_62.4	Unnamed	Full	No	Culvert upgraded
TCH_63.0	Unnamed	Partial	No	Culvert upgraded
TCH_63.9	Unnamed	Full	No	3 small to one large multi species underpass

Culvert Number	Watercourse Name	2006 Barrier Status	2017 Barrier Status	Comments on change to crossing
TCH_64.0	Unnamed	Not assessed	No	Culvert upgraded
TCH_65.0	Moraine Ck	Not assessed	No	Bridge raised – bird passage, terrestrial passage
TCH_67.4	Unnamed	Not assessed	No	Culvert upgraded
TCH_68.8	Unnamed	Not assessed	No	Culvert removed - multispecies underpass with creek
TCH_69.8	Unnamed	Not assessed	No	Culvert upgraded
TCH_70.0	Bow River	Not assessed	No	Twin Bridges
TCH_79.3	Unnamed	Partial	No	Culvert upgraded
TCH_81.4	Bath Ck	Full	No	Culvert removed - multispecies underpass with creek
Moraine_2.7	Paradise Ck	Not assessed	Full	Not measured in 2006 due to dangerous water levels
93N_55.4	Noyes Ck	Full	No	Post flood channel work fixed culvert
93N_60.3	Totem Ck	Full	Full	Flow has switched sides

Table 3. Park-wide result summary for Banff National Park.

	Full Barrier	Partial Barrier	No Barrier	Total Assessed
2007	103	67	18 (10%)	188
2017	94	66	36 (18%)	196
Change	-9	-1	+18 (8%)	8



Figure 2. Trans-Canada Highway KM63.9 Unnamed culvert before and after photos.



Figure 3. Trans-Canada Highway KM81.4 Bath Creek culvert before and after photos.

Condition and Trend

Condition: Poor (36/196 or 19% of road stream crossings can pass all life stages and species of fish year round).
Trend: Stable with slight improvement (the rating has improved from 12% to 19%)

Assessment Confidence

The protocol is complete and our confidence in the evaluation is high.

Discussion

Banff National Park has an extensive road network and thus, a very large number of road stream crossings. It is encouraging to see important improvements occurring over time, as each investment not only improves ecological integrity, by restoring connectivity and natural processes, but also reduces ongoing costs and associated impacts of emergency maintenance while ensuring the viability of critical infrastructure.

The proximity of the highway to the rivers and creeks means that natural fluvial movements of the watercourses (meandering) cannot occur without bank erosion and risk to infrastructure. This can be further exacerbated during extreme events such as the flooding that occurred in 2012 and 2013. Emergency flood measures included the use of heavy equipment to actively remove debris from stream channels and bridge abutments, as well as emergency bank armouring. Significant damage to road infrastructure occurred in locations where bridges and culverts spanned watercourses with active alluvial fans (e.g. Carrot Creek, Noyes Creek, Totem Creek). Many of these structures were not sized or located to handle the debris movements associated with the flooding because the importance of maintaining natural alluvial processes and reducing long term maintenance costs and impacts was not understood or valued by those designing these structures years ago.

With the twinning of the Trans-Canada Highway many structures have been upgraded; benefitting fish and other wildlife. Two recent examples include Taylor and Bath Creeks. Both of these creeks are significant tributaries to the Bow River. Prior to culvert replacements mountain whitefish (a species with limited jumping ability) was not found upstream of the barrier culverts. After the culverts were replaced or removed we captured whitefish in habitats from which they had been excluded for many decades. Current highway upgrading is putting a much higher emphasis on terrestrial and aquatic passage than did historic construction. We must undertake careful assessment and consideration before restoring connectivity, as some fish barriers are currently providing ecological benefit. For example, the culvert on Outlet creek isolates a rare – pure population of Westslope cutthroat trout from invasion by hybrid fish and non-native species and should not be restored until these non-native fish can be removed.

However, in addition to the road crossing assessed in this measure, Banff Park contains many other potential aquatic barriers that are not included in this assessment. The Canadian Pacific Railway mainline bisects BNP; running parallel to the TransCanada Highway and the Bow Valley Parkway. This creates situations where many tributary streams pass through multiple culverts, in series, before reaching the Bow River. Along much of the railway, ephemeral flows are diverted to run parallel to the railway embankment until reaching a culvert that allows passage under the railway. Such diversions on roads or rails increase exposure to pollution from hydrocarbons, herbicides and leakage of cargo (e.g. sulphur, potash, fly ash). Historical fire roads, long-abandoned, but now used as hiking trails in the backcountry of Banff, contain many unmaintained culvert crossings that may impede aquatic connectivity. Finally, BNP contains many man-made dams and reservoirs that affect aquatic connectivity and flow rates; these are discussed in a separate summary on Hydropower mitigations and monitoring.

Despite small improvements (≈8%) in the past decade, over 80% of the inventoried road stream crossings in Banff National Park remain a barrier to at least some species or some life history stages of fish. Many species such as mountain whitefish and spoonhead sculpin as well as smaller life-stages of fish, are not capable of jumping even the smallest barrier. Because the primary road and railway corridors are located low in the valley bottom, their entire length crosses exclusively fish bearing waters; affecting two species of fish of conservation concern – bull trout and westslope cutthroat trout.

Culvert maintenance and replacement is expensive and disruptive to traffic flow. We are now re-assessing most culverts for replacement with a larger span structures (bridge or box culvert) that meet full fish passage criteria and incorporate slack water and terrestrial passage for other riparian organisms such as amphibians, waterfowl, and small mammals that use this niche, (e.g. mink, Richardson's water vole). In addition to providing connectivity for fish and wildlife structures should be sized to ensure passage of debris and extreme flows in an effort to reduce ongoing emergency work and in support of the maintenance of natural processes

The culverts at Totem Creek, Louise Creek and Rampart Creek are excellent candidates for full replacement. The geometry of Louise Creek would lend itself well to a bridge or a large culvert designed to pass debris and provide dry terrestrial passage for wildlife.

A key success for aquatic connectivity, in the past decade, is the partial removal of the 40 Mile Dam which historically prevented bull trout and other fish from accessing over 35 km of spawning habitat in the upper portion of this drainage. Please see the 40 Mile Dam removal project under Management Effectiveness Monitoring, for more details.

Acknowledgements/Partners

The Highway Service Center should be acknowledged for their contributions to the restoration efforts to date. An EI Innovation grant to HSC funded the original inventory of the road stream crossings. From 2009 to 2014 they also managed the Action on the Ground fund. Fisheries and Oceans Canada also provided us excellent engineering support and advice.

Contact

Shelley Humphries, Aquatic Ecologist
Lake Louise, Yoho and Kootenay Field Unit
P: (250) 347-6159
E: shelley.humphries@pc.gc.ca

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CONDITION AND TREND (UNRATED)

NR

Freshwater Measure: Amphibian Occupancy

Introduction



Figure 1. Columbia spotted frog on emergent vegetation at Johnson Lake in Banff National Park. Photo: W. Hunt.

Parks Canada surveys the presence of native amphibian species at breeding sites throughout the montane ecoregion of Banff National Park as part of a mountain park-wide amphibian condition monitoring program. The state of amphibian populations will help inform the assessment of the health of Freshwater ecosystems in the park. Amphibians are considered important indicators of environmental health and ecosystem change. They are vulnerable to an array of environmental changes because of their permeable skin, complex life history, and a dependence on moist terrestrial or wetland habitats. These attributes make them sensitive indicators of ecological health, and appropriate subjects for monitoring programs looking at changes to ecosystem condition over time (Blaustein and Bancroft, 2007).

In addition to being a measure for the Freshwater indicator, by monitoring changes in amphibian occupancy and key covariates, we will gain insight towards threat mitigations, inform future planning and support environmental assessments related to various development or human use projects.

Parks Canada and the Bow Valley Naturalists have undertaken amphibian monitoring in Banff Park, intermittently, over the past several decades. Studies from the 1990's-early 2000, performed by staff and volunteers, surveyed for the distribution and abundance of amphibians at various sites throughout the park (Banff National Park, 2007). This work led to a focussed monitoring program that began in 2004 to evaluate the effects of prescribed burns and fire breaks on amphibian abundance and distribution in the Fairholme Range (Banff National Park, 2007). However, this work ended prematurely; resulting in about a 9 year gap in amphibian monitoring in Banff Park. To contribute to the mountain park amphibian monitoring initiative (underway in Yoho, Kootenay and Jasper), we renewed our efforts in Banff starting in 2016, and for consistency, we adopted the existing monitoring protocols. By integrating this effort into the formal Parks Canada condition monitoring program, we hope to collect these data in a consistent manner to provide a long-term ecological data set for Banff National Park.

We monitored four amphibian species: long-toed salamander (*Ambystoma macrodactylum*), western toad (*Anaxyrus boreas*), Columbia spotted frog (*Rana luteiventris*) (Figure 1), and wood frog (*Rana sylvatica*). The western toad is currently designated by SARA as a species of "Special Concern" and is therefore a priority for Parks Canada's ecological integrity monitoring program. There have also been two recognized sub-species of the western toad: a) Boreal Toad (*Anaxyrus boreas boreas),* which is found in British Columbia and Alberta, and b) California Toad (*Anaxyrus boreas halophilus)* which is found only in the United States. You will therefore notice that data presented throughout this report refers to the Boreal Toad.

This year (2017) represents the second year of amphibian occupancy monitoring for BNP.

Monitoring Question

How many amphibian species are declining in occupancy by ≥30% or ≥50% over 10 years in the montane ecoregion of Banff National Park?

Metric

Number of species declining in occupancy by ≥30% or ≥50% over 10 years.

Thresholds

GOOD	No species are declining by ≥30% over 10 years.
FAIR	One of four species is declining by ≥30% over 10 years.
POOR	Two of four species are declining by ≥30% or one species is declining by ≥50% over 10 years.

We used thresholds derived from the International Union for Conservation of Nature (IUCN) criteria at which species' global populations are listed for *vulnerable* (≥30% population decline over 10 years) or *endangered* (≥50% population decline over 10 years) (IUCN 2017).

To assess thresholds when monitoring was less than 10 years we used the following formula to calculate annual threshold changes (*Y*) (C. Schwartz, pers. comm.):

$$Y = (1 + X)^{1/(Z-1)} - 1$$

where *X*=proportion of threshold change over 10 years monitoring (e.g. 0.5 inserted for 50%) and *Z*=number of years of monitoring data. The resulting conversions for BNP:

1. 30% decline/10 yrs = 3.0% decline annually
2. 50% decline/10 yrs = 4.6% decline annually

Methods

Field Methods

We surveyed to determine the presence or absence of four native amphibian species in wetlands throughout the eastern section of Banff National Park, and recorded specific covariates that may be used to assess changes in environmental conditions and amphibian populations.

We performed auditory and visual surveys of 60 pre-determined breeding s ites (Figure 2) within the eastern section of Banff National Park, primarily in the Bow River valley from Castle Junction to the east park gates and within a 2 km distance of roads. Breeding sites included ponds, pools, wet meadows or other wetland features that are capable of hosting breeding amphibians. We surveyed each site twice during a sampling period between mid-April and the end of May in 2016 and 2017. We conducted auditory surveys by recording amphibian calls at the edge of each site for a 5-minute period prior to the visual survey. We conducted visual surveys for one hour with two observers in order to standardize survey effort across sites. We assessed the presence of amphibian adults, eggs (Figure 3), tadpoles, and juveniles in visual surveys.

In order to mitigate the potential for transmission of aquatic invasive species we decontaminated all gear and outerwear between sampling sites in accordance with the Decontamination Protocol for Parks Canada Fisheries and Aquatics Technicians, May 2017.

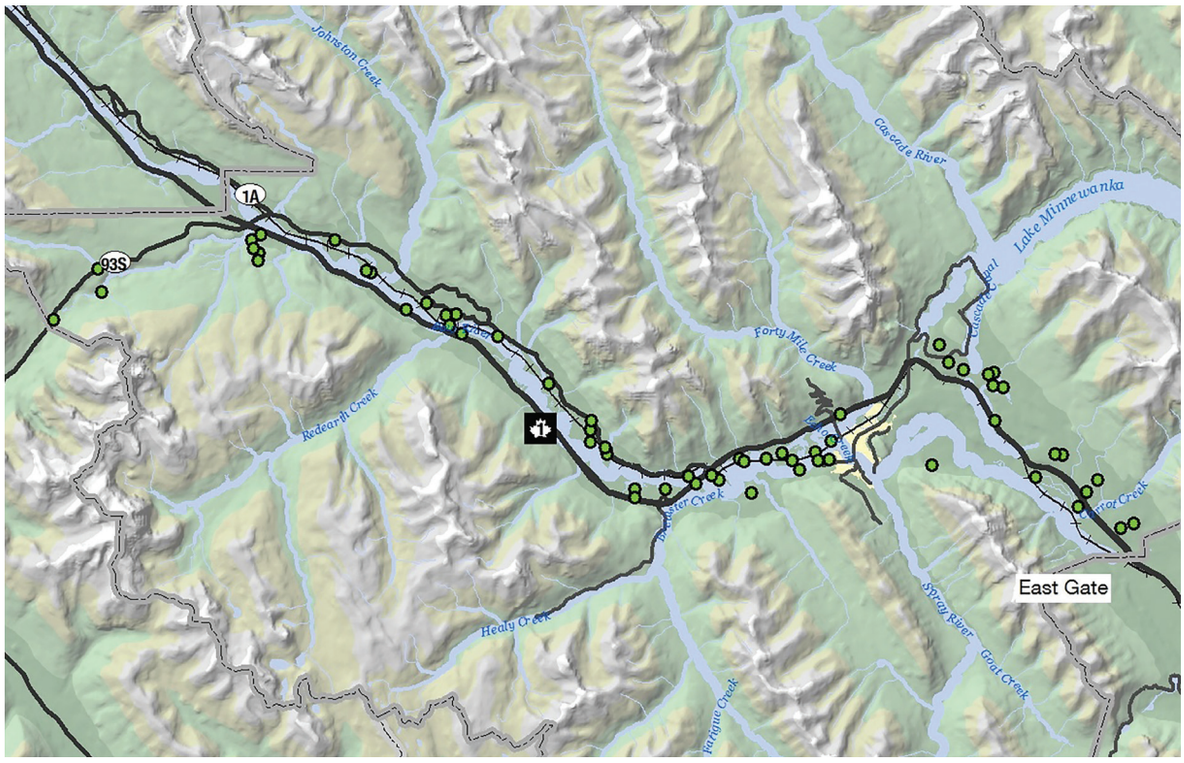


Figure 2. Map showing the 60 amphibian monitoring sites in Banff National Park.

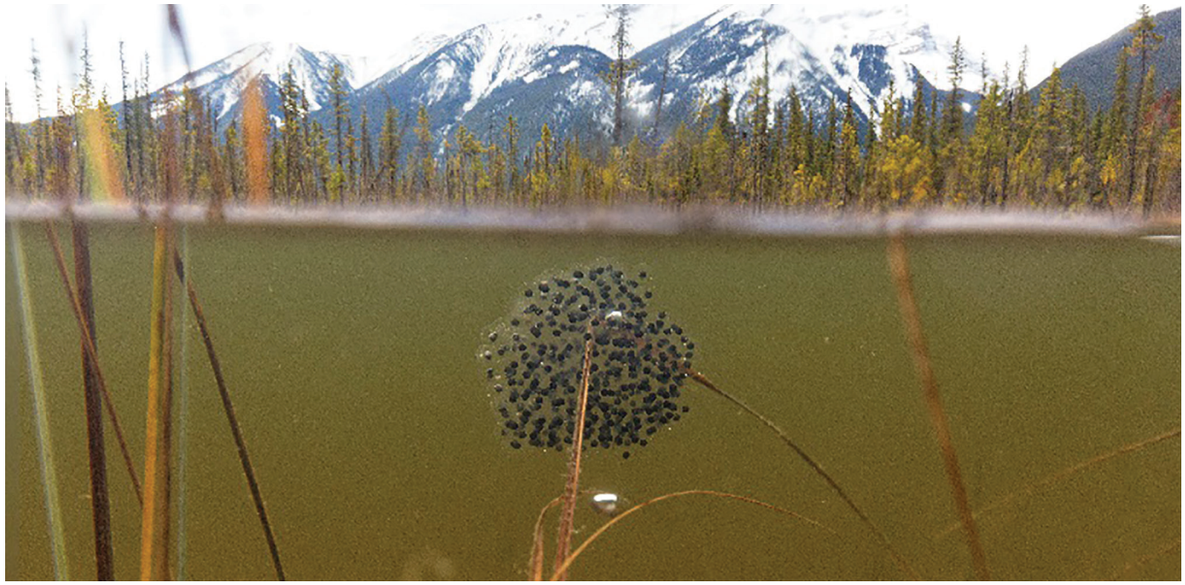


Figure 3. Wood frog egg mass on submerged vegetation. Photo: A. Baus, 2017.

Statistical methods

We analyzed our data using the occupancy modelling program PRESENCE 12.7 developed by the USGS (Hines, J. E, 2006). For each species we ran multi-season models that allowed detectability to vary across all years, individual years and surveys. We did not have sufficient years of data to model colonization (gamma) or extinction (eps). For each species, we selected the best fit model based on the lowest Akaike Information Criterion (AIC) value. From this model, we estimated the probability of occupancy (Ψ) for each species along with the associated standard error and 95% confidence intervals.

We calculated the rate of change over time using the modelled parameter lambda, which represents the ratio of successive occupancy estimates between two surveys. For example a lambda value greater than 1 represents an increase in occupancy over time, while a lambda less than 1 indicates a decline in occupancy.

As we currently have data for only two years, (which represents one change in time) we cannot estimate a trend, based on the above noted thresholds, but our estimate of change will improve over time.

Results

We found the best fit models for all species assumed a constant rate of colonization (gamma), extinction (eps), and detectability (p) over time except for the Wood Frog for which the best fit model included detectability varying by survey (Table 1). The probability of occurrence (Ψ) was lowest for the Colombian Spotted Frog (0.2614) and highest for the Wood Frog (0.6533).

Three of four species recorded lower Ψ values in 2017 than in 2016, however, large confidence intervals were inclusive of both Ψ values. Therefore, the changes observed are not significant (Table 1, Figure 4).

Table 1. Best fit occupancy models for four amphibian species in BNP with predicted occupancy Ψ and Lambda (Lam) the annual rate of change with associated standard error (SE) and 95% confidence intervals.

Species	Model	Year	Ψ	Ψ SE	Ψ Lower 95%	Ψ Upper 95%	Lam	Lam SE	Lam Lower 95%	Lam Upper 95%
Boreal Toad	psi, gamma(), eps(), p()	2016	0.421	0.087	0.250	0.591	0.693	0.1446	0.410	0.976
		2017	0.292	0.074	0.147	0.437				
Columbia Spotted Frog	psi, gamma(), eps(), p()	2016	0.298	0.143	0.019	0.577	0.877	0.3439	0.203	1.552
		2017	0.261	0.129	0.009	0.514				
Long-toed Salamander	psi, gamma(), eps(), p()	2016	0.540	0.112	0.321	0.759	0.686	0.1645	0.363	1.008
		2017	0.371	0.092	0.190	0.551				
Wood Frog	psi, gamma(), eps(), p(survey)	2016	0.633	0.068	0.500	0.765	1.032	0.1014	0.834	1.231
		2017	0.653	0.074	0.508	0.799				

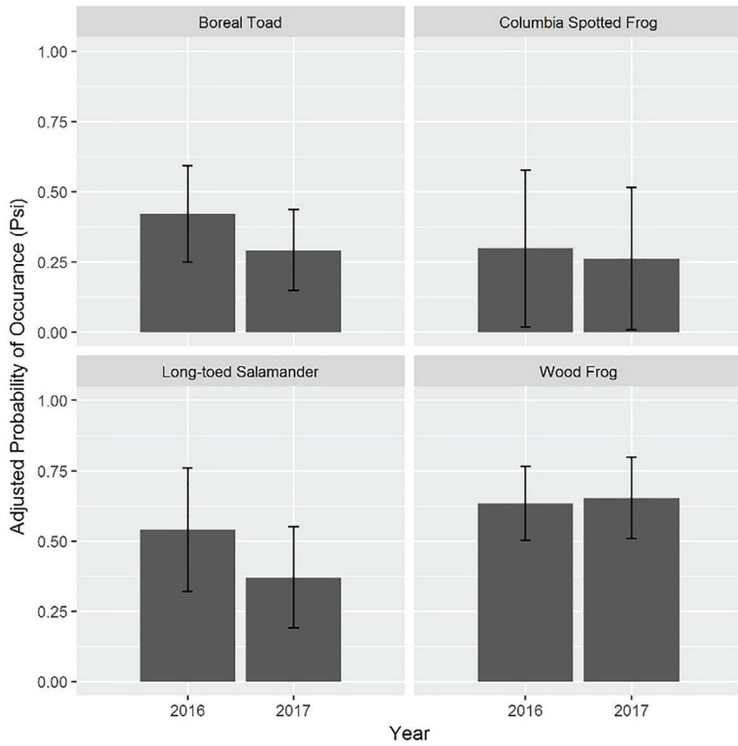


Figure 4. Probability of occupancy Ψ for the four species of amphibians in 60 wetland sites in Banff National Park. Error bars represent 95% confidence interval.

We observed that the annual rate of change (lambda) was below the 5% threshold in 3 of 4 species (Figure 5), suggesting a decline of greater than 5% per year. However, the wide range of confidence intervals suggests the trend could also be increasing and the trend results are highly uncertain. These wide ranges of uncertainty are due to the limited data set available (2 years) and will improve with more years of data. On-going data collection will enable us to refine the uncertainty of these estimates and provide more precise trend measures.

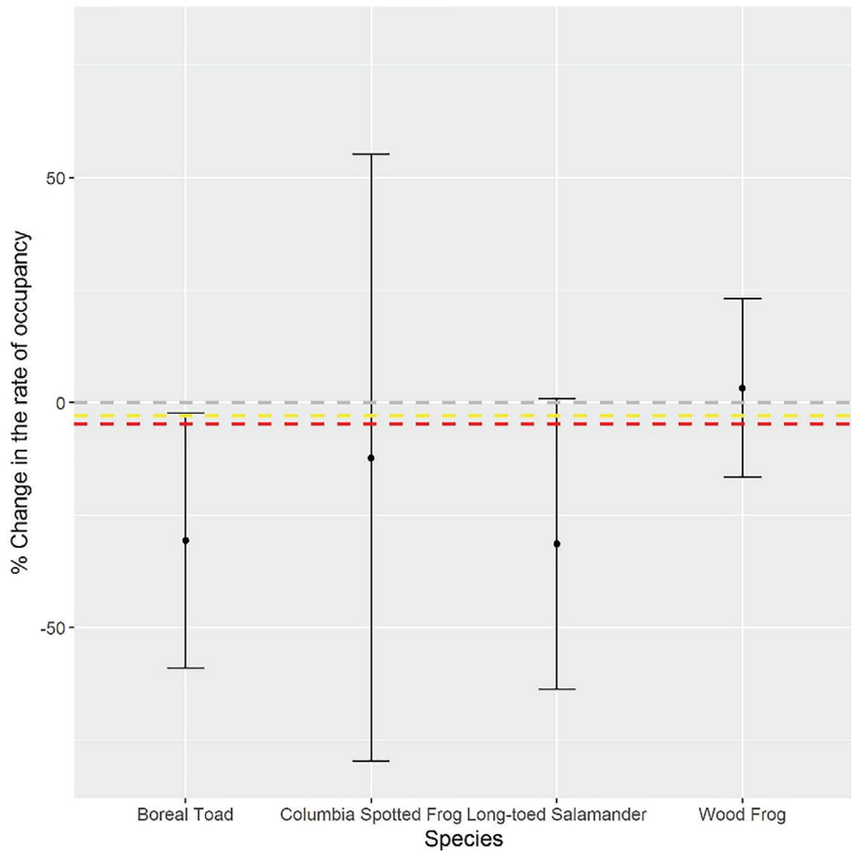


Figure 5. The rate of change (%) in occupancy for four amphibian species in Banff National Park (2016-2017). Error bars represent the 95% confidence interval of the rate of change.

Condition and Trend

Not Rated.

We initiated the amphibian monitoring program in BNP just two years ago. Because of the high levels of uncertainty (large 95% CI ranges) from low sample sizes (2) it is not appropriate to provide a condition and trend rating. Once we obtain more sampling data, uncertainty levels will likely decrease, allowing us to more clearly assess and report on amphibian population condition and trend.

Assessment Confidence

We have successfully applied the mountain park amphibian monitoring protocols to complete both fieldwork and statistical methods for amphibian monitoring in Banff National Park however, we are unable to provide a condition rating or trend at this time because we only have 2 years of data.

Discussion

Since our results are preliminary and represent only the second year of monitoring data, the long-term monitoring of amphibian occupancy in future years will provide for a more rigorous analysis of the condition/trend for our amphibian measure in Banff National Park. Once further years of monitoring are complete, we will assess condition and trends using linear models similar to that which was performed for Kootenay and Yoho National Parks (which each have 4 monitoring seasons over an 8 year sampling period).

We will also explore the effects of survey specific, site level, and landscape scale covariates on amphibian occupancy changes. Preliminary analysis of covariate data in Kootenay National Park found that fish presence, water temperature and air temperature may be important factors in determining amphibian occupancy and detection (Stafl 2012). In similar studies outside the mountain national parks, researchers found that herb, floating vegetation, and submerged vegetation cover were important in explaining the probability of frog occurrence at monitored ponds (Mazerolle et al. 2004); and vegetation complexity and cover by shrubs and persistent non-woody vegetation were associated with larger egg mass pond deposition (Egan et al. 2004). Landscape scale covariates to consider include wetland site connectivity, proximity of nearby wetlands, and the type and amount of forest cover adjacent to wetland areas, which were attributes within top ranked amphibian models (Gould et al. 2012, Scherer et al. 2012, and Mazerolle et al. 2004).

In Banff National Park, we are currently collecting pH, conductivity, and climate data along with amphibian presence and we may consider assessing other covariates based on the above literature. These data will allow us to assess potentially important attributes associated with changes in amphibian occupancy and may provide more insight into the drivers of amphibian occupancy. Furthermore, a thorough understanding of amphibian occupancy will assist managers in developing appropriate management plans to ensure the ecological integrity of wetland ecosystems in Banff National Park.

Acknowledgements/Partners

Thank you to Parks Canada citizen scientists, public volunteers and the Alberta Conservation Association for their assistance and support with field surveys during the 2016 monitoring season and the 2017 Banff Bioblitz.

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Freshwater Measure: Lake Fish Index

Introduction

Lakes are a significant aquatic feature across the mountain parks. Prior to anthropogenic stocking, many lakes were fishless or had low diversity fish assemblages typical of the Rocky Mountains. Historic stocking practices altered aquatic communities. In many locations, the presence of non-native fish have put native fish populations in jeopardy. In addition, the stocking of fishless lakes has impacted zooplankton, amphibians and possibly avian distribution. Following changes in national policy, Parks Canada ceased all fish stocking in BNP in the 1980's, and since that time we have only, rarely, stocked native species as part of species-at-risk conservation efforts (e.g. Rainbow Lake project).

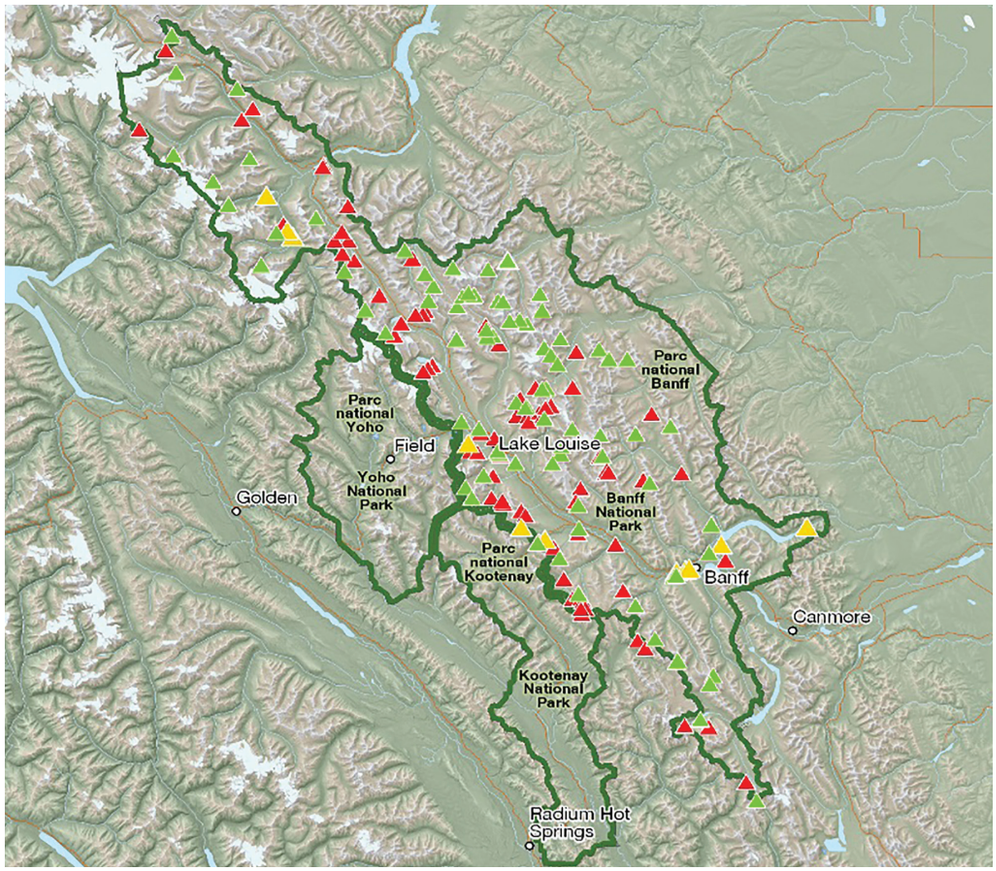


Figure 1. Map of lakes rated according to the Lake Fish Index protocol in Banff National Park. Color of icons correspond to score of lake as described over the page.

We are using this index as a measure to assess and report on the magnitude of stocking impacts and help quantify the effectiveness and persistence of fish restoration efforts. We developed this measure to provide a simple way to describe deviations of current lake fish diversity from historic diversity. This index addresses the question of how similar or different current lake fish communities are compared to historic lake fish communities prior to fish stocking. This measure can be used to report on fish restoration activities and negative changes such as non-native fish invasion or illegal stocking.

Monitoring Question

How similar or different current lake fish communities are compared to historic lake fish communities prior to fish stocking?

Metric

The metric for this measure is fish species presence/absence, and the score is based on the present day fish community compared to the historic fish community. Each lake is scored as follows:

RED: This is the score for a lake that has non-native (introduced or exotic) species of fish, or for a lake that has native fish introduced outside their historic watershed. If the lake currently has a mixture of native and non-native fish it can also be scored red particularly if the mix of non-native fish has extirpated a native fish – or if there is reasonable expectation that this will occur within the next decade. Genetic interactions of the species was also considered.

YELLOW: This is the score for a lake that historically contained native fish, and still continues to contain fish, but may now also include non-native fish. Yellow is used if the status of the native fish is currently stable and likely to remain so for the next decade.

GREEN: This is the score for a historically fishless lake that is currently fishless. This is also the score for a historic fish bearing lake that currently contains only the historic native fish assemblage.

Thresholds

For the final evaluation the number of 'good' (GREEN) lakes were expressed as a percentage of the total number of lakes evaluated (GREEN, YELLOW and RED). The overall measure evaluation is as follows:

GOOD	> 70% of lakes are in 'good' condition
FAIR	Between 70% and 50% of lakes are in 'good' condition
POOR	< 50% of lakes are in 'good' condition

These thresholds align with COSEWIC decline rates:
Reduction in 50% over 10 years or 3 generations (up to 100 yrs) (IUCN Endangered).
Reduction by 30% over 10 years or 3 generations (up to 100 yrs) (IUCN Vulnerable).

Methods

We developed this measure primarily from an extensive data mining exercise of historic documents and the stocking records. Ward (1974) was a key document as were more recent sampling reports. In instances where there was insufficient or conflicting information, we gathered new data by electrofishing and test netting.

We evaluated all lakes larger than 6 hectares. Lakes smaller than 6 hectares were only evaluated if they were included in the stocking records or from any other high quality reports available. Fish populations were scored for two time periods, historic and current. All fish species were considered in this analysis.

Native fish species for BNP include: westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), bull trout (*Salvelinus confluentus*), mountain whitefish (*Prosopium williamsoni*), lake trout (*Salvelinus namaycush*), burbot (*Lota lota*), white sucker (*Catostomus commersonii*), longnose sucker (*Catostomus catostomus*), mountain sucker (*Catostomus platyrhynchus*), longnose dace (*Rhinichthys cataractae*) and sculpin species (*Cottus spp.*).

Non-native fish that were stocked in BNP include: brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri)*, brown trout (*Salmo trutta*), arctic char (*Salvelinus alpinus*), cisco (*Coregonus artedi*), Atlantic salmon (*Salmo salar*), golden trout (*Oncorhynchus mykiss aguabonita*), smallmouth bass (*Micropterus dolomieu*) and splake (lake trout x brook trout).

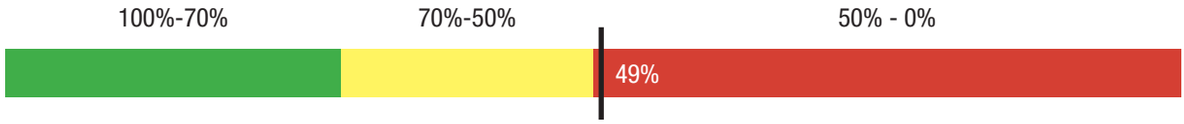
Where the stocking records do not indicate which subspecies of cutthroat trout was stocked in a lake, or where present day genetics of cutthroat trout are unknown, we made no distinction and the species is referred to by the four letter code CTTR.

Results

Condition and Trend

Condition: Poor
Trend: Stable with some improvements

Of the 170 waterbodies we evaluated, 83 are in good condition; meaning their historic condition and the current condition are the same (Appendix A). The overall rating for the Lake Fish Index is “poor”, with only 83 of 170 lakes (49%) in good condition. Twenty-nine waterbodies that were historically stocked with non-native fish have naturally reverted to their historic fishless state (Appendix A).



In an effort to continue to improve the status of lakes in BNP, we have mechanically removed two populations of non-native fish (Devon Lake Project and Rainbow Lake Project) by netting, electrofishing and excluding fish from key spawning habitat. Although these two projects were a tremendous success and allowed us to meet ecological restoration "targets" identified in the Park Management Plan, we are a long way from reaching ecological thresholds needed to improve the overall condition rating from poor to fair.

Assessment Confidence

The protocol for this measure has been completed. Confidence in the protocol is high.

Where we lacked recent sampling data, we deferred to stocking records, angler reports, and habitat availability. For example, if a lake was in the stocking records but has no recent sampling data, we assumed that the stocked population of non-native fish persists.

Discussion

The current condition of the Lake Fish Occupancy in Banff National Park is a direct result of historic stocking of non-native fish including, but not limited to, brook trout, rainbow trout, and lake trout. We now know that these non-native fish competitively exclude displace, and hybridize with native fish. These interactions are key threats to native fish populations including westslope cutthroat trout and bull trout. With over 50% of freshwater lakes containing non-native fish species, this is one of the most significant impairments to ecological integrity in Banff National Park. The effects of these non-native fish populations extend throughout the food web impacting invertebrate, amphibian, waterfowl and potentially even songbird communities.

We consider the condition trend to be stable, but optimistically acknowledge that it is improving slightly because some stocked lakes have reverted back to fishless conditions and a handful of removal efforts are completed or underway (Appendix A). However, the impact of non-native fish populations in the headwater lakes of the Bow and North Saskatchewan rivers continues to have negative implications for downstream populations of native fish. Fifty-one of the historically fishless lakes in Banff National Park are now headwater sources of non-native fish in the Bow and North Saskatchewan River watersheds.

Over the past 10 years, we have successfully removed non-native fish populations from Devon and Rainbow Lakes. Both of these projects directly assisted threatened native fishes by preventing downstream movement of these fish into critical habitat. The success of these projects has initiated additional removal strategies in Hidden Lake, Johnson Lake reservoir, and Badger Lake to protect vulnerable populations of westslope cutthroat trout. Additional lakes may be considered for non-native fish removal.

Acknowledgements/Partners

Parks Canada, Fisheries and Oceans Canada, University of Alberta, University of British Columbia, Alberta Conservation Association

Contact

Shelley Humphries, Aquatic Ecologist
Lake Louise, Yoho, and Kootenay Field Unit
P: (250) 343-6108
E: *shelley.humphries@pc.gc.ca*

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Appendix A Evaluation results for individual water bodies in Banff National Park

Common Name	Historic Condition	Stocking Records	Present Condition	Rating
Alexandra Pond	Unknown	SPLK	SPLK[1]	
Alice Lake	Fishless	RNTR	Fishless	4
Allenby Lake	Fishless	RNTR	Fishless	4
Altrude (1)	Fishless	WSCT	Fishless	4
Altrude (2)	Fishless	WSCT	WSCT	
Altrude (3)	Fishless	WSCT	Fishless	4
Annette Lake	Fishless	CTTR, RNTR	Fishless	4
Arnica	Fishless	WSCT	WSCT	
Badger	Fishless	BKTR	BKTR	
Baker Lake	Fishless	BKTR, CTTR	BKTR	
Beau Lake	Fishless	BKTR, RNTR	Fishless	4
Belgium	Fishless	CTTR	Fishless	4
Bighorn	Fishless	BKTR	Fishless	5
Black Rock	Fishless	CTTR	CTTR	
Block (1)	Fishless	WSCT, ARCH	WSCT, ARCH	
Block (2)	Fishless	WSCT, ARCH	WSCT, ARCH	
Block (3)	Fishless	WSCT	WSCT	
Boom	WSCT, MNWH, BLTR	CTTR, RNTR	WSCT	
Boulder	Fishless	CTTR	Fishless	4
Bourgeau	Fishless	BKTR	BKTR	
Bow Lake	BLTR, WSCT, MNWH	CTTR, RNTR, LKTR	BLTR, CTTR, LKTR, MNWH, RNTR	
Brachiopod	Fishless	CTTR, BKTR	Fishless	4
Caldron Lake	Fishless	No Records	Fishless[1]	
Capricorn Lake	Fishless[1]	No Records	Fishless[1]	
Cascade Pond	Fishless	RNTR	Fishless	4
Castilleja Lake	Fishless	RNTR	BKTR	
Chephren Lake	Fishless	BKTR, CTTR, RNTR	BKTR	
Cirque Lake	Fishless	BKTR, RNTR	BKTR	
Citadel	Fishless	RNTR	RNTR	
Coleman Lake	Fishless[1]	No Records	Fishless[1]	

Common Name	Historic Condition	Stocking Records	Present Condition	Rating
Consolation Lakes	WSCT	BKTR, WSCT	BKTR, WSCT[3]	
Consolation Lakes	WSCT	BKTR, WSCT	BKTR, WSCT[3]	
Copper Lake	Fishless	CTTR, RNTR	Fishless	4
Cuthead Lake	BLTR	ATLS, CTTR	BLTR	
David Lake	Fishless	No Records	Fishless	
Devon Lakes	Fishless	BKTR, CTTR	Fishless	5
Dolomite (Upper)	Fishless	RNTR	RNTR[1]	
Douglas Lake	Fishless	BKTR, CTTR	BKTR, CTTR[1]	
Drummond Lake	Fishless	No Records	Fishless	
Egypt Lake	Fishless	CTTR, BKTR	CTTR,BKTR	
Eiffel Lake	Fishless	No Records	Fishless	
Epaulette Lake	Fishless[1]	No Records	Fishless[1]	
Fatigue	Fishless	RNTR	Fishless	4
Fish Lakes	WSCT	No Records	WSCT	
Fish Lakes #?	Fishless	BKTR	Fishless	4
Fish Lakes #2	WSCT	No Records	WSCT	
Flint Lake	Fishless	ARCH, CTTR	Fishless	4
Freshfield Lake	Fishless[1]	No Records	Fishless[1]	
Ghost Lake (3)	LKWH, MNWH, LNSC, WHSC, LKTR, WSCT, BLTR	CTTR, RNTR, BKTR	MNWH, LKTR, LNSC, WHSC, CISC	
Glacier Lake	BLTR[1], MNWH[1]	LKTR	BLTR, CTTR, MNWH, LKTR	
Gloria Lake	Fishless	WSCT	WSCT	
Goat Lake	Fishless	No Records	Fishless	
Goat's Eye	Fishless	RNTR	Fishless	4
Grouse Lake	Fishless	BKTR	Fishless	4
Haiduk Lake	Fishless	YSCT	YSCT	
Hector Lake	BLTR, WSCT, MNWH	BKTR, CTTR, LKTR, RNTR, SPLK	BKTR, BLTR CTTR (N&I), LKTR, MNWH	
Helen Lake	Fishless	BKTR, RNTR	BKTR	
Herbert Lake	Fishless	BKTR, CTTR, LNSC, RNTR, MNWH, SPLK	Fishless	4
Hidden Lake	Fishless	CTTR	BKTR	
Howard Douglas	Fishless	BKTR	BKTR	
Isabella Lake	Fishless	RNTR	RNTR	

Common Name	Historic Condition	Stocking Records	Present Condition	Rating
Island Lake	Fishless	BKTR, CTTR, RNTR	Fishless	4
Johnson Lake	WHSC	RNTR, BKTR, CTTR	BKTR, WHSC, RNTR, BNTR	
Kingfisher Lake	Fishless	CTTR, RNTR	Fishless	4
Kingfisher Pond	Fishless	BKTR, RNTR	Fishless	4
Lagoon Lake	BLTR[1], MNWH[1]	RNTR	BKTR, MNWH	
Lake Agnes	Fishless	SPLK	BKTR, SPLK	
Lake Katherine	Fishless	YSCT	YSCT	
Lake Louise	BLTR, LKTR, MNWH, WSCT	BKTR, CTTR, MATR, RNTR, SPLK	LKTR, MNWH	
Lake Margaret	WSCT	BKTR, YSCT	BKTR, WSCT[3]	
Lake Merlin	Fishless	BKTR, RNTR	Fishless	4
Leman Lake	Fishless	YSCT	YSCT	
Little Baker Lake	Fishless	BKTR	BKTR[1]	
Little Herbert Lake	Fishless	BKTR, CTTR, RNTR	RNTR	
Lost Lake	Fishless	BKTR, CTTR	Fishless	4
Luellen Lake	Fishless	YSCT	YSCT	
Martin Lake	LKTR	BKTR	LKTR, BKTR	
Martin Creek Lake (Lower)	Fishless	No Records	Fishless	
Martin Creek Lake (Upper)	Fishless	No Records	Fishless	
Marvel Lake	WSCT	WSCT	WSCT	
Mary Lake	Fishless	BKTR, CTTR	BKTR[1], CTTR[1]	
McNair Pond	Unknown	BKTR, CTTR, RNTR	BKTR	
Minewakun Lake	Fishless	BKTR	BKTR[1]	
Minnewanka Lake	LKWH, MNWH, LNSC, WHSC, LKTR, WSCT, BLTR	LKTR, CISC, ATLS, BKTR, RNTR, CTTR, LKWH, SPLK	LKTR, CISC, BKTR, CTTR, LKWH, BNTR, BLTR	
Mistaya Lake	Fishless	CTTR	CTTR[1],[2]	
Moose Lake	Fishless	BKTR	WSCT	
Moraine Lake	BLTR, WSCT	BKTR, CTTR, RNTR, SPLK	BKTR, CTTR (hybrids)	
Mud Lake	LNDC	BKTR, CTTR, RNTR	BKTR, CTTR, LNDC, RNTR	
Mummy Lake	Fishless	YSCT	YSCT	
Myosotis Lake	Fishless	BKTR, RNTR	Fishless	4
Norman Lake	Fishless	BKTR	BKTR[1]	

Common Name	Historic Condition	Stocking Records	Present Condition	Rating
O'Brien Lake	Fishless	CTTR hybrids	CTTR hybrids	
Outram Lake	BLTR, MNWH	LKTR, RNTR, BKTR	BKTR, LKTR, SUCK	
Owl Lake	Fishless	BKTR	BKTR	
Oyster Lake	Fishless	BKTR	BKTR[1]	
Peyto Lake	Fishless	YSCT	BKTR[1], YSCT[1]	
Pharoah Lake	Fishless	WSCT	WSCT	
Pilot Pond	Fishless	CTTR, RNTR, BKTR	BKTR	
Pipestone/Deer Lake	Fishless	RNTR, WSCT	WSCT	
Pipit	Fishless	RNTR	Fishless	4
Ptarmigan Lake	Fishless	BKTR, CTTR	BKTR	
Rainbow	Fishless	RNTR, WSCT	WSCT	5
Rainy Bay	Fishless	No Records	Fishless	
Red Deer Lake/Hatchet	Fishless	RNTR	Fishless	4
Red Deer Lakes	BLTR, MNWH, WSCT	BKTR, CTTR, RNTR	BKTR	
Redoubt Lake	Fishless	BKTR, CTTR	BKTR	
Rockbound	Fishless	RNTR, CTTR, SPLK	BKTR	
Scarab	Fishless	YSCT	YSCT	
Shadow	Fishless	CTTR, BKTR, RNTR	BKTR, CTTR[1], RNTR[1]	
Skeleton	Fishless	RNTR, BKTR	RNTR, BKTR	
Smith	Fishless	WSCT	WSCT	
Snowflake	Fishless	CTTR, BKTR	Fishless	4
Sphinx	Fishless	CTTR	Fishless	4
Stenton Pond	Fishless	RNTR, BKTR	Fishless	4
Stoney Creek Pond	Fishless	RNTR, BKTR	BKTR	
Sunwapta (Boundary)	Fishless	BKTR, CTTR[2], SPLK	BKTR[1], CTTR[1], SPLK[1]	
Taylor Lake	Fishless	YSCT	YSCT	
Temple Lake	Fishless	BKTR, RNTR	BKTR, RNTR	
Tilted Lake	Fishless	BKTR, CTTR	BKTR[1], CTTR[1]	
Totem Lake	Fishless	RNTR	RNTR[1]	
Tower	Fishless	SPLK	Fishless	
Turquoise Lake	Fishless	SPLK	SPLK	
Twin (Lower)	WSCT	WSCT	WSCT	
Twin (Upper)	WSCT	WSCT	WSCT	

Common Name	Historic Condition	Stocking Records	Present Condition	Rating
Two Jack	LKWH, MNWH, LNSC, WHSC, LKTR, WSCT, BLTR	CTTR, RNTR, BKTR, SPLK, LKWH	MNWH, LKTR, WHSC, LNSC	
unidentified - 159	Fishless	No Records	Fishless	
unidentified - 163	Fishless	No Records	Fishless	
unidentified - 320	Fishless	No Records	Fishless	
unidentified - 433	Fishless[1]	No Records	Fishless[1]	
unidentified - 434	Fishless[1]	No Records	Fishless	
unidentified - B14	Fishless	No Records	Fishless	
unidentified - B156	Fishless	No Records	Fishless	
unidentified - B193	Fishless	No Records	Fishless	
unidentified - B333	Fishless	No Records	Fishless	
unidentified - B337	Fishless[1]	No Records	Fishless	
unidentified - B490	Fishless[1]	No Records	Fishless	
unidentified - B513	BLTR[1], MNWH[1]	No Records	BKTR, BLTR, LKTR, LNSC	
unidentified - B611	Fishless	No Records	Fishless	
unidentified - B614	Fishless	No Records	Fishless	
unidentified - B665	Fishless[1]	No Records	Fishless[1]	
unidentified - B671	Fishless[1]	No Records	Fishless[1]	
unidentified - B685	Fishless[1]	No Records	Fishless	
unidentified - B80	Fishless	No Records	Fishless	
unidentified - B89	Fishless	No Records	Fishless	
Unnamed-23	Fishless	No Records	Fishless	
Unnamed-24	Fishless	No Records	Fishless	
Unnamed-257	Fishless	No Records	Fishless	
Unnamed-259	Fishless	No Records	Fishless	
Unnamed-323	Fishless	No Records	Fishless	
Unnamed-327	Fishless	No Records	Fishless	
Unnamed-330	Fishless	No Records	Fishless	
Unnamed-335	Fishless	No Records	Fishless	
Unnamed-347	Fishless	No Records	Fishless	
Unnamed-353	Fishless	No Records	Fishless	
Unnamed-355	Fishless	No Records	Fishless	
Unnamed-B233	Fishless	No Records	Fishless	
Unnamed-B281	Fishless	No Records	Fishless	

Common Name	Historic Condition	Stocking Records	Present Condition	Rating
Unnamed-B618	Fishless	No Records	Fishless	
Unnamed-B642	Fishless	No Records	Fishless	
Vermillion (1)	MNWH, WSCT, WHSC, BLTR, LNSC	CTTR, BKTR, SPLK, RNTR	BKTR, WHSC	
Vermillion (2)	MNWH, WSCT, WHSC, BLTR, LNSC	CTTR, BKTR, RNTR	BKTR, WHSC	
Vermillion (3)	MNWH, WSCT, WHSC, BLTR, LNSC	CTTR, BKTR, ARCH, SPLK, RNTR	BKTR, WHSC	
Vista	WSCT, BLTR, MNWH, WHSC	CTTR, BKTR	CTTR, BKTR, BLTR	
Warden Lake - lower	Unknown	BKTR	BKTR[1]	
Warden Lake - upper	Unknown	RNTR, BKTR, SPLK	BKTR[1], RNTR[1], SPLK[1]	
Watchman Lake	Fishless	CTTR[2]	CTTR	
Waterfowl (Lower)	Fishless	BKTR, CTTR[2], RNTR, CTTRxRNTR	BKTR, RNTR	
Waterfowl (Upper)	Fishless	BKTR, CTTR[2], RNTR, CTTRxRNTR	BKTR, RNTR	
Wigmore	Fishless	BKTR, RNTR	BKTR	
Zigadenus Lake	Fishless	RNTR	Fishless	4

ATLS = Atlantic Salmon; BKTR = Eastern Brook Trout; BLTR = Bull Trout; CISC = Cisco; CTTR = cutthroat trout; LKTR = Lake Trout; LKWH = Lake Whitefish; LNDC = Longnose Dace; LNSC = Longnose Sucker; MATR = Arctic Char; MNWH = Mountain Whitefish; RNTR = Rainbow Trout; SPLK = Lake Trout x Brook Trout Hybrid; SCUL = Sculpin sp.; WHSC = White Sucker; WSCT = Westslope Cutthroat Trout; YSCT = Yellowstone Cutthroat Trout

1 – Assumption best on best available information.

2 – Cutthroat trout species outside of their native range.

3 – Small population, not likely to survive without intervention.

4 – Historically fishless lakes that naturally reverted back to fishless condition.

5 – Non-native fish removed through active management.

Freshwater Measure: Water Quality (*water chemistry*)

Introduction



Figure 1. Bow River in Banff National Park.

Only 42% of Canada's freshwater is rated as having "good" or "excellent" water quality (ECCC 2017). Protected areas have the smallest land-use modifications and therefore maintain much of the cleanest water. The mountain national parks are expected to maintain a high standard for water quality as they contain the headwaters of major rivers upstream of most land use modifications. However, mountain protected areas are not without a footprint of transportation corridors, tourism, residential and commercial use, waste disposal, etc. Some pollutants can even originate from the atmosphere (e.g. Donald et al. 1999). Parks Canada has a responsibility to monitor the water quality of major rivers to determine long-term trends and detect patterns that may be improved with management.

Environment and Climate Change Canada (ECCC) and Parks Canada Agency (PCA) collaborate in a jointly funded water quality monitoring program begun in 1972 in Banff National Park (BNP; Block and Gummer 1976, Block et al. 1993; Glozier et al. 2004; Environment Canada 2015). This regional program, led by ECCC, is part of a larger national program serving to describe spatial and temporal patterns in water quality on many major rivers in Canada (Figure 1). Physical and chemical variables are measured regularly at monitoring sites located on major rivers. In addition to contributing to the national long-term monitoring program, Parks Canada uses the sites in each mountain national park as one of the long-term measures of ecological integrity (EI) of freshwater ecosystems. For the purpose of this report, we focused on water quality data from 2007 – 2017 (the reporting period for the State of the Parks Report) from two major rivers (North Saskatchewan and Bow) in BNP.

Monitoring Questions

1 How do physical and chemical water quality parameters in BNP compare to national water quality guidelines?

2 How do physical and chemical water quality parameters in BNP change over time?

Metric

The metric is the Canadian Council of Ministers (CCME) water quality index (CCME WQI) which is a unitless value between 0 and 100.

Thresholds

GOOD	CCME WQI value of >80
FAIR	CCME WQI value of <80
POOR	CCME WQI value of <45

The </> 80 threshold was developed by CCME based on a formula by the British Columbia Ministry of Environment, Lands and Parks and modified by Alberta Environment and Parks (CCME 2001).

Methods

We used data from 3 monitoring stations in BNP for this analysis: North Saskatchewan River at Whirlpool Point, Bow River upstream of Lake Louise, and Bow River upstream of Canmore (Figure 2). Sampling sites were chosen to be representative of the headwaters of the Bow and North Saskatchewan Rivers. Technicians collected samples monthly throughout the year and analysed a core group of parameters at all monitoring locations. These parameters can be subdivided into five groups: physicals, major ions, bacterial, nutrients and metals (Glozier et al. 2004). Water samples were sent to ECCC's national laboratories for environmental testing. All labs are accredited under the Canadian Association for Environmental Analytical Laboratories Inc.

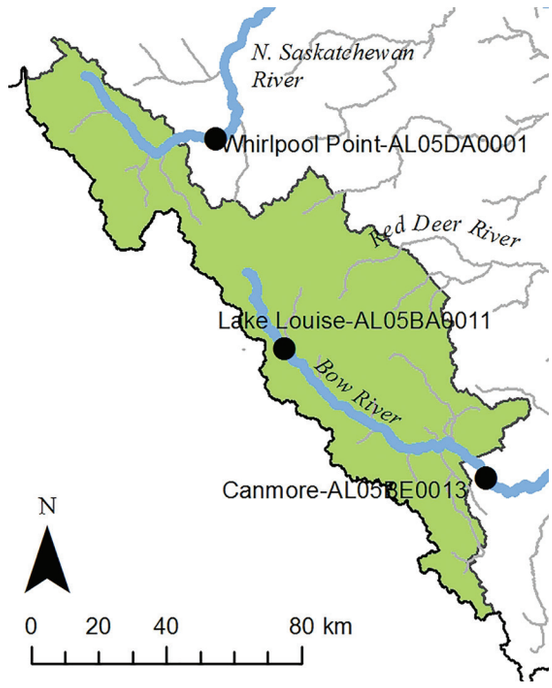


Figure 2. Water quality monitoring stations in Banff National Park.

The CCME WQI is a tool for the reporting water quality data (CCME 2001). The purpose of this index was to provide a convenient way to summarise complex water quality data and facilitate its communication to a general audience. The index assesses water quality relative to a desired state, as defined by Canadian Environmental Quality Guidelines, and provides insight into the degree to which water quality is affected by human activity (CCME 2001).

The CCME developed the Canadian Environmental Quality Guidelines to provide national environmental quality guidelines for all environmental medium, including water. Environmental quality guidelines are numerical values, narratives and equations or guidance frameworks for physical, chemical, radiological, or biological characteristics of water that, when exceeded, have the potential to cause adverse effects. Guidelines are preferentially derived from toxicity studies on sensitive aquatic organisms.

The index incorporates three elements:

1 **Scope:** the number of variables not complying with the guidelines relative to the total number of variables measured.

2 **Frequency:** the percentage of individual tests that do not meet objectives.

3 **Amplitude:** the amount by which observations exceed the corresponding guidelines.

Not all parameters analysed from these sites are used to calculate the index. Only some of these parameters have CCME guideline values. We based these results on the following parameters: ammonia, total arsenic, chloride, total copper, total lead, pH, total nitrogen, total phosphorus, total nickel and total zinc.

The results are combined to produce a single value between 0 and 100. The index is calculated based on a three-year rolling average to dampen temporal variability in WQI results caused by annual fluctuations in weather and hydrology (Environment Canada 2014, Government of Canada 2008). CCME WQI values were calculated for each year (as a 3-year rolling average) at each site. The final value for BNP is an average value for each site across years followed by a weighted average across sites. Change in the numerical value of the WQI should be considered in the context of confidence intervals. A decrease in WQI scores is only concerning if no overlap exists between confidence intervals of time period scores (Environment Canada 2014).

Results

Table 1. CCME WQI values for each year at three sites on the Bow River and North Saskatchewan River.

	Water Quality Index					
Period	North Saskatchewan River at Whirlpool Point AL05DA0001	Change	Bow River above Lake Louise AL05BA0011	Change	Bow River above Canmore AL05BE0013	Change
2007-2009	Good 88.4 (88.3 – 94.2)	–	Good 94.2 (94.2 – 100)	–	Good 94.2 (94.2 – 100)	–
2008-2010	Good 82.6 (81.9 – 94.2)	–	Good 94.2 (94.2 – 100)	–	Good 94.2 (94.2 – 100)	–
2009-2011	Good 82.6 (81.9 – 94.2)	–	Excellent 100 (100 – 100)	↑	Good 94.2 (94.2 – 100)	–
2010-2012	Good 82.5 (81.8 – 94.2)	–	Excellent 100 (100 – 100)	–	Good 94.2 (94.1 – 100)	–
2011-2013	Good 94.1 (93.8 - 94.2)	–	Excellent 100 (100 – 100)	–	Good 94.1 (93.5 – 94.2)	–
2012-2014	Good 94.1 (93.7 - 94.2)	–	Excellent 100 (100 – 100)	–	Good 82.6 (82.3 – 94.2)	–
2013-2015	Good 94.0 (93.6 - 94.2)	–	Excellent 100 (100 – 100)	–	Good 82.6 (82.4 – 94.2)	–
2014-2016	Good 93.3 (92.9 - 93.5)	–	Excellent 100 (100 – 100)	–	Good 80.7 (80.7 – 100)	–

For each 3-year period, the calculated WQI value, its confidence interval estimate, and assessed rating is presented, as well as an indicator of change from one period to the subsequent period, as follows: ↑ increase; ↓ decrease; – unchanged; ◊ undetermined.



Figure 3. Relationship between CCME WQI values and State of the Parks Measure scores.

Condition and Trend

Condition: Good
Trend: Stable
Individual station scores were: North Saskatchewan (89); Bow River above Lake Louise (98.5); and Bow River at Canmore (89).

Assessment Confidence

Assessment confidence is high, with final assessment up to 2016.

Discussion

Severe algal blooms in Lake Winnipeg, Lake Erie and Lake Simcoe have been occurring in recent years. As a result, there has been public concern about nutrient loading in major rivers in Canada (ECCC 2017). Water quality in BNP, at least in the North Saskatchewan and Bow Rivers, is high quality as it was rated "good" by the measure scoring. Although our sites have been sampled and tested since 1972, we focused on water quality data from 2007 – 2017 (the reporting period for the State of the Parks Report). However, longer trends also show a history of good water quality in BNP. Water quality improved in the Bow River following the upgrade at waste water treatment plants at Lake Louise and Banff, in the early 2000s (Bowman 2013).

Despite the "good" rating for these rivers, they have had excursions from the water quality guidelines. For example, 34 of 167 samples from the North Saskatchewan River exceeded the site objective for total phosphorus. During the same time period, there was only one exceedance of this kind detected at the Bow River in Lake Louise suggesting that the water in the upper Bow River is pristine. However, as there were 9 of 164 exceedances for total phosphorus in the Bow River upstream of Canmore, there is likely nutrient loading downstream of Lake Louise.

Typical of most surface waters, rivers in BNP receive higher sediment and nutrient loadings during spring runoff. Nitrogen is largely transported in dissolved forms and phosphorus is primarily transported in the particulate phase, with higher discharge carrying more of both dissolved and particulate substances (Horne and Goldman 1994). Rivers in BNP attain their peak flow from snowmelt and rainfall during June and July. Discharge diminishes thereafter with smaller peaks occurring only after heavy rainfall.

Total phosphorus is generally closely coupled to discharge because of particulate transport (Block and Gummer 1976). For example, in the North Saskatchewan River, total phosphorus ranged from undetectable to 0.22 mg/L. This maximum value for total phosphorus was recorded during peak discharge in June 2010. The maximum value for total phosphorus in the Bow River during the monitoring period occurred four days after the highest discharge event for the monitoring period (2003-2016). Trace metals such as arsenic and zinc can also correlate well with discharge due to weathering and transport by overland flow (Block and Gummer 1976).

Climate change may be expected to increase river "flashiness" as the result of rain storms and temperature fluctuations (Donnelly et al. 2017; Baker et al. 2004). Earlier snowmelt may increase the amount of time that nutrients and metals are mobile in the watershed (Whitehead et al. 2009). Given this, we will continue to monitor water quality for the long term and be prepared to quantify and report any negative trends. In the meantime, we will follow best practices for mitigating cumulative effects of roads and other transportation corridors, impervious surfaces, storm water management, and sanitary water management in the interest of maintaining high water quality.

Acknowledgements/Partners

Dorothy Lindeman, Environment and Climate Change Canada

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: (403) 431-2132
E: *mark.taylor@pc.gc.ca*

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CONDITION (NO TREND):

Freshwater Measure: Water Quality (*aquatic insects*)

Introduction

Banff National Park protects the glacially fed headwaters of several nationally significant watersheds including the Bow, Red Deer and Saskatchewan Rivers. These headwater streams are characterized by cold clean water with uniquely low levels of nutrients and are therefore sensitive to relatively minute impacts from human activity. For this reason water quality is a monitoring measure of our Freshwater indicator for Mountain Parks in Alberta and British Columbia. Monitoring biologists are increasingly using biological communities (e.g., benthic algae, benthic macroinvertebrates, fish) to monitor the condition of surface waters because they reflect cumulative conditions compared to results from studies of water chemistry which tend to provide a brief snap-shot in time. In Canada, protocols to monitor the condition of streams and rivers using biological communities have been developed by the Canadian Aquatic Biomonitoring Network (CABIN). The network is maintained by Environment Canada to support the collection, assessment, reporting and distribution of biological monitoring information. Parks Canada is an active member of CABIN.

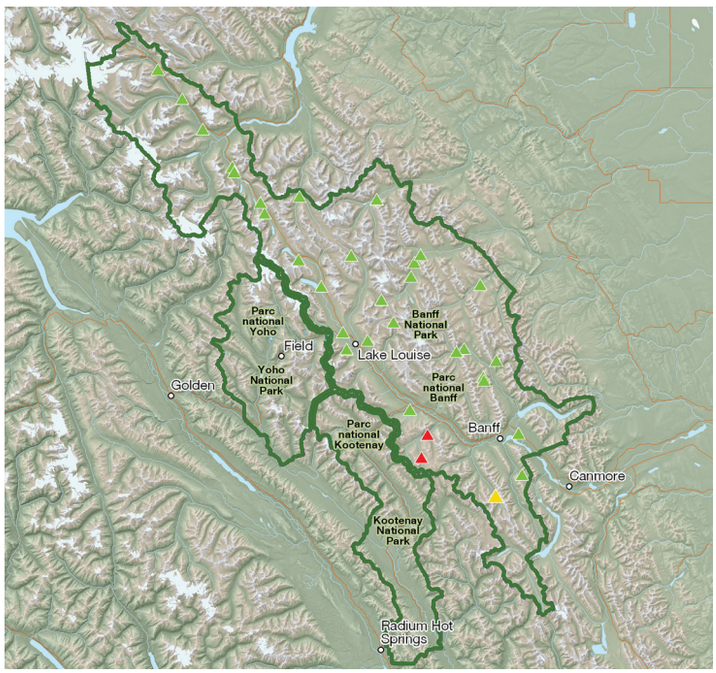


Figure 1. Green triangles show random water quality sites sampled mostly in 2015 and 2016. Yellow and red triangles represent sample sites that were divergent from reference conditions.

These models evaluate water quality by comparing the biological community at reference sites to that at a test site. A test site is defined as a site where water quality is unknown but needs to be determined. When the structure of the benthic macroinvertebrate community at the test sites falls within the range of natural variation at the suite of reference sites, it is deemed to be in reference condition. Conversely, if the structure of the benthic macroinvertebrate community at the test sites falls outside of the range of natural variation at the suite of reference sites it is deemed to be deviant (e.g., outside of reference condition).

The mountain national parks developed a predictive reference condition model in 2011. Here we report on the results of random sampling completed for Banff National Park to assess overall park water quality using benthic macroinvertebrates as a biological indicator. Figure 1 shows the random sites that we used to assess water quality in Banff National Park.

Monitoring Question

What is the overall water quality of Banff National Park?

Metric

The metric is an ordination from a multivariate analysis. Sites can either be classified as within reference (ie. similar), divergent or highly divergent (Figure 2).

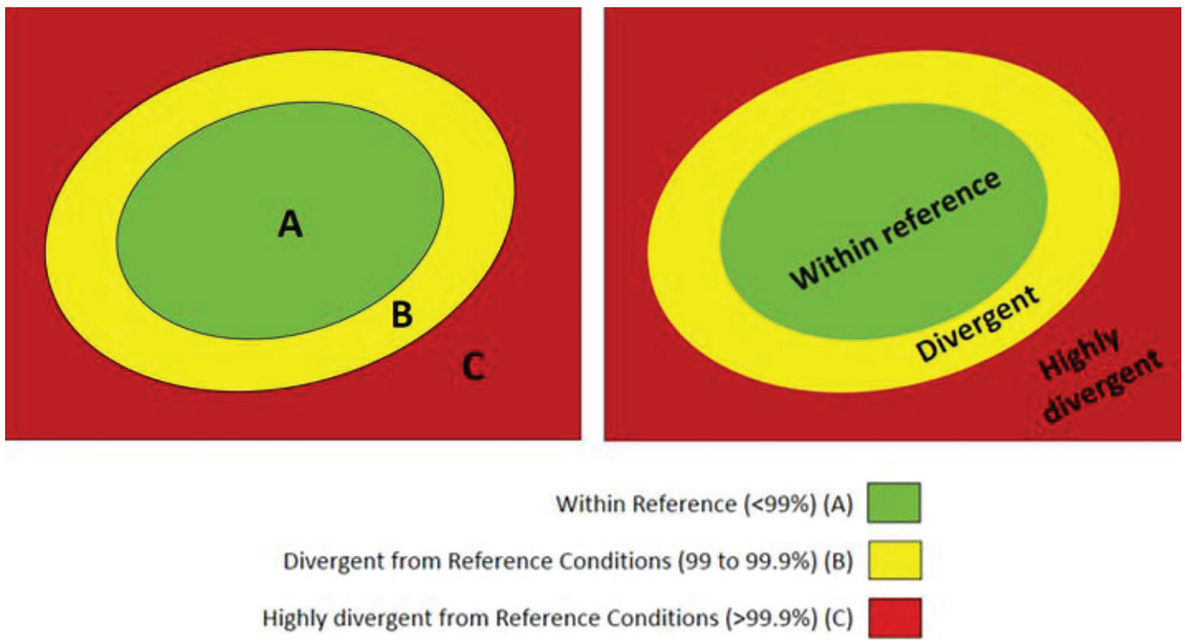


Figure 2. Figure shows ordination space where the reference cloud is located in the middle and the bands become more divergent as you move to the outside.

Thresholds

Aquatic specialists have identified three condition categories of poor, fair and good based on the percent of sites that are within reference condition. Using a percentage and a range manages Type 1 and Type 2 errors.

GOOD	>80
FAIR	60-80
POOR	<60

Methods

Banff aquatics specialists applied a random design to select sampling sites to describe large-scale patterns in the condition of streams and rivers in the park. Scrimgeour (2015) provides an additional details on sampling designs capable of large scale assessment to support condition monitoring.

Monitoring personnel follow a nationally-standardized protocol when conducting CABIN sampling. Detailed field methods are available on the Environment Canada website: *http://publications.gc.ca/site/eng/422979/publication.html*

Personnel are trained and certified in the CABIN protocol. During the field visit, researchers kick rocks in the streambed for three minutes while collecting dislodged aquatic insect in a standardized dip net held just downstream. They preserve the insects in formalin for later identification by a certified taxonomist. Researchers also collect standardized field habitat measurements and water samples. Water samples are sent to Environment Canada's lab in Vancouver for analysis. A GIS specialists calculates the catchment size based on site locations and field technicians enter data into the CABIN website and complete the site analysis using the web platform analytic tools.

Results

We used thirty one sites to evaluate the overall condition of water quality in Banff National Park. Twenty eight of the thirty one sites or 90.3% were within reference (Table 1). This exceeds the 80% threshold and the overall measure of water quality in the park is rated as good.

Table 1. Banff National Park site status summary table

#	Site ID	Park	Year	Sample Date	Sampled Stream	Site Status Assessment
1	BNP-1006	Banff	2016	2016-10-13	Stoney Creek	Within Reference (<99%)
2	B-Panther3	Banff	2016	2016-10-03	Panther bison site	Within Reference (<99%)
3	BNP-1015	Banff	2016	2016-09-29	Goat Creek	Within Reference (<99%)
4	BNP-1027	Banff	2016	2016-10-13	Elk Creek Trib	Within Reference (<99%)
5	BNP-1033	Banff	2016	2016-10-04	Red Deer Trib	Within Reference (<99%)
6	BNP-1035	Banff	2016	2016-10-17	Brewster Creek	Divergent (99-99.99%)
7	BNP-1036	Banff	2016	2016-10-06	Red Deer Trib	Within Reference (<99%)
8	BNP-1038	Banff	2016	2016-09-28	Altrude Creek	Within Reference (<99%)
9	BNP-1042	Banff	2016	2016-10-12	Flints	Within Reference (<99%)
10	BNP-1043	Banff	2016	2016-10-11	Pharaoh Creek	Divergent (>99%)
11	BNP-1056	Banff	2016	2106-10-12	Lost Horse Creek	Divergent (>99%)
12	BNP-1060	Banff	2016	2016-10-05	Red Deer Trib	Within Reference (<99%)
13	B-Clearwtr3	Banff	2016	2016-09-28	Clearwater bison site	Within Reference (<99%)
14	BNP-2085	Banff	2016	2016-10-13	Elk Creek	Within Reference (<99%)
15	BNP-2087	Banff	2016	2016-10-12	Flints	Within Reference (<99%)
16	LL-B-14-04	Banff	2014	2014-11-06	Corral Creek	Within Reference (< 99%)
17	B-B-15-1040	Banff	2015	2015-10-28	Bow River	Within Reference (< 99%)
18	B-B-15-1055	Banff	2015	2015-10-28	Bow River	Within Reference (< 99%)
19	B-B-15-1057	Banff	2015	2015-10-26	Louise Creek	Within Reference (< 99%)
20	B-NS-15-1005	Banff	2015	2015-10-19	Unknown	Within Reference (< 99%)
21	B-NS-15-1008	Banff	2015	2015-10-27	Mistaya River	Within Reference (< 99%)
22	B-NS-15-1034	Banff	2015	2015-10-06	Mistaya River	Within Reference (< 99%)
23	B-NS-15-1053	Banff	2015	2015-10-19	Unknown	Within Reference (< 99%)
24	BNP-1011	Banff	2016	2016-10-27	Unnamed tributary to Bow River	Within Reference (< 99%)
25	BNP-1013	Banff	2016	2016-10-23	Moose Creek	Within Reference (< 99%)
26	BNP-1019	Banff	2016	2016-10-17	Norman	Within Reference (< 99%)
27	BNP-1045	Banff	2016	2016-10-19	Little Pipe	Within Reference (< 99%)
28	BNP-1052	Banff	2016	2016-10-19	Baker	Within Reference (< 99%)
29	BNP-2082	Banff	2016	2016-10-17	Arctomys	Within Reference (< 99%)
30	B-NS-16-1041	Banff	2016	2016-10-23	Dolomite	Within Reference (< 99%)
31	B-NS-16-2090	Banff	2016	2016-10-17	Silverhorn	Within Reference (< 99%)
Total					**31** Sites	**28** are within reference
Percentage of test sites within reference condition						90.3%
EI Measure Status:						GOOD

Three sites, BNP-1035, BNP-1056 and BNP-1043 had benthic communities that did not match what the model predicted for those sites and were classified as divergent.

BNP-1043, located downstream of Egypt Lake, on Pharaoh Creek (a tributary of Red Earth Creek), was found to be highly divergent from the reference condition (Figure 3). The RIVPACS[1] ratio for BNP-1043 was 0.94 (p>0.5) and 0.859 (p>0.7) (Appendix A), and found fewer observed than expected species at the site. Further analysis of benthic macro invertebrate population abundance at BNP-1043, BNP-1056 and BNP-1035 found that the pollution sensitive species, Ephemoptera (mayflies), Plectoptera (stoneflies), and Trichoptera (caddisflies), known as EPT abundance, were compromised. BNP-1043 had an EPT abundance of 16.8% of the benthic sample whereas, 77.8% of the sample included pollution tolerant Diptera species (True flies).

BNP-1056, which is located Lost Horse Creek, was also found to be highly divergent from the reference condition (Figure 4). RIVPACS ratios show an observed/expected ratio of 1.10 (p>0.5) and 0.98 (p>0.7) (Appendix A). EPT abundance at BNP-1056 was higher than BNP-043 (63.4% EPT abundance) and the pollution tolerant Diptera species was lower than BNP-1043 (34.8% abundance). model.

The water quality at BNP-1035 was identified as fair based on the reference model (Figure 5). The RIVPACS ratio was 1.02 (p>0.5) and 0.91 (p>0.7) (Appendix A) indicating that water quality is compromised. Further analysis using EPT abundance found that 82.5% of the benthic macro invertebrate sample was comprised of sensitive benthic species (EPT) and Diptera abundance was at 15.4%.

Condition and Trend

Condition: Good
Trend: Not rated but expected to be stable

Assessment Confidence

Assessment confidence is high. We are using a predictive model developed on local reference sites.

Discussion

Banff National Park is primarily comprised of wilderness. This includes coniferous and broadleaf forest, alpine, wetland and grassland cover types. Development is limited within the park

1 Note - River InVertebrate Prediction And Classification System (RIVPACS)-type predictive models assess the biological conditions of streams by comparing observed assemblage composition (O) with an expected assemblage composition derived from reference site observations (E). The ratio of the 2 values (O/E) can be interpreted as a measure of taxonomic completeness. Values of O/E that are near 1 at a test site suggest that the site is comparable to reference sites, whereas values that differ substantially from 1 suggest that the site is degraded. (Yuan L.L. 2006). *Journal of the North American Benthological Society* © 2006)

with two town sites including Banff and Lake Louise, while regulated facilities are present on the landscape. Visitor numbers within the park are on the rise with various activities available for leisure and recreation in designated areas and on designated trail systems. Recreational activities occurring in the park include but are not limed to, hiking, biking, skiing, camping and horse use. These activities occur both in the front and back country. Many front country activities are unrestricted in terms of capacity, whereas, overnight back country activities are regulated by permits.

With increasing numbers of people entering the park for recreation and leisure it is important to ensure that the ecological integrity of the natural resource base is maintained. Overall, the water quality of aquatic ecosystems in Banff National Park are good, with 90.3% of our test sites achieving results that are within those predicted by the reference condition. However, the presence of three sites that indicate impairment in water quality raise an alert on the influence that human activity may be having on water quality in certain areas.

The levels of human activity in each of the catchment areas ranged from no human activity to heavy traffic areas with camping (front and back country), hiking, biking and horse use on trail networks throughout the catchment. Of the three sites identified as divergent from the reference sites, BNP-1043 and BNP-1056 exhibit the greatest divergence. Sites BNP-1043 and BNP-1056 occur in the Red Earth Creek watershed. Red Earth Creek is one of the more popular trail systems in Banff National Park. In 2016 (June 23-October 8), approximately 3 045 hikers, 48 horse and 475 bikers were recorded on trail cameras at the Red Earth Trailhead (Parks Canada, 2017). Multiple facilities are present in the catchment area including four backcountry campgrounds, a patrol cabin, camping shelter and lodge.

Site BNP-1043 is on Pharaoh Creek, a tributary to Red Earth Creek and located approximately 2,7 km downstream from the campground located at Egypt Lake. The site is situated below the patrol cabin and campground and includes the popular Eqypt Lake which services numerous back country campers and day visitors. A remote camera on Healy Pass near Eqypt Lake identified 3 497 hikers in 2016 (June 25-Oct. 3), indicating a high human use trail.

Site BNP-1056 is located on Lost Horse Creek, approximately 5 km upstream from the Red Earth Creek trailhead parking lot, and 8 km downstream from BNP-1043. In total there are four backcountry campgrounds, a lodge (supplied by horse use), and patrol cabin located in the catchment upstream of this site. However the closest campground to BNP-1056 is 5 km upstream of the site on Red Earth Creek and no hiking trails or facilities exist in Lost Horse Creek. Therefore, the divergent result for BNP-1056 may be a result of an anomaly in stream topology that was not captured by the reference model. Conversely, these two sites along Red Earth Creek experience the greatest number of visitors, and potential human activity compared to all other sites sampled (N=31). Due to the presence of this level of human activity in the area, it is important to monitor the region and understand if the activities in these catchments may be compromising water quality and identify sources that may be responsible for these changes.

BNP-1035 is the only site sampled in Banff National Park that is categorized as mildly divergent. BNP-1035 is located on Brewster creek, and has a trail that crosses the creek at various locations.

Activities in this catchment upstream of the site are dominated by commercial horse use. In 2016 (March 1 to Nov. 11) 27 hikers and 416 horses were identified on a remote camera located along Brewster Creek. This trail also experiences a greater concentration of horse traffic along the trail system compared to other sites included in the model. Horse trails are characterized by erosion due to the impact that heavy loads have on the soil cohesion, especially during rain events or when trails are muddy. There are two separate, redundant, horse trails in this valley and the "packer" trail includes numerous stream crossings. Based on the reference condition, the water quality at this site is degrading. However, benthic communities consisted of a majority of sensitive species (82.5%), therefore, any potential stressor at this location is likely mild in magnitude. Monitoring will continue in the future.

The overall state of water quality in the park is rated as good, with 29/32 sites meeting reference condition. The identification of 3/31 sites in 2016 with compromised water quality presents an opportunity to further improve our knowledge and understanding of factors that may influence the ecological integrity of the park, and specifically aquatic environments. Through monitoring, investigation and assessment, water quality throughout the park can be maintained through the application of research based management decision making and enforcement.

Acknowledgements/Partners

This monitoring program is not possible without the strong partnership with Environment and Climate Change Canada, in particular, Stephanie Strachan, Environmental Monitoring Scientist for Pacific, Athabasca Arctic Watershed. Garry Scrimgeour was instrumental in design and coordination of the 2007 and 2008 field campaign across seven mountain parks to complete the reference collection and subsequent predictive model development. Ghost Consulting completed the Mountain Park Model. Taxonomist: Susan Salter. Water Chemistry Environment Canada Pacific Lab.

Some of the CABIN sampling field work, completed in the Banff Field Unit is done through a Citizen Science project that enlists the support of a small team of highly trained volunteers who work alongside Parks Canada aquatic specialists to collect these important data.

Contact

Shelley Humphries, Aquatic Ecologist
Lake Louise, Yoho and Kootenay Field Unit
P: (250) 347-6159
E: *shelley.humphries@pc.gc.ca*

References

Srimgeour, G. 2015. State of the Park Reporting for Mountain Parks: Advice on Condition Monitoring of the Water Quality Measure using CABIN protocols. Technical Note. 9 p.

Freshwater Measure: Stream Fish Occupancy

Introduction

Freshwater fishes are some of the most imperiled taxa worldwide as is evidenced by the number of threatened and endangered species (Dudgeon et al. 2006). For example, westslope cutthroat trout (WSCT; *Oncorhynchus clarkii lewisi*) and bull trout (BLTR; *Salvelinus confluentus*) have been assessed as "threatened" nationally (COSEWIC 2012; Fisheries and Oceans Canada 2013). Non-native trout, stocked historically, are one of the main threats to these native species in Banff National Park (BNP). Brook trout (BKTR; *Salvelinus fontinalis*) exist in nearly all native fish habitats in BNP, and may cause displacement of WSCT and BLTR via competition and introgression (Rieman et al. 2006). Climate change is expected to facilitate this interaction (Rahel and Olden 2008). Consequently, we may need to increase control efforts for non-native fishes. One of the challenges we faced in BNP was not having comprehensive survey data to determine if non-native fish were continuing to expand their range in flowing waters. By determining occupancy estimates for native and non-native species in BNP, we can track this problem over time and prioritize restoration efforts for those streams where native species are most at risk.



Figure 1. Native westslope cutthroat trout in Banff National Park.

Monitoring Question

1. How much native fish habitat in BNP is occupied by non-native fishes?
2. How is the distribution of non-native fishes changing over time?

Metric

Ψ(non-native fishes)/ Ψ(native fishes)
where [Ψ=occupancy]

Thresholds

GOOD: Ψ(non-native fishes) = 0
FAIR: Ψ(non-native fishes)/ Ψ(native fishes) ≤ 1
POOR: Ψ(non-native fishes)/ Ψ(native fishes) > 1

Methods

The stream fish occupancy protocol is an electrofishing-based survey with analysis that accounts for the imperfect detection efficiency of the capture methods. The details of the survey and analytical procedures can be found in a separate protocol document (Taylor 2015). Briefly, we used a single-season occupancy modelling approach, which allows for two nested processes: the species occurrence state at the site (i.e. occupied/not occupied) and the success of the observation (i.e. detected/not detected; MacKenzie et al. 2002). The likelihood of observing a detection history for a site is a function of the occurrence probability (occupancy, Ψ), and detection probability (detectability, *p*). Maximum likelihood methods were used to estimate the detection and occupancy parameters. The Cascade, Panther and Spray River watersheds were sampled in 2015, 2016 and 2017, respectively. The final result is an average value between 0 and 1 which represents 3 watersheds. The thresholds for reporting this metric are as follows:

GOOD	Ψ(non-native fishes) = 0
FAIR	Ψ(non-native fishes)/Ψ(native fishes) ≤ 1;
POOR	Ψ(non-native fishes)/Ψ(native fishes) > 1

Results

We sampled 99 sites in the Cascade watershed (2015), 73 sites in the Panther watershed (2016), and 61 sites in the Spray watershed (2017). For the Cascade watershed, modelled occupancy was Ψ = 0.67 (SE=0.05) for native fishes and Ψ = 0.16 (SE=0.04) for non-native fishes (Figure 2). For the Panther watershed, modelled occupancy was Ψ = 0.57 (SE=0.06) for native fishes and Ψ = 0.19 (SE=0.05) for non-native fishes (Figure 2). However, modelled occupancy was only Ψ = 0.37 (SE=0.06) for native fishes and Ψ = 0.80 (SE=0.05) for non-native fishes in the Spray River (Figure 2). The combined ratio of Ψ(non-native)/ Ψ(native) for all three watershed was 0.47 which results in a condition rating of “fair” (yellow).

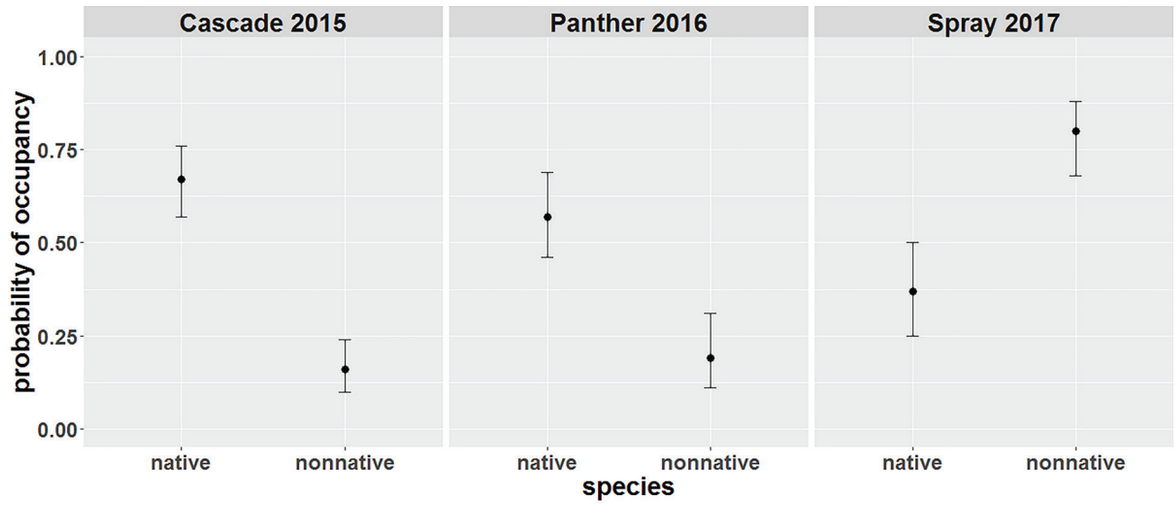


Figure 2. Occupancy estimates for native and non-native fishes in the Cascade, Panther and Spray River watersheds.

Condition and Trend

Condition: Fair
Trend: Not Rated

Assessment Confidence

Protocol complete. High confidence in data and modelling.

Discussion

The measure is "fair" (yellow) for both the Cascade and Panther watersheds, but "poor" (red) for the Spray watershed. This is the first comprehensive, statistically rigorous stream fish survey in BNP. At this time, we can only provide quantitative occupancy estimates for the Cascade, Panther and Spray watersheds. However, we plan to replicate this study design in other watersheds in the future.

Historically, Parks Canada stocked each of these watersheds with non-native fishes, but BKTR were the only non-native fishes caught during our surveys in 2015, 2016 and 2017. Between the years of 1940 and 1969, these watersheds were stocked with over 500,000 rainbow trout (RBTR; *Oncorhynchus mykiss*), 80,000 Atlantic salmon (*Salmo salar*) and 5,000 splake (*Salvelinus fontinalis* × *S. namaycush*). In comparison, only 36,000 BKTR were stocked in the three watersheds during the same time period. BKTR must be a superior competitor in BNP given they are the only non-native fish species persistent on the lanscape according to our stream surveys. Based on our results, the Spray River has the largest distribution of BKTR.

In addition to the contemporay changes to the distribution of native fishes, we may expect future changes as the result of climate change. Non-native fishes such as BKTR and RBTR are more suited to warmer water temperatures than native fishes like bull trout and westslope cutthroat trout (Dunham et al. 2002). Regional temperature increases associated with climate change have led to unfavourable predictions about the persistence of bull trout in the U.S. (Rieman et al. 2007; Wenger et al. 2013).

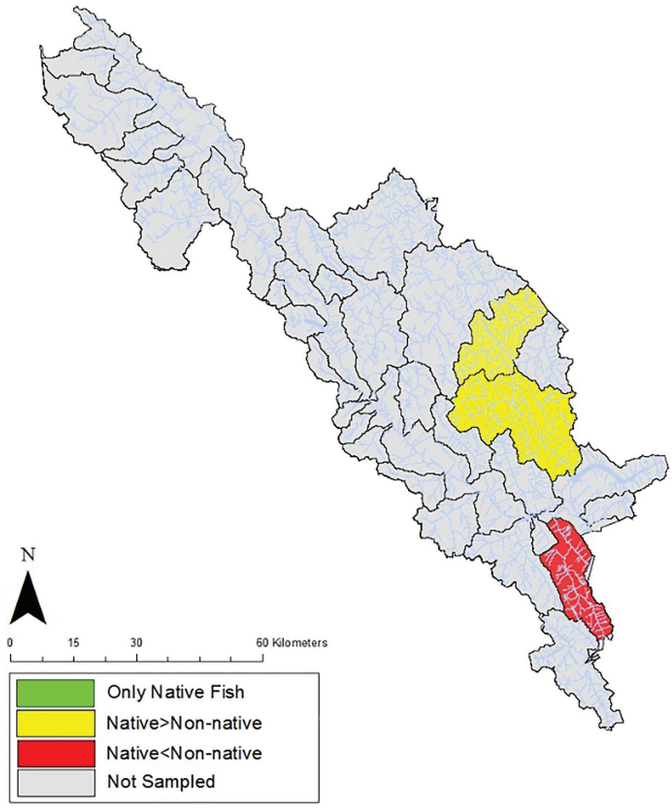


Figure 3. Condition Measure thresholds (Good, fair, poor) for each watershed from which occupancy estimates for native and non-native fishes were calculated.

In addition to warming water temperatures, flow regimes are expected to change with climate warming. Climate models indicate that mountainous areas will likely continue having earlier and more rapid snowmelt in the spring (Luce and Holden 2009), increased winter precipitation and flooding (Hamlet and Lettenmaier, 2007), warmer, drier summers (Westerling et al. 2006), and increased drought (Pederson et al. 2010). Indeed, the Canadian Rocky Mountains have already experienced flow declines of 0.22%/year from 1910 to 2002 (Rood et al. 2005). Coupled climatic and hydrologic changes contribute to warmer water temperatures in the summer months (Rood et al. 2005) reducing the amount of thermally suitable habitat for many aquatic species (Isaak et al. 2010; Wenger et al. 2011).

Wildfire is a frequent natural disturbance that can lead to the decades-long elevation of summer stream temperatures (Isaak et al. 2010; Mahlum et al. 2011). A recent increase in wildfire severity and size in the western U.S. has been linked to climate change (Westerling et al. 2006). On a relatively shorter time scale, large wildfires can remove substantial streamside vegetation, resulting in reduced shading, increased temperatures, erosion and turbidity, and fewer terrestrial invertebrates entering the stream – a key food item for many fish species.

Maintaining natural alluvial processes by allowing gravel bed rivers to “roam” and meander with high water events, contributes to the maintenance of underground rivers (hyporheic flow) (Hauer, et al. 2016). These sub-stream flows are fortuitously facilitated by the lineal size-sorting of alluvial materials, (which optimizes the interstitial spaces between equally sized rocks or cobbles); a process which only occurs during seasonal flood events, and is vital to the renewal of a healthy gravel bed river system. The end result is that fast flowing underground streams

produce cold-water upwelling further downstream; this natural process provides cold water habitats that may become increasingly critical for native species as climate change proceeds. Preventing a wild gravel bed river from "roaming" laterally disrupts this natural disturbance process and reduces habitat quality and diversity.

The combination of natural threats (water warming, water receding, wildfire) in addition to climate projections that favor thermally tolerant non-native species (e.g. BKTR; Wenger et al. 2011) has the potential to reduce the distribution of native trout (e.g. Rieman et al. 2006). The dynamics of the non-native fish distribution over time (i.e. colonization rates), as inferred by the replicate surveys in the future, will help us prioritize interventions (e.g. non-native fish removal; Pacas and Taylor 2015). We hope to detected both future and on-going threats (e.g. climate change) by the trend in native fish occupancy over subsequent cycles of the BNP State of Park assessment.

Acknowledgements/Partners

We developed the methods used for this measure, in collaboration with Neil Mochnacz, Fisheries Research Biologist, Arctic Science Division, Central & Arctic Region, Fisheries and Oceans Canada.

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: (403) 762-1418
E: *mark.taylor@pc.gc.ca*

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Species at Risk

Introduction

Understanding species at risk designations in Canada can be complicated. Some species are recognized under provincial legislation but not under the federal Species at Risk Act (SARA). Other species are recognized in one population/region or subspecies (often called a designatable unit), but not throughout their entire range or population.

Under the federal system, species assessments are prepared under contract and are reviewed periodically by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This non-government body then applies a suggested status (designation) and makes a recommendation to the federal government. This can cause confusion, as you will often see reference to a species being listed as endangered under COSEWIC, however this designation does not result in any legal protection for a species - it is the tool used to make a recommendation for listing. If a COSEWIC designation is accepted by the federal government, it is then listed under Schedule I of the Species at Risk Act and is considered "listed" and the species will be protected under the federal Species at Risk Act. Once listed, the federal government must prepare both a "Recovery Strategy" (RS) that includes the identification of "Critical Habitat" (CH) and an "Action Plan" (AP) that identifies key recovery actions.

Within Banff National Park, seven species were formally protected (listed) under Schedule I of SARA as endangered or threatened at the time of this report. Since then, two more species (bank and barn swallows) have been added, but are not addressed in this report. SARA listing provides additional processes and penalties for impacting these species, but it is important to remember that all native species are already protected within Banff National Park; under the Canada National Parks Act.

The following table summarizes key species, found in Banff National Park, that are in various stages of assessment as species at risk:

	Species		COSEWIC recommendation	SARA listed	BNP	Ability of BNP to Influence Species Status
Regular occurrences in Banff National Park	1	Banff Springs snail	Endangered	YES	X	High
	2	Whitebark pine	Endangered	YES	X	Medium
	3	Westslope cutthroat trout – AB population	Threatened	YES	X	Medium
	4	Woodland caribou – southern Mtn population	Threatened	YES	X	Medium
	5	Little brown Myotis	Endangered	YES	X	Low
	6	Common nighthawk	Threatened	YES	X	Low
	7	Olive-sided flycatcher	Threatened	YES	X	Low
	8	Bank swallow	Threatened	YES (new)	X	Low
	9	Barn swallow	Threatened	YES (new)	X	Low
		Black swift	Endangered	No	X	
		Limber pine	Endangered	No	X	
		Bull trout - Saskatchewan-Nelson River population	Threatened	No	X	
		Plains bison	Threatened	No	X	
		Rusty blackbird	Special Concern	YES	X	
		Western toad	Special Concern	YES	X	
		Wolverine - western population	Special Concern	YES	X	
		Grizzly bear, western population	Special Concern	YES	X	
		Vivid dancer	Special Concern	No	X	
		Western grebe	Special Concern	No	X	
		American badger taxus subspecies	Special Concern	No	X	
Occasional		Northern Myotis	Endangered	YES	?	
		Canada warbler	Threatened	YES	no	
		Ferruginous hawk	Threatened	YES	no	
		Lewis' woodpecker	Threatened	YES	no	

The Banff longnose dace is considered "extinct" - it was formerly found at the Cave and Basin in Banff and is no longer present. It may have been affected by the introduction of several species of exotic tropical fish that were unlawfully released at this site many years ago.

Much effort goes into assessing and managing the listing and designation of species at risk, however the real priority is taking meaningful actions to protect and recover these species. To better focus our efforts and reduce the amount of energy spent on process, Parks Canada has recently adopted the Multi-Species Action Plan (MSAP) approach – identifying and prioritizing key actions needed to protect and recover all SAR in a given park. Our new Multi-species Action Plan for BNP was completed and approved in 2017. *(https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=A8819D2B-1)*

Setting priorities and identifying key actions is critical. For many of the nine SARA listed species found in BNP, little can be done to affect a change in their Species at Risk status other than the protections already offered by the Canadian National Parks Act. In most cases these species are either transients who winter elsewhere, species that occur at low densities inside the parks, or species for which the cause of their decline remains unclear.

For a handful of threatened or endangered species within the national parks, additional management and restoration activities have the potential to make a significant difference to their SAR status. It is for these species that we have identified and dedicated resources to inventory, monitoring, or restoration efforts. In this section we will describe such projects for the following key species: Banff Spring snail (found exclusively inside BNP); westslope cutthroat trout, whitebark pine, caribou (extirpated from BNP) and little brown bat.

Other Federal Designations

It is important to understand there are numerous species such as wolverine, western toad, limber pine, and rusty blackbird, which are listed under SARA but only as species of "Special Concern". This means they have not been identified under SARA as a species at risk (endangered, threatened, or extirpated). Special Concern species do not require a Recovery Strategy or an Action Plan, but do require a Management Plan.

Other Provincial Designations

There are a whole host of other species that may be listed under provincial species at risk legislation in Alberta (e.g. grizzly bear, long-toed salamander or harlequin duck), but are not recognized federally under the Species at Risk Act. Conversely, some species such as plains bison (COSEWIC recommended a threatened status in 2004) are not currently considered wildlife in the province of Alberta.

SARA STATUS:
ENDANGERED

Banff Springs Snail

ABILITY TO INFLUENCE STATUS IN BNP: HIGH

Introduction

The Banff Springs Snail (Physella johnsoni) was discovered in 1926 in the hot springs on Sulphur Mountain in Banff National Park (BNP). When we began focused research in 1995, the snail was living in only five of the nine thermal springs it historically occupied. These springs are in three main areas: the Cave & Basin, Middle Springs, and the Upper Hot/Kidney Spring. All depend on thermal waters from the same source: precipitation falling on the local mountains. In 1997, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the snail as threatened because of its restricted distribution, 10-fold annual population fluctuations, and continued threats from human disturbance (Lepitzki and Pacas 2010). In 2000, it was reassessed as endangered and in 2003, listed as endangered under the Species at Risk Act (SARA), a status re-confirmed in 2008 and 2017.



Figure 1 Banff Springs Snail (note – they are about the size of a grapefruit seed)

Objectives

The following conservation targets are outlined in the Banff National Park Species at Risk Multi-species Action Plan (Parks Canada Agency, 2017):

Site-based Population and Distribution Objectives:

- Maintain self-sustaining populations and habitats by mitigating human-related threats.

Conservation and Recovery Measures:

- Increase understanding of snail genetics to better inform both emergency response options and considerations for repeated reintroduction in response to extirpation of current populations as a result of thermal water failure (natural drying events).

- Ensure continued protection of snails through current measures which include a combination of area closures, surveillance, public education and enforcement.
- Monitor current distribution. Through active management (two reintroductions) and natural dispersal, the Banff Springs Snail now occupies all viable habitats within its known native range. Continued baseline monitoring will track changes over time at an annual scale.
- Continue communication activities identified for protecting the critical habitat of the Banff Springs Snail on the Sulphur slopes. Enhance communication products aimed at external target markets.

In 2007, we developed a Recovery Strategy and Action Plan for the Banff Springs Snail, the first for any species under the SARA. This document's goal of re-establishing snail populations and restoring and maintaining self-sustaining populations of the Banff Springs Snail (Physella johnsoni) within the species' historic range, was to be achieved via the following three objectives:

1. To protect snail populations and habitats by mitigating human and natural threats.
2. To restore self-sustaining snail populations and habitat within historic range where and when possible.
3. To increase the knowledge and understanding of snail ecology, thermal spring ecosystems, and threats to them.

Status of Implementation of the Recovery Strategy and Action Plan

Parks Canada successfully reintroduced the Banff Springs Snail to the "Upper Middle" and "Kidney" springs in 2003 and 2004, respectively. Since publication of the recovery strategy and action plan, we have assessed the remaining three sites from which the species has been extirpated (Banff Springs Hotel, Upper Hot Springs and Gord's Pool) as not feasible for reintroduction. We also assessed the creation of additional habitats, where none existed previously (e.g., at the outflows at the Cave and Basin) but deemed this not appropriate nor viable as a recovery approach.

Initiatives to protect Banff Springs Snails and their habitat, and to manage for both the ecological and commemorative integrity values at the Cave and Basin National Historic Site (NHS), are ongoing. Electronic surveillance continues at springs at the NHS, the Upper Middle Hot springs and the Kidney springs. A thermal waters touch feature was installed at the NHS in 2013 to reduce limb-dipping in the natural springs, however the design proved problematic so has been disabled and is currently being re-designed. Thermal habitat conservation messaging is also incorporated into regular programming at the NHS. The updating of boardwalk signage at the NHS has been deferred due to plans to relocate much of the boardwalk out of this sensitive and dynamic habitat to help avoid future conflicts. Additional training is also required for internal trades staff, e.g., towards ensuring protection of critical habitat while conducting plumbing maintenance. The habitat at each thermal spring is checked as a part of monthly population

monitoring during the spring and summer. In addition, staff conduct daily habitat checks at the springs occurring within the NHS year-round. Mitigations and education have resulted in a reduction of human disturbance at the springs; however, complete elimination of human disturbance is likely not feasible given that some populations occur within a NHS.

In 2017, Parks Canada posted the final version of a Multi-species Action Plan for Banff National Park; which replaces species specific Action Plans such as that for the Banff Springs Snail. The plan took a holistic approach, incorporating all species at risk in Banff National Park that required an action plan under Sec.49 of SARA. Actions that are beneficial to multiple species at risk were identified and prioritized, to maximize the effectiveness of species at risk recovery efforts in the park. Lessons learned over the past 10 years of recovery efforts for Banff Springs Snail were incorporated into the planning, and the action plan identified a site-based population and distribution objective for the species to "maintain self-sustaining populations and habitats by mitigating human-related threats". Results from research, monitoring and mitigation efforts outlined above will continue to be evaluated and incorporated into man-agement and recovery efforts for the species.

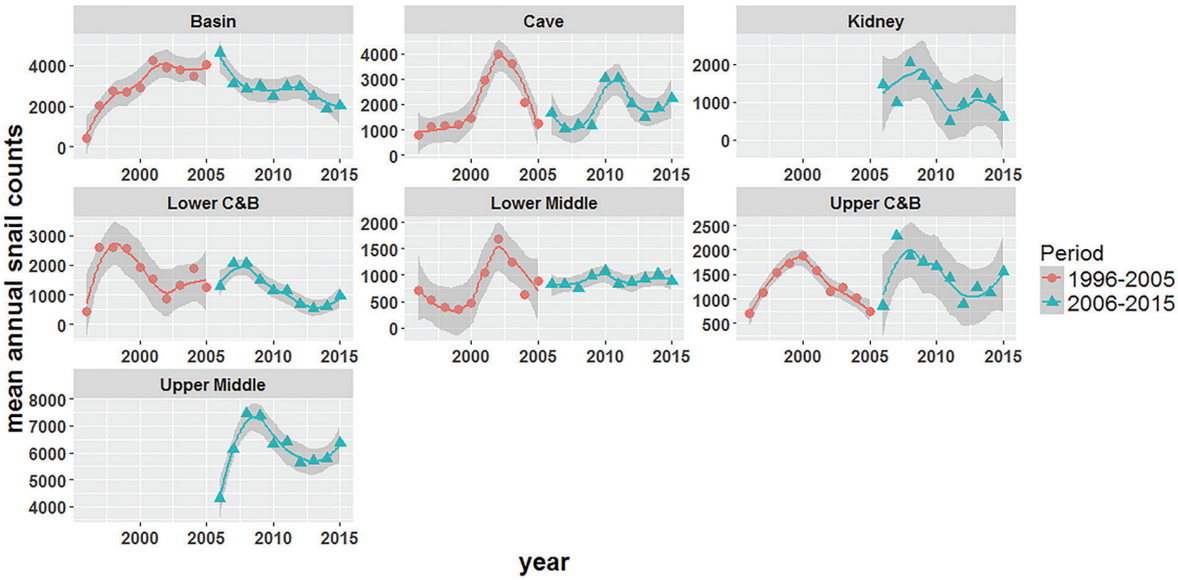


Figure 2 Mean annual snail counts from 7 thermal springs in Banff National Park, representing two COSEWIC assessment periods (1996-2005 and 2006-2015)

Progress towards Meeting its Objectives

Data from the monitoring program shows that both restored and original populations are self-sustaining, while exhibiting a charac-teristic oscillating pattern of population increases and decreases both within and among years (Figure 2). Overall, between 2007 and 2017, four populations (Cave, Lower Middle, Kidney and Upper Cave and Basin) were stable and three populations (Basin, Upper Middle, and Lower Cave and Basin) declined. The Basin population has declined the most; however, declines of that magnitude were also observed in 1996 and 1999.

The Recovery Strategy and Action Plan for the Banff Springs Snail (Physella johnsoni) in Canada identified a goal to "restore and maintain self-sustaining populations of the Banff Springs Snail within the species' historic range", and then identified objectives and approaches associated with achieving this goal. The goal has been achieved throughout the reporting period; however, research and monitoring programs are ongoing to help ensure this goal can continue to be realized into the future.

Monitoring of thermal water volumes and stoppages is ongoing. Population trends in relation to environmental covariates such as spring discharge, temperature and conductivity have been analyzed, but need to be updated to also incorporate regional climate data.

A research project initiated in 2016 is using genomics to compare Banff Springs Snail to other Physella species such as Tadpole Physa (Physella gyrina), and to also determine the extent of genetic variation among thermal springs containing Banff Springs Snail. This research will be vital for establishing appropriate emergency response plans in the event of thermal pool drying events.

Acknowledgements/Partners

Dwayne Lepitzki, Wildlife Systems Research, University of Calgary.

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: (403) 762-1418
E: *mark.taylor@pc.gc.ca*

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SARA STATUS:
ENDANGERED

Whitebark Pine

ABILITY TO INFLUENCE STATUS IN BANFF NATIONAL PARK: MODERATE

Introduction

Whitebark pine (*Pinus albicaulis*) is an important component of western high-elevation forests and it is listed under Schedule 1 of SARA as endangered. These trees have undergone extensive population declines across much of their range due to a number of interacting factors: the combined effects of mountain pine beetle (*Dendroctonus ponderosae*) outbreaks, fire exclusion policies, the spread of the exotic disease white pine blister rust (*Cronartium ribicola*), and climate change. Whitebark pine communities are keystone systems that support increased biodiversity and eco-system functions. Parks Canada has been working on whitebark pine restoration since the late 1990's and in 2015 initiated a collaborative conservation and restoration project across the seven national parks where whitebark pine occur. The objective of this project is to arrest the decline of whitebark pine populations and restore populations to a level and distribution that allows for persistence of natural dispersal, natural stand density ranges, and genetic dmassiversity to ensure perpetuation of the species throughout its range in the Canadian national parks.

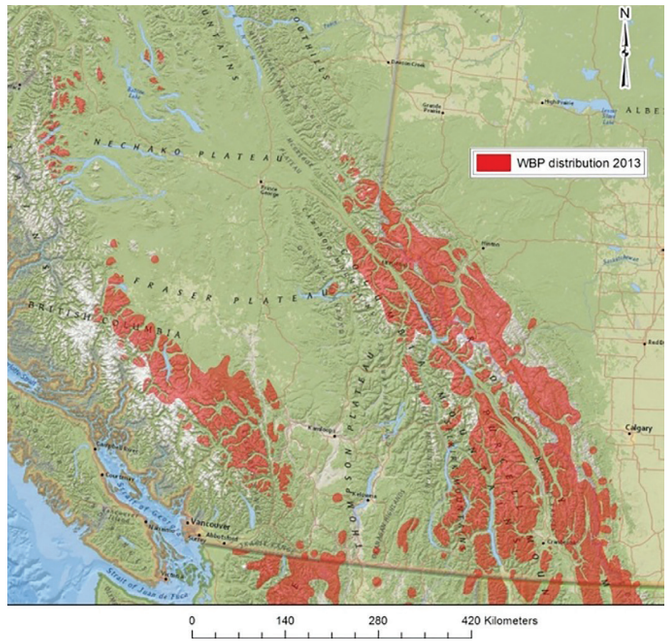


Figure 1. Global distribution of Whitebark Pine (COSEWIC, 2013).

Objectives

The following conservation targets are outlined in the Banff, Yoho and Kootenay National Parks Species at Risk Multi-species Action Plan (Parks Canada Agency, 2017):

Site-based Population and Distribution Objectives

- Establish a self-sustaining, rust-resistant population of Whitebark Pine throughout the species range in the park that demonstrates natural seed dispersal, connectivity, genetic diversity and adaptability to changing climate.

Conservation and Recovery Measures

- Identify what appear to be rust resistant individuals (Plus Trees) at high priority sites. Conduct Plus Tree seed resistance testing for high probability trees. Collect seed for genetic conservation. Protect high value Plus Trees from mountain pine beetle.
- Complete a predictive habitat model and map of Whitebark Pine distribution for the park. Where stand assessments are completed, they include aspects of stand health (i.e. rust presence/absence and stand density).
- Plant putatively rust resistant seedlings, and when available, confirmed rust resistant seedlings, in priority restoration sites. Inoculate seedlings with mycorrhizal fungi to improve establishment.

To respond to the commitments in the multi-species action plans, we have identified the following objectives for the whitebark pine restoration programs in Banff National Park:

1. Increase the frequency of trees with genetic resistance to blister rust,
2. Conserve and enhance genetic diversity of whitebark pine within and between populations through a combination of restoration and protection,
3. Maintain ecosystem function and maximize resilience in stands under threat from white pine blister rust using fire and mechanical thinning,
4. Improve mapping and inventory data to aid in meeting objectives and addressing threats,
5. Provide inspiring experiences and outreach opportunities to better understand and appreciate species at risk.

Results

1. **Increase the frequency of trees with genetic resistance to blister rust: Outcome – *Partially achieved.***

Cone caging and seed collection started in 2012 (Figure 2) occurring only on trees that presented a high likelihood of being resistant to blister rust. In total 28,973 potential blister rust resistant seeds have been collected from 49 whitebark pine caging trees. The years 2013, 2015 and 2016 were very abundant cone crop years across all the sites. In 2015, we collected over 6,800 seeds from 20 potentially blister rust resistant whitebark pine trees and in 2016, we collected 17,325 seeds from 36 potentially blister-rust resistant trees. We experienced a very low cone year in 2017

with only 15 cones caged and only 2 of these maturing to produce 21 seeds. Low cone years are to be expected as whitebark pine reproduction is cyclical; with abundant years and scarce years.

Collected seeds can be used in three ways: 1) grown into seedlings for immediate planting, 2) grown into seedlings to be tested for resistance to blister rust or, 3) stored for genetic conservation. Genetic testing for blister rust resistance is currently being done for 24 whitebark pine trees in partnership with the Province of British Columbia. A representative range of whitebark pine seeds, collected from LLYK and Banff Field Units, have been sent to the National Seed Centre for genetic conservation. We visit each caging tree annually to collect long-term health monitoring data and install pheromone patches (Verbenone and Green Leaf Volatiles) to protect against mountain pine beetle attack.

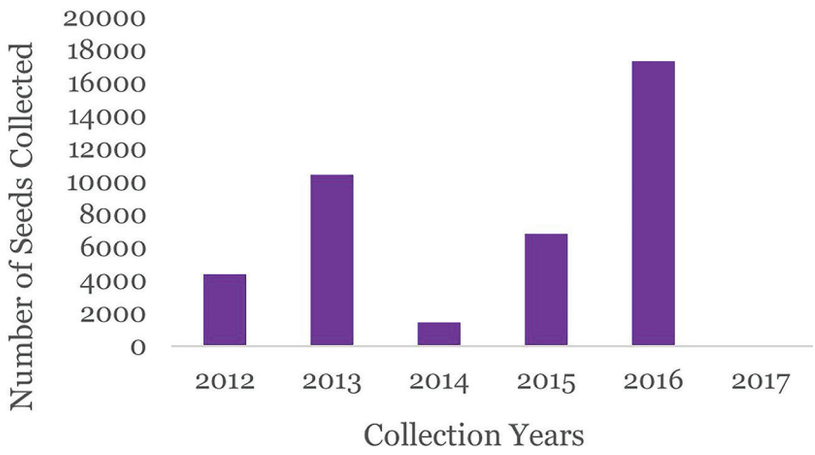


Figure 2. Number of whitebark pine seeds collected annually.

2 Conserve and enhance genetic diversity of whitebark pine within and between populations through a combination of restoration and protection: Outcome – *Partially achieved.*



Figure 3. Seedling planting in Sawback Prescribed Fire area.

In 2015, we completed the first round of whitebark pine seedling planting in Banff National Park. In 2016, we planted 12 seedlings in the Sawback prescribed fire area in Banff National Park. The fall of 2017 was the largest tree-planting effort to date with 400 seedlings planted in the Sawback prescribed fire area (Figure 3). We monitor a sub-sample of seedlings for health and survivorship. More seeds are currently at nurseries undergoing germination and seedling establishment for future restoration efforts in Banff National Park.

3 Maintain ecosystem function and maximize resilience in stands under threat from white pine blister rust using fire and mechanical thinning: Outcome – *Partially achieved*.

Since 2008 we have only completed one prescribed fire in whitebark pine habitat, the Sawback prescribed fire, which opened up forests directly adjacent to regeneration habitat (667 ha). By actively managing wildfires such as the Spreading Creek and Snarl Peak wildfires we helped reduce encroachment of shade tolerant species such as Englemann spruce and subalpine fir. Future prescribed fires (Alexandra, Dormer, and Baker Creek) will include whitebark pine specific habitat objectives. Through the Crown Managers Partnership we co-authored a best management practices paper with US Forest Service in 2016. This paper provides direction on best practices for managing wildfires and prescribed fires in whitebark pine habitat.

4 Improve mapping and inventory data to aid in meeting objectives and addressing threats: Outcome – *Completed*.

High resolution aerial photographs for Banff National Park were taken in 2014 and interpreted in 2016; providing additional information on the distribution of whitebark pine in Banff National Park. Ground truthing of this new vegetation inventory was completed in 2017.

In 2014, we completed long-term monitoring (every 5 years) for mortality and infection of whitebark pine trees across fixed plot locations in Banff, Yoho and Kootenay (Figure 4). Results from 2014 showed an average increase of 18% infection and a 3% increase in mortality from 2009 levels in Banff National Park. The next long term monitoring survey will be in 2019.

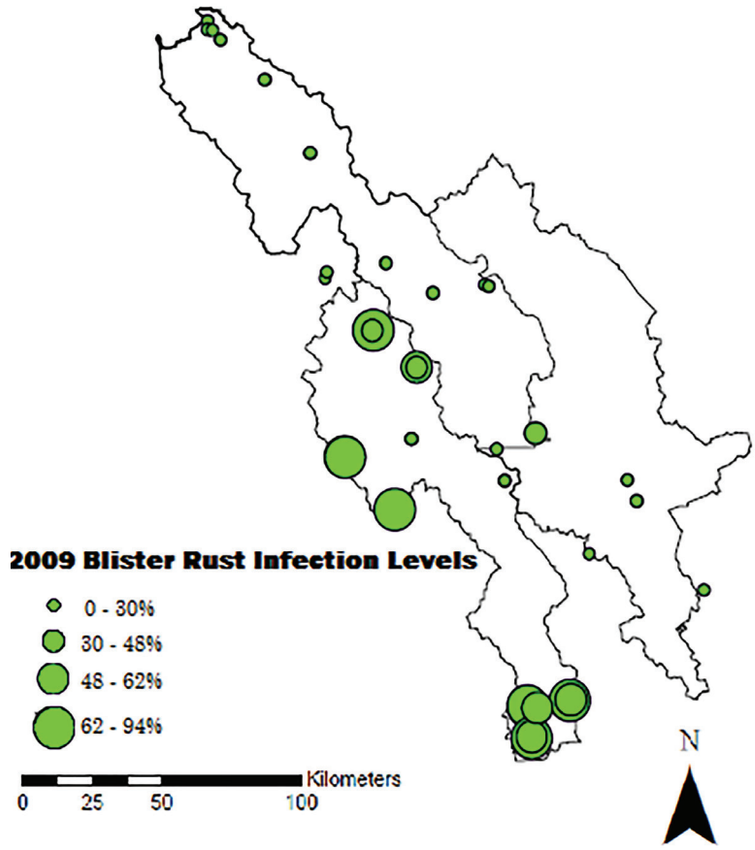


Figure 4. Blister Rust infection levels in Banff, Yoho and Kootenay National Parks.

Stand assessments, with 100 whitebark pine trees in each sample, are used to determine infections rates for blister rust and mountain pine beetle, as part of the ground truthing exercise. This is a necessary step to find resistant trees. Each healthy whitebark pine individual, within stands of blister rust infected trees, will be selected to collect cones for rust resistant trials.

5 Provide inspiring experiences and outreach opportunities to better understand and appreciate species at risk: Outcome – *Partially achieved.*

In 2016, the mountain national parks officially launched a travelling urban outreach exhibit to increase public engagement in Parks Canada restoration and conservation programs, including whitebark pine initiatives. We also installed interpretive signage regarding whitebark pine on the Sulphur Mountain boardwalk in Banff and other whitebark pine related signage was developed and fabricated for installation across the mountain parks in future years. Interpretive evening programs about the importance and ecology of whitebark pine have run throughout the summer months. A partnership with Tentree, an international clothing company, will provide support for tree planting and inform popular media on the plight of whitebark pine. Social media campaigns and updates have been released through Parks Canada social media websites to reach a broad audience.

Discussion

We propose the following actions for Banff National Park:

1. Continue stand surveys, cone caging, seed collection and genetic testing.
2. Plant seedlings grown from rust resistant seeds with the objective of planting 10,000 whitebark pine seedlings across the mountain parks by 2019.
3. Complete predictive habitat modelling.
4. Work with the provinces (BC and Alberta) to provide opportunities for seed storage and blight resistance screening.
5. Support further research on five-needle pine-mycorrhizal interactions that could deepen our understanding of seedling survival requirements.
6. Continue to use prescribed fire to mimic lightning strikes that open up the canopy in small areas for planting of whitebark pine seedlings.
7. Increase public understanding and support for whitebark pine recovery.

The following is a listing of the issues that we have identified related to our efforts at maintaining whitebark pine in Banff, Yoho and Kootenay National Parks:

1. To date it has proven difficult to locate healthy rust resistant whitebark pine trees, but enhanced efforts to do so will become our highest priority in the coming years. Once we receive results on the genetic testing for blister rust resistance we will be able to expand our restoration efforts. As more blister rust resistant trees are identified there will be a larger genetic pool of known resistant seedlings to plant.
2. Banff National Park has received national CoRe funding that will end in 2020. Securing future funding is necessary to continue with the conservation and restoration of whitebark pine and related ecosystems.
3. Climate change is rapidly changing mountain landscapes, however, it is uncertain how these changes will affect long term health and vitality of whitebark pine stands.
4. Ironically, Banff National Park is limited by the lack of white bark blister rust within the park (Figure 3) as we are only able to identify rust resistant trees within infected stands. However we will investigate proactive stand management techniques to ensure continued low infection rates in our stands.

Acknowledgements/Partners

US Forest Service collaborated with us on a best practices document related to managing fire and whitebark pine.

Tentree Clothing Company has supported tree propagation/planting and public outreach.

Contact

Jed Cochrane, Fire and Vegetation Ecologist
Lake Louise, Yoho and Kootenay National Park Field Unit
P: (250) 347-6161
E: *jed.cochrane@pc.gc.ca*

SARA STATUS:
ENDANGERED

Little Brown Myotis and Northern Myotis

ABILITY TO INFLUENCE STATUS IN BNP: LOW

Introduction

Little Brown Myotis *(Myotis lucifugus)* and Northern Myotis *(Myotis septentrionalis)* bats (Fig. 1) are two species of bats that are listed as endangered because eastern populations of these species are facing rapid population declines resulting from 'white-nose syndrome' (Environment and Climate Change Canada, 2017). White-nose syndrome is caused by a non-native fungus. Once the fungus appears within a hibernation site, it spreads quickly from bat-to-bat and can kill up to 99% of all the individuals at a site. Since 2006 the fungus has rapidly spread westward. As of 2017, researchers in Canada have identified white-nose syndrome as far west as Ontario (Fig. 2). The single greatest threat to Little Brown Myotis and Northern Myotis is white-nose syndrome. Critical habitat is identified as "any site where the endangered species have been observed hibernating during the winter at least once since 1995" (Environment and Climate Change Canada, 2017).

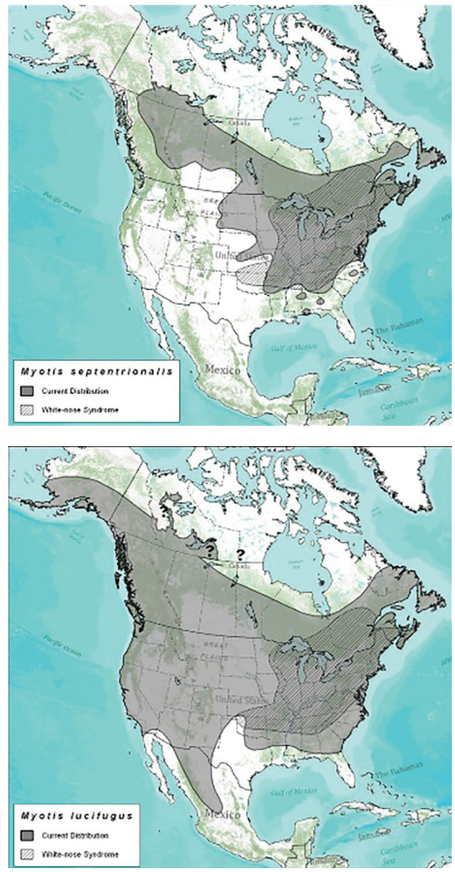


Figure 1. Distribution of Little Brown Myotis and Northern Myotis in Canada, relative to known areas of White-nose syndrome. (SARA registry).

Objectives

The following conservation targets are outlined in the Banff National Park`s Species at Risk Multi-species Action Plan (Parks Canada Agency, 2017):

Site-based Population and Distribution Objectives:

- Maintain current spatial and temporal distribution.
- Protect all known hibernacula and maternity roosts.

Conservation and Recovery Measures:

- Determine the distribution and relative abundance of Little Brown Myotis, with emphasis on identifying hibernacula and maternity roosting sites.
- Limit spread of white-nose syndrome by sharing protocols (such as the Canadian National White-Nose Syndrome Decontamination Protocol) for cave researchers, and maintaining access restrictions, to protect bats and their residences.

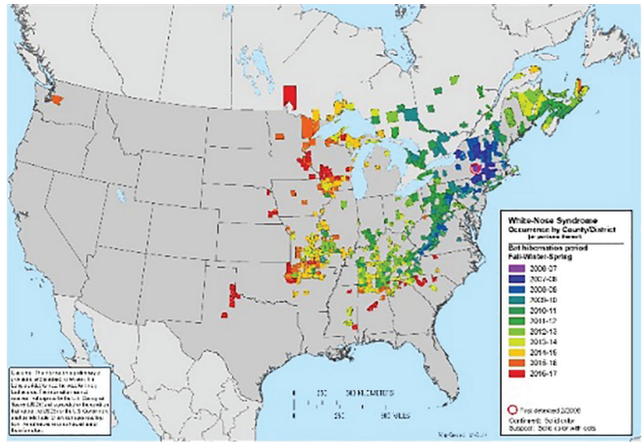


Figure 2. White-nose syndrome occurrence map. *https://www.whitenosesyndrome.org/*

- Adopt best practices for the maintenance or decommissioning of park infrastructure that contains Little Brown Myotis roosts. Work with partners and the community to protect important bat sites in buildings.
- Enhance current communications aimed at raising awareness, and develop targeted communications in support of actions to prevent disturbance, disease transmission, and potential human-caused mortality.

Results

Population monitoring

Outcome: Partial

Since 2015, Parks Canada staff have completed bat inventories to better understand species presence and distribution, abundance, roosting sites and maternity sites.

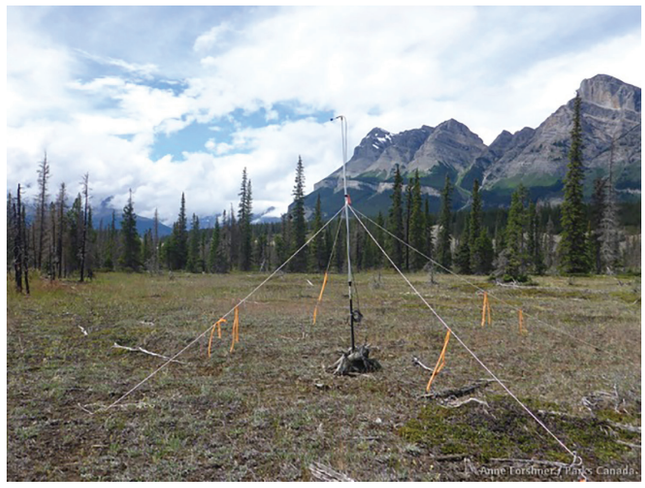


Figure 3. Stationary bat detector at Saskatchewan Crossing. Photo: Anne Forshner/Parks Canada

We used stationary surveys adopted from the North American Bat Monitoring Program (NABat) to survey locations and habitats throughout Banff National Park (Fig. 3 and 4). We also collected mobile transect data from the Bow Valley Parkway and Sunshine access road to contribute to the NABat continental monitoring program (Loeb et al. 2015). The purpose of NABat is to create a continent-wide program to monitor bats at local to range-wide scales that will provide reliable data to promote effective conservation decision-making and the long-term viability of bat populations across the continent (Loeb et al. 2015).

We completed a comprehensive inventory in the Saskatchewan crossing area (Fig. 4). Park staff and volunteers combined acoustic surveys with mist-netting captures. Genetic data from Little Brown Myotis and Long-eared Myotis are being analyzed by a researcher at the University of Calgary to assess patterns of connectivity between bat populations across Alberta, British Columbia and the Northwest Territories.

Results from all surveys indicate there are six species across Banff National Park: Little Brown Myotis, Hoary Bat, Silver-haired Bat, Big Brown Bat, Little Brown Myotis, Long-eared Myotis, and Long-legged Myotis. Northern Myotis was possible based on known distribution, but cannot be reliably separated from other species using acoustic information. Yuma Myotis has been documented recently in Banff National Park but data are still preliminary (Olson, 2017 in progress).

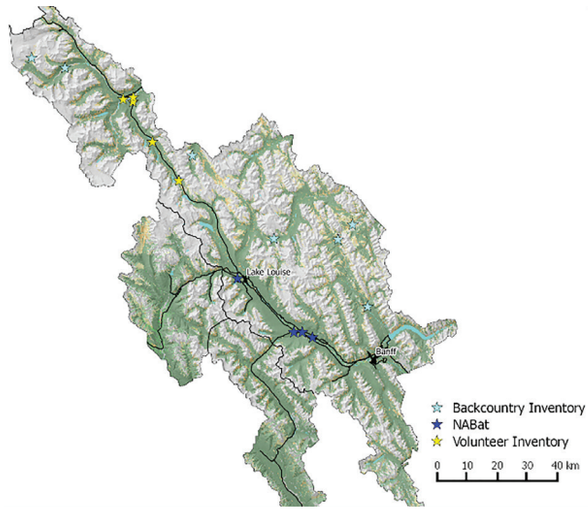


Figure 4: Acoustic survey locations for bats in Banff National Park. Blue stars indicate sites that are monitored to contribute data to NABat. Yellow stars indicate sites that were inventoried by volunteers in 2016. Light blue stars indicate sites that have been opportunistically surveyed in backcountry areas.

Population monitoring in caves and mines to detect hibernation activity

Outcome: Partial

Batcaver and the Wildlife Conservation Society Canada (http://www.batcaver.org/) submitted a research proposal to Mountain National Parks to monitor caves and mines for hibernating bats. Mountain National Parks are reviewing this permit to determine if adequate information can be gathered without entering caves, to eliminate both the risk of spreading white-nose syndrome and of injury to researchers (Parks Canada has no cave rescue response capability).

Hibernaculum and maternity roosts

There is a Little Brown Myotis hibernaculum in a cave off the Icefields parkway in Banff National Park. This site is protected as critical habitat in the Recovery Strategy (Environment and Climate Change Canada, 2016).

In 2016, we found a maternity roost of Little Brown Myotis in a cook shelter at Waterfowl Lakes campground (Fig. 5). This roost was identified through a volunteer bat inventory in the Saskatchewan crossing area (Olson, 2016). We closed the shelter and monitored the site in 2017 with roost loggers to determine the timing of use. We are developing a plan for managing the roost

into the future, in consultation with Asset Management and Visitor Experience. This may include placing bat boxes in the area to provide alternative habitat for the bats, and monitoring use in 2018.

This maternity roost occurs in an older shelter with a cinder block chimney. The female bats and pups roost between the chimney and the wall, presumably to take advantage of the thermal heat retaining properties of the cinder blocks.

There were 2 bat roosts identified in the town of Banff in late summer 2017. It is not clear if they are maternity roosts because monitoring was completed in October after the bat breeding season.

Limit spread of white-nose syndrome by sharing protocols

Outcome: Partial

We are limiting human-caused spread of white-nose syndrome:

- Parks Canada teamed up with the Canadian Cooperative Wildlife Health Centre (CCWHC) to create an online video that documents proper decontamination protocols for those entering caves and mines *https://www.pc.gc.ca/en/nature/science/especes-species/chauve-souris-bats*.
- All caves and mines are closed in Banff National Park under General Regulations Section 8. Anyone entering a cave requires a restricted activity permit, and one condition is that the most current decontamination protocols from CCWHC are followed. All efforts will be made to minimize all permitted cave entry to further reduce the risk of spreading this fungus within Banff National Park.
- Decontamination protocols have also been highlighted in numerous newspaper and radio interviews over the past three years.



Figure 5: Volunteers recording bat calls at the Little Brown Myotis maternity roost at Waterfowl lakes campground. Photo by: Anne Forshner

Adopt best practices for the maintenance or decommissioning of park infrastructure that contains Little Brown Myotis roosts; work with partners and the community to protect important bat sites in buildings

Outcome: Partial

Banff, Yoho and Kootenay have adopted several best practices and guidance documents related to bats in buildings:

- Parks Canada Agency Standards for Managing Bats in Protected Heritage Places,
- National Best Management Practices for Management of Bat Maternity Roosts in Built Assets,
- Banff National Park Pre-Construction Bat Roost Survey Guidelines for Projects Requiring Tree Removal from 15 April to 01 September,
- Fundy National Park Guidance for Inspecting Built Assets for Bats.

These documents have been used recently to manage two bat roosts in the town of Banff and the maternity roost at Waterfowl campground. Pre-construction bat roost survey guidelines are part of current Environmental Assessment review processes.

In Banff Park we have limited knowledge on locations of hibernacula and maternity roosts. Most bats in this area hibernate in caves, so these are currently well protected. We must focus our efforts on locating hibernacula while minimizing entry to caves to avoid risks of disturbance or spreading white-nose syndrome. Most human-caused impacts occur in frontcountry areas where summer maternity roosts occur in buildings. Identifying and managing these sites is a key priority.

Enhance current communications

Outcome: Partial

In 2015 - 2017, Species of Concern Ecologist gave presentations on bats and other species at risk to resource conservation and interpretation staff.

In 2015 - 2017, Species of Concern Ecologist worked with external relations and media to share stories regarding bats, and ongoing work in Banff, Yoho and Kootenay National Parks.

Ongoing media coverage of bat/human conflict related to maternity roosting sites and two recently confirmed cases of rabid bats in BNP; one near Cave and Basin NHS, the other near Lake Louise.

Discussion

With bat distribution data from our acoustic, mist-netting and roost surveys over the past 3 years, we're better positioned to protect Little Brown Myotis (and if necessary other hibernating bat species) once white-nose syndrome arrives. We have acoustic, mist-netting and roost survey data that show Little Brown Myotis occurs widely throughout Banff National Park.

We do not have acoustic, mist-netting or roosting data for Northern Myotis in Banff National Park. Occurrences are possible based on known distribution, but calls of this species cannot be reliably separated from other species (Olson, 2016).

We have some information on maternity roosts and a hibernaculum, but more work remains to identify additional sites.

Future recommended actions towards species conservation targets could include:



Figure 6: *Setting up a mist-net at Saskatchewan Crossing in 2016*

1. Partner with other organizations to look for initial evidence of hibernacula in caves and mines in Banff while avoiding human intrusions into caves as this has the potential to accelerate the dispersal of White-nosed Syndrome via human vectors. Research partners have expressed interest in inventorying cave environments in Banff National Park. However before entering caves (which carries the risk of spreading white-nose syndrome) we will first focus on completing a park-wide inventory by placing detectors at entrances to caves and mines to look for evidence of swarming, which could indicate hibernation.
2. Develop and distribute clear written information to key stakeholders and leaseholders so they understand the current status of these species and what they must do (or not do) should they encounter bats in or near facilities they own or manage.
3. For bat roosts in buildings scheduled to be decommissioned, consider installing and monitoring success of bat boxes as alternative habitat, particularly if little adjacent roosting habitat is available. However, bat boxes are experimental. 'Further investigating the use of bat boxes to mitigate loss of anthropogenic or natural roosting structures' is listed in Appendix B – Further Research Needs - of the Recovery Strategy (Environment and Climate Change Canada, 2017).
4. Complete volunteer inventories in south Banff National Park using acoustic, mist-netting (Fig. 6), and roost surveys. Acoustic monitoring devices are a powerful tool for bat species inventories however, they are limited in their accuracy of identification of bats by species. Lemen et al. (2015) highlighted poor agreement (40%) between four different software programs when identifying calls by bat species. A combination of mist-nets, acoustic surveys and roost surveys should be used to accurately inventory species composition of bat communities (O'Farrell and Gannon 1999, Flaquer et al. 2007).
5. Complete a systematic inventory of known maternity roosts in frontcountry areas, where conflict with human activity is most likely. As a secondary priority, complete similar surveys in backcountry areas to get a better picture of habitat use across higher elevations and remote areas.
6. Contribute data to North American Bat Monitoring Program when their online site becomes operational.

7 Adjust time periods indicated in best management practices based on new information as it becomes available. In 2017, we had evidence that various bat species were still migrating and occupying building roosts at the end of October (Olson, 2017 in progress). Current guidelines recommend 'deferring projects so they will take place between September and April when bats are not roosting in the work location'.

8 Enhanced communication with wider range of Parks Canada staff. Continue to work with Parks Canada's External Relations staff to share results of inventory work, and decontamination protocols to prevent the human transmission of white-nose syndrome to Banff National Park.

All of North America's hibernating bats are at risk of developing white-nose syndrome. While there are only 3 species listed currently, more species could be affected as white-nose syndrome spreads across the country. Experts believe that without action, Canada could lose all of its cave-dwelling bats (Parks Canada, 2016). White-nose syndrome has not been documented yet in Banff National Park.

In 2017, we identified 2 cases of rabies in silver-haired bats in Banff National Park. On average, 4-6 cases of rabid bats are reported in Alberta each year (Margo Pybus, personal communication). How we communicate about bats with rabies could have significant effects on public support for bat conservation and recovery.

Acknowledgements/Partners

Ecological Integrity Monitoring and Species of Concern staff from Banff Field Unit and Lake Louise, Yoho and Kootenay Field Unit completed inventory work in Banff National Park. Specifically, Anne Forshner from LLYK has lead much of this work for both field units.

The volunteer inventory at Saskatchewan crossing involved the following individuals and organizations: Cory Olson (Sky Ecological Consulting / Coordinator for AB Community Bat Program – Volunteer Survey Coordinator), Dave Hobson (Alberta Fish and Wildlife), Erin Low, Geoff Skinner (Parks Canada), Anne Forshner (Parks Canada), Joanna Burgar (Alberta Fish and Wildlife), Kelsey Low, Lisa Wilkinson (Alberta Fish and Wildlife), Lizelle Odendaal (University of Calgary), Lynne Burns (Canadian Wildlife Service), Meaghan Bouchard, Michael Kelly, Sara Pearce-Meijerink (STRIX Ecological Consulting Ltd.) and Susan Holroyd. Equipment used during the inventory was provided by Delanie Player (Matrix Solutions Inc.), STRIX Ecological Consulting Ltd, Susan Holroyd, Cory Olson, Parks Canada, and others.

Cory Olson, Greg Horne and Saakje Hazenberg analyzed call data.

Contact

Dr. Bryan Macbeth, Wildlife Ecologist for Species of Concern
Banff Field Unit
P: 403-762-1482
E: *Bryan.Macbeth@pc.gc.ca*

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SARA STATUS:
THREATENED

Westslope Cutthroat Trout

ABILITY TO INFLUENCE STATUS IN BANFF NATIONAL PARK: MODERATE

Introduction

Westslope cutthroat trout (*Oncorhynchus clarkii lewisi;* Figure 1*)* were historically distributed from the southern Rocky Mountain drainages of British Columbia, Alberta, to Montana and Idaho in the south. Isolated populations also exist in Oregon and Washington (Behnke 1992). However, anthropogenic changes to habitat, stocking of non-native fish, increased competition, and gene introgression from non-native species such as rainbow trout *(Oncorhynchus mykiss*) have pushed westslope cutthroat trout into headwater streams or lakes that encompass only 25% of their native range. (The Alberta Westslope Cutthroat Trout Recovery Team 2012; COSEWIC 2006; Mayhood 1995). Of the estimated 157 populations of genetically pure (≥ 0.99 westslope cutthroat trout genes) westslope cutthroat trout that existed historically in Alberta, only 45 remain in 5% of their original range (The Alberta Westslope Cutthroat Trout Recovery Team 2012; Mayhood 1995, 2009). Of these, only 10 "core" populations are thought to exist in Banff National Park; these are genetically pure populations occurring in their native waters (not stocked).

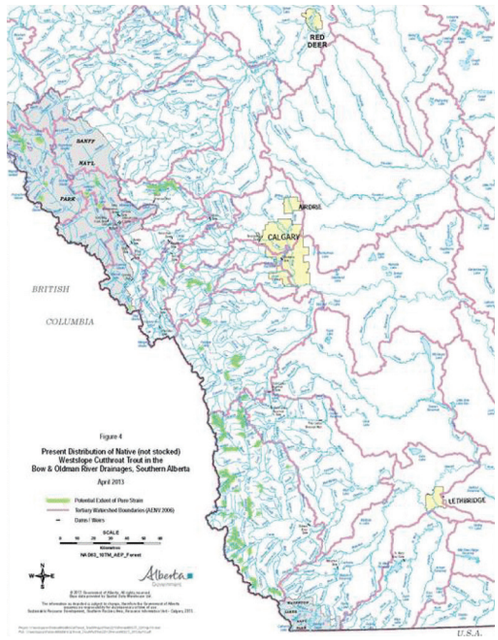


Figure 1. Present distribution of Westslope Cutthroat Trout in Alberta (Alberta recovery plan, 2013).

In 2009, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Alberta westslope cutthroat trout and listed them as threatened due to the drastic decrease in distribution, severely fragmented populations, continued habitat destruction, and presence of barriers to natural dispersal. In 2013, Alberta westslope cutthroat trout were listed as threatened under the *Species at Risk Act* (SARA).

Objectives

The following conservation targets are outlined in the Banff National Park Species at Risk Multi-species Action Plan (Parks Canada Agency, 2017):

Site-based Population and Distribution Objectives:



Figure 2. Pure Westslope cutthroat trout from Marvel Lake, Banff National Park.

- To protect and maintain the existing ≥ 0.99 pure populations of westslope cutthroat trout at self-sustaining levels and re-establish additional pure populations to self-sustaining levels, within the species' historic range in Banff National Park, using the following broad strategies and recovery actions.

Conservation and Recovery Measures

Conduct research on the ecology and genetics of westslope cutthroat trout to help identify critical habitat, understand threats and develop restoration techniques.

- Conduct inventory/mapping to determine distribution of pure westslope cutthroat trout vs hybrids. Identify potential new critical habitat. Identify candidate sites for protection and restoration.
- Remove non-native fish populations, if logistically feasible, when and where they threaten westslope cutthroat trout via hybridization or direct competition.
- Re-introduce westslope cutthroat trout as habitat is made available within the historic range.
- Enhance current communication products aimed at increasing awareness and reducing human-caused impacts on westslope cutthroat trout.

Previous to the Multi-species Action Plan, we had developed a joint recovery strategy in 2012 in conjunction with Alberta Environment and Parks and the Department of Fisheries and Oceans Canada. In that document four strategies and actions were chosen to aid in the recovery of the species.

1. Research
2. Monitoring
3. Management and regulation; and
4. Education and outreach

Results

Progress towards achieving recovery actions

Research

- We used environmental DNA analysis, from lake sediments, to discover that Marvel and Mystic Lakes historically contained native westslope cutthroat trout (See Figure 2 and 3). As these populations remain genetically pure, they are now protected under SARA.
- We are currently sampling for the presence of *Tubifex tubifex* worms in westslope cutthroat trout critical habitat. The distribution of these worms will determine the susceptibility of westslope cutthroat trout populations to whirling disease, a non-native salmonid parasite that has dispersed throughout much of Alberta predominately through retail of untested farmed fish.

Monitoring

- In 2015, we initiated an electrofishing-based stream fish occupancy survey that standardises sampling efforts across Banff National Park based on best sampling practices, statistical rigour and consistency with other regions. Prior to this, we lacked appropriate survey data to quantitatively determine population trends.
- We sampled three watersheds in Banff National Park.
- We initiated and hosted an international westslope cutthroat trout Genetics Workshop, at Banff, in 2017 to better standardize genetic and sampling methods throughout the westslope cutthroat trout range. Discussion was led by genetic experts from the University of Montana, University of Alberta, University of British Columbia, University of Calgary, and Montana Fish, Wildlife, and Parks. Participants included members from: Dept of Fisheries and Oceans, Ab Environmental Protection, Parks Canada, BC Ministry of Forests, Lands and Natural Resource Operations, and the United States Geological Survey.
- The University of Montana is developing a RADcapture genomic technique. Researchers are using genetic material from westslope cutthroat trout, and closely related species throughout their entire range (e.g. Yellowstone cutthroat trout, rainbow trout, golden trout, and CCTR) to determine appropriate markers that can be used by management agencies to distinguish between pure westslope cutthroat trout and various hybrids.

Management and regulation

- In 2016, we closed all westslope cutthroat trout critical habitat in Banff National Park, in response to the discovery of whirling disease in the Bow River watershed. Risk analysis to inform the long term status of these closures is underway; focussed on surveys to map the distribution of tubifex worms – which are the intermediate host of the whirling disease.
- Additionally Banff Park has banned all felt-soled waders, restricted access to a the Minnewanka boat launch, and adopted zero possession limits for fishing, at all waterbodies

(except lake trout in Minnewanka) to further reduce the spread of whirling disease and other aquatic invasive species.

- We are attempting to remove all fish from Johnson Lake reservoir which was impacted by whirling disease (apparently through the dispersal of non-native brown trout), to eradicate whirling disease from this waterbody. This work is a priority due to proximity to the upper Cascade watershed and several core westslope cutthroat trout populations.
- We mechanically removed all non-native rainbow trout from Rainbow Lake and Rainbow Creek (2011-2014). This effectively stopped the one source of rainbow trout in the upper Cascade watershed.
- We then introduced pure westslope cutthroat trout from Sawback Lake into Rainbow Lake (2015) with the support of volunteers from Trout Unlimited. Rainbow Lake is now listed as a conservation westslope cutthroat trout population. Some of these fish will migrate downstream into Sawback Creek and contribute pure westslope cutthroat trout genes to the local population.
- We mechanically removed non-native rainbow trout and hybridized cutthroat trout from Sawback Creek (2011-2014). This shifted the population's overall q-value above 0.99 (genetic purity). Sawback Creek can now be listed as Banff's 11th "core" population of westslope cutthroat trout.
- We mechanically removed the entire population of over 23,280 non-native brook trout from middle Cascade Creek below the Minnewanka reservoir (2011-2016) and are working with TransAlta to restore hydrological conditions suitable for westslope cutthroat trout reintroduction.
- We are currently removing brook trout from Hidden Lake, near Lake Louise, to prevent downstream movement of brook trout into westslope cutthroat trout habitat.
- We collaborated with the Town of Banff to remove a portion of the Forty-Mile Creek dam (2014) creating a man-made fish-way, which restored connectivity for westslope cutthroat trout and bull trout; allowing access to over 35km of spawning habitat that had been inaccessible for almost a century because of the concrete dam.
- We are assessing other locations in Banff National Park as potential candidates for future removal projects to help protect westslope cutthroat trout populations. Badger Lake, for example, is the last lake containing non-native fish in the upper Cascade watershed. Parks Canada plans to remove this population of brook trout in 2018.
- We are assessing the potential of re-introducing pure westslope cutthroat trout into Cascade Creek, below Lake Minnewanka once the habitat restoration is completed.

Education and outreach

- We created an educational video on the Rainbow Lake restoration project. The video, available in French and English, has been submitted to the 2018 Fly-fishing film festival.

- A number of Parks Canada planning forums have been held in Banff to inform the public about westslope cutthroat trout research and management in Banff National Park.
- Parks Canada interpreters have developed and delivered an evening play at the Tunnel Mountain campsite during the summers of 2014 and 2015 to engage the public in westslope cutthroat trout conservation.

Progress towards population distribution objectives

The site-based population and distribution objectives for this species are to protect existing pure populations and re-establish new ones within the species historic range. As directed by the Multi-species Action Plan, we have increased the number of native, pure westslope cutthroat trout populations in Banff National Park from 10 to 13. Previously misidentified as stocked populations, we have now correctly identified Marvel and Mystic Lakes as native fish populations, through a novel approach using environmental DNA research (Figure 2). The third new pure westslope cutthroat trout population in Banff National Park is Sawback Creek which we restored by genetically assessing selectively removing individual rainbow trout and rainbow trout x westslope cutthroat trout hybrids. Therefore, our recovery efforts over the last decade have directly contributed to the recovery of this species.

The success of our projects has provided impetus for other similar projects throughout the Alberta range of westslope cutthroat trout. We will continue to prioritize other near-pure westslope cutthroat trout populations for restoration.

While hybridization with rainbow trout and displacement from brook trout remain major threats to the persistence of westslope cutthroat trout in Banff National Park, the discovery of whirling disease in Alberta adds another threat to native salmonids. We identified the protozoan, *Myxobolus cerebralis*, which is the causative agent for whirling disease, in Johnson Lake in August 2016. This was the first documented case in Canada. The close proximity of Johnson Lake to pure populations of westslope cutthroat trout triggered the closure of all westslope cutthroat trout critical habitat in Banff National Park. Research identifying the distribution of Tubifex worms (*Tubifex tubifex)*, the secondary host of *Myxobolus cerebralis*, in westslope cutthroat trout critical habitat will help identify areas in Banff National Park where whirling disease has the potential to exist. Furthermore, advancements in environmental DNA research may provide a non-lethal sampling technique to better understand the extent of the disease into westslope cutthroat trout habitat. We are currently sampling sediment, from westslope cutthroat trout critical habitats, to better understand the risk of whirling disease impacting these populations.

In order to measure our progress at recovering westslope cutthroat trout, quantitative population estimates that can be repeated in time, need to occur. Unfortunately, our knowledge of population distributions and abundances is limited because systematic surveys were not conducted. In 2015, we began stream fish occupancy surveys on three watersheds in Banff National Park, which are extremely successful at quantifying the distribution of both native and non-native fishes in Banff National Park. Expanding these surveys and repeating them over

time will provide quantitative estimates of westslope cutthroat trout distributions and abundance. Complementary stream temperature models further explain the distribution of native and non-native fishes. We are in the process of using the fish occupancy and temperature data to map areas that will be the most vulnerable to the threat of climate change and the interaction between climate change and non-native species. Our quantitative monitoring program can also track the success of restoration projects. Considering the challenges ahead, we will diligently maintain a long term database of fish occurrences and temperature to provide a model for evidence-based conservation that can be applied in other jurisdictions.

Our ongoing restoration efforts keep Parks Canada on the leading edge of westslope cutthroat trout recovery. More specifically, the continued eradication effort of brook trout from Hidden Lake will help to protect westslope cutthroat trout populations in the upper Bow River drainage. Additional lakes in the Lake Louise area are under consideration for future non-native fish removals. Further, Badger Lake contains the last brook trout population in the upper Cascade River drainage and we are planning for full removal of these non-native fish to secure the genetic integrity of this important watershed.

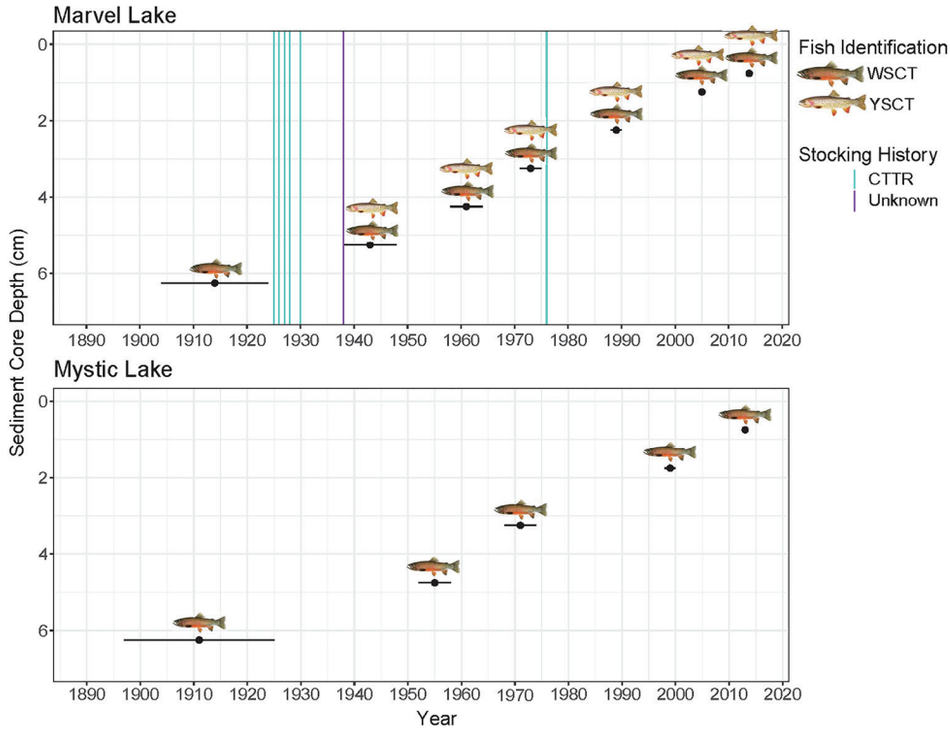


Figure 3. Historical fish presence in Marvel and Mystic Lakes. Paleolimnological aeDNA analysis revealed a shift in species composition following the introduction of fish in Marvel Lake in the mid to late 1920s. Points are stratigraphically plotted using Pb-210 radioisotopes. Horizontal error bars represent all possible error in the dating process. Fish presence/absence for each point is illustrated with an icon of westslope cutthroat trout (westslope cutthroat trout) and/or yellowstone cutthroat trout (Yellowstone cutthroat trout). Vertical bars represent individual stocking events with colors respective of different fish species. As sub-species data was not present in original stocking reports, CTTR represents all cutthroat trout variants.

Acknowledgements/Partners

Parks Canada Agency
Fisheries and Oceans Canada
Alberta Environment and Parks
University of Alberta
University of British Columbia
University of Calgary
University of Montana
BC Ministry of Forests, Lands and Natural Resource Operations
United States Geological Survey

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: (403) 762-1418
E: *mark.taylor@pc.gc.ca*

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SARA STATUS:
THREATENED

Woodland Caribou

ABILITY TO INFLUENCE STATUS IN BANFF NATIONAL PARK: MODERATE

Introduction

Woodland caribou *(Rangifer tarandus caribou)* are declining across much of Canada. The Southern Mountain population, which includes caribou from Banff, Jasper, Mount Revelstoke, and Glacier National Parks, are classified as *Threatened* under the Species at Risk Act (Environment Canada 2014). Caribou were extirpated from Banff National Park in 209.

Caribou survive best in areas with few other prey species and low probability of encountering predators such as wolves. In the Canadian Rocky Mountains, caribou generally occur along high, rolling alpine meadows during summer and some migrate to lower elevations or east to the Foothills in winter (Figure 1). Predation risk to caribou generally increases when old growth forests are converted into young forests that support more deer and moose and thus increased wolf density. Predation risk also increases when roads or trails facilitate wolf access into caribou range (Whittington et al. 2011). Other threats to caribou in national parks include small population dynamics, habitat loss, and direct disturbance (Parks Canada 2011).

Historically Banff had a small sub-population of 25-40 caribou. The sub-population declined to 5-10 animals by the mid-1990s, likely because of small population effects and wolf-mediated apparent competition with elk (Hebblewhite et al. 2007). Decades of predator control created an unnaturally high population of elk. Wolf density

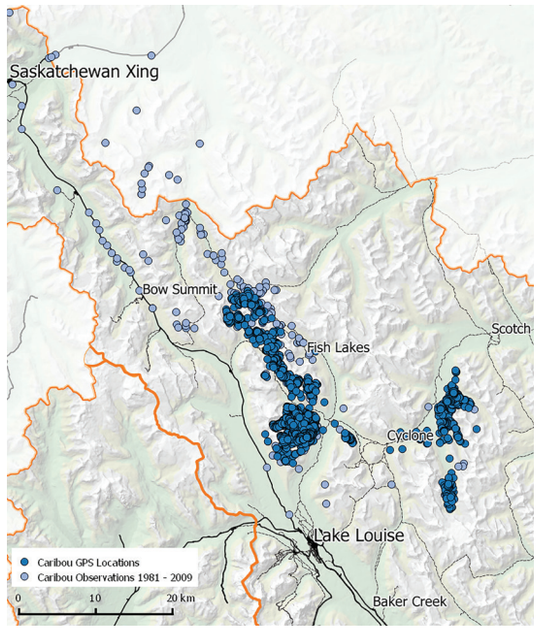


Figure 1. Caribou locations from Banff National Park .



Figure 2. Male Woodland caribou during the fall rut.

increased to 6 wolves per 1000 km^2 when wolves recolonized Banff in the late 1980's and early 1990's, which likely increased predation rates of caribou. In spring 2009, an avalanche killed the remaining four animals in Banff National Park.

Regionally, caribou in Jasper and Mount Revelstoke Glacier National Parks have also declined and are unlikely to persist without population augmentation (Wittmer et al. 2010, DeCesare et al. 2011, Neufeld and Bisaillon 2017). While re-introduction is a recovery option for Banff National Park, source populations are scarce and translocated animals face high risks of mortality (Boutin et al. 2016). Thus, Banff is supporting Jasper National Park's investigation of alternative options including the development of a captive breeding facility to provide a stable source of caribou for population augmentation. If caribou become available for population augmentation or re-introduction, they should be placed where they have the highest likelihood of survival and the greatest conservation value. Thus, Banff National Park and other jurisdictions are monitoring predator-prey dynamics in caribou range to evaluate the likelihood of translocation success and the potential contributions to broader caribou conservation.

Objectives

Site-based Population and Distribution Objectives – from the Multi-Species Action Plan (Parks Canada Agency 2017)

- For the Jasper/Banff National Park Local Population Unit, achieve stable to increasing numbers to a minimum of 100 animals (as defined in the Southern Mountain Caribou Recovery Strategy) as a step towards achieving self-sustaining local herds in which natural processes (dispersal, migration) can occur. Where caribou have been extirpated, examine opportunities for restoration.

Conservation and Recovery Measures – from the Multi-Species Action Plan (Parks Canada Agency 2017)

- Work with partners to determine next steps for augmentation of the Jasper/Banff Local Population Unit in Jasper National Park, and investigate the feasibility of re-introduction within the historic range in Banff National Park. Prioritize actions based on assessment of conditions including predator-prey dynamics, predation risk, and translocation recovery priority of other caribou populations (e.g., British Columbia).

Results

Wolves are a primary predator of caribou (DeCesare et al. 2014, Environment Canada 2014, Neufeld and Bisaillon 2017). On-going monitoring of wolves and other prey species (deer, elk, moose, bighorn sheep and mountain goats) will inform future caribou recovery efforts. We have

tracked changes in wolf abundance and movements in Banff National Park, using a combination of remote camera, snow tracking, and GPS radio-collar data. Wolf densities in historical caribou range and the surrounding 20 km predation zone have averaged 2.25 wolves per 1000 km² (SD = 0.79) since 2007 (Figure 3, for methods see Wolf Density and Predation) and has generally been below the target of 3 wolves per 1000² set in the Southern Mountain Caribou Recovery Strategy (Environment Canada 2014). However, the Red Deer and sometimes the Bow Valley wolf packs summered in core caribou range near Pipestone Pass and frequently travelled through all high elevation meadows.

An analysis of GPS data suggests the probability of caribou encountering wolves was much higher in Banff compared to Jasper sub-populations (Whittington et al. 2011). Graphically, raw encounter rates of wolves, grizzly bears, and deer on remote cameras were higher in Banff compared to the Maligne-Brazeau and Tonquin sub-populations (Figure 4), which suggests higher caribou predation risk for Banff. An in-depth analysis of remote camera data from Banff and Jasper National Parks would help quantify how predator-prey use of caribou range has changed over time for each caribou sub-population. This analysis would help determine whether conditions for caribou persistence have improved.

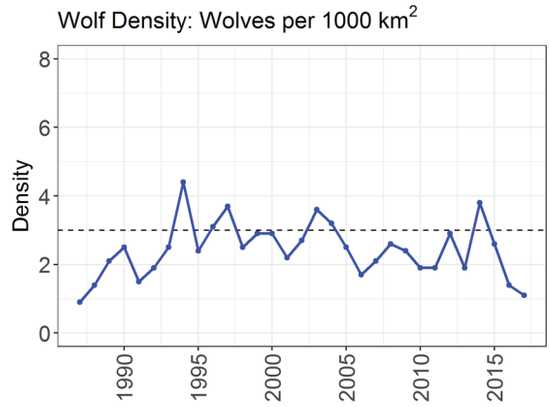


Figure 3. Wolf densities in caribou range, Banff National Park.

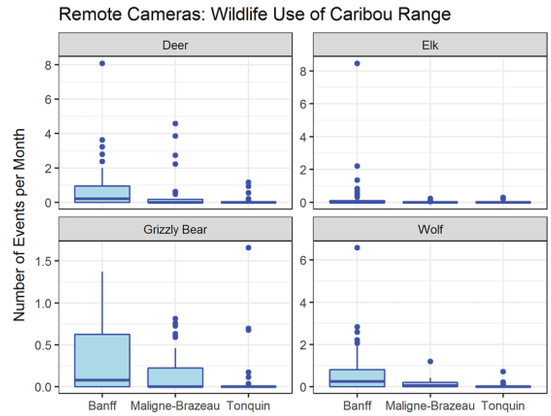


Figure 4. Remote camera raw detection rates of wolves, grizzly bears, elk, and deer in core caribou range for Banff and Jasper (Maligne-Brazeau and Tonquin).

The Southern Mountain Caribou Recovery Strategy (section 7.1) applies three types of critical habitat to caribou in Banff National Park (Environment Canada 2014). Draft maps of critical habitat have been submitted to Environment Canada (Figure 4).

1. High Elevation Range within the local population unit boundaries. For Banff National Park this is core habitat where caribou occurred since 1981.
2. Type I matrix is connectivity habitat within annual high elevation ranges.
3. Type II matrix is a predation zone surrounding high elevation range. Wolves have large home ranges that encompass areas both inside and outside of caribou high elevation habitat. Predator-prey dynamics adjacent to high elevation habitat can affect caribou survival and recruitment rates. Type II matrix strives for an overall ecological condition with low

predation risk, defined as wolf densities less than 3 wolves per 1000 km^2. Given wide ranging wolf movements, Type II matrix includes areas within a 20 km of high elevation range.

COSEWIC recommended in 2011 that the Southern Mountain Caribou be divided into three designatable units based on genetics and evolutionary history (COSEWIC 2011). In 2014, COSEWIC assessed the three units as Southern (*Endangered*), Central including Jasper and Banff (*Endangered*), and Northern (*Special Concern*) (Figure 6).

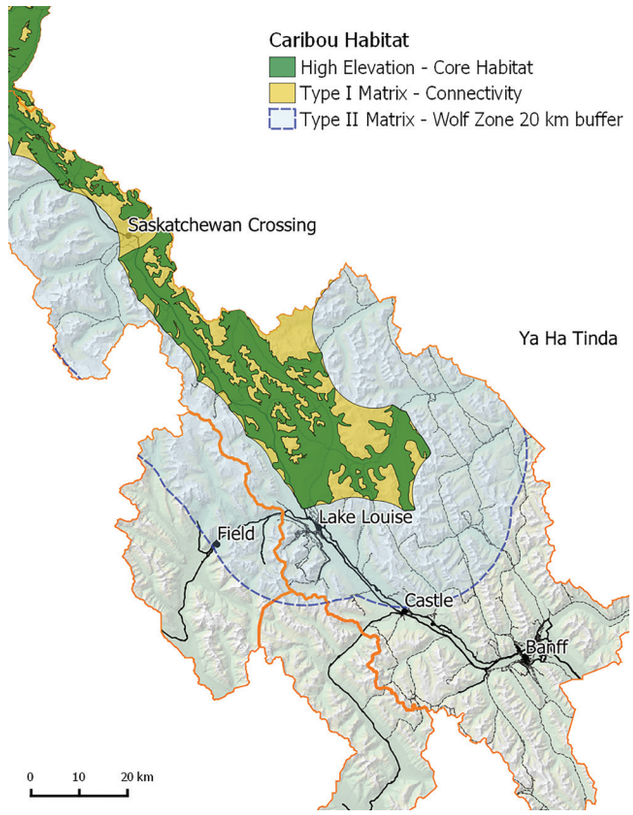


Figure 5. Draft caribou habitat zones for Banff National Park.

Discussion

Southern Mountain Woodland caribou have struggled, especially within the southern portion of their range where most sub-populations are declining and many have fewer than 20 animals. Most of the subpopulations have low probability of persistence because of poor survival rates and of small population effects (demographic stochasticity) that have stronger effects as populations drop below 100 animals (Wittmer et al. 2010).

Population augmentation or re-introduction through translocation can improve population viability. Challenges with translocations are that: a) large, stable source populations are scarce, b) potential source populations in northern British Columbia may differ in terms of genetics, movement, and survival strategies, and c) translocated animals face high rates of mortality. Given the large number of struggling sub-populations and the lack of source populations, Jasper and Banff National Parks investigated the feasibility of developing a captive breeding facility that could supply a steady source of animals to augment wild populations (Parks Canada 2011). Challenges with developing a captive breeding facility include site-based logistics and high mortality rates of predator-naïve caribou when released into the wild.

Banff National Park will continue to support Jasper National Park's broader caribou conservation initiatives and potential development of a captive rearing facility. Within Banff National Park, the current state of predator densities, alternate prey trends, wolf-caribou overlap, caribou numbers, habitat extent, and historic population size suggests that population augmentation would have a greater conservation value in Jasper National Park.

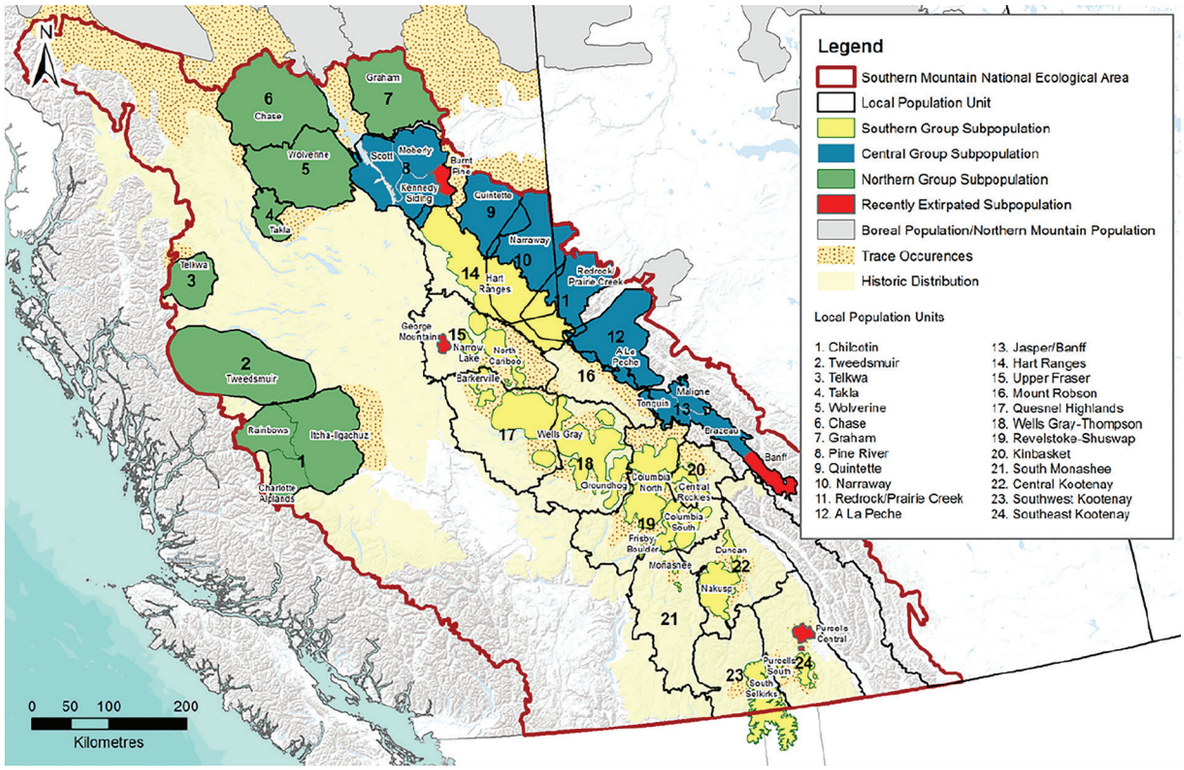


Figure 6. Current distribution of southern mountain caribou local population units and subpopulations (Environment Canada 2014).

Acknowledgements/Partners

Prepared by Jesse Whittington. Resource Conservation staff from Banff, Kootenay, & Yoho National Parks collected remote camera data. Jean-Francois Bisaillon, Lalenia Neufeld, and Mark Bradley from Jasper National Park collected caribou and wolf data. Mark Hebblewhite and Nick DeCesare from the University of Montana analysed factors affecting caribou habitat quality, predation risk, and translocation success.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403) 763-8865
E: *jesse.whittington@pc.gc.ca*

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SARA STATUS:
THREATENED

Common Nighthawk

ABILITY TO INFLUENCE STATUS IN BANFF NATIONAL PARK: LOW

Introduction

Common Nighthawk *(Chordeiles minor)* is a medium-sized grey-brown bird usually seen or heard, overhead, at dusk and dawn; with long pointed white-barred wings and unique bounding flight (Figure 1). The species breeds across Canada and the USA and winters in South America (Figure 2). It is listed as Threatened on Schedule 1 of the federal Species at Risk Act (SARA), because of significant long- and short-term declines across the portion of its range covered by bird population monitoring programs (Environment Canada, 2016).

Common Nighthawk nests on the ground in open land or forest clearings, and forages on insects in a wide range of habitats (Environment Canada, 2016).

Many threats to Common Nighthawk have been postulated, but there are few data to directly link a single threat to observed population declines. The threats to the species are found within the following categories: natural system modifications (e.g., reduced insect prey and fire suppression), habitat loss and degradation, climate change and severe weather, accidental mortality, pollution, and problematic native and invasive non-native species (Environment Canada, 2016).



Figure 1. Breeding, migrating and winter distribution of Common Nighthawk (adapted from BirdLife International and NatureServe (2014), using data from Haché et al. (2014), and eBird (2014)).

Objectives

The following conservation targets are outlined in the Banff and Kootenay National Park Species at Risk Multi-species Action Plan (Parks Canada Agency, 2017).

Site-based Population and Distribution Objectives:

- Maintain occupancy of Common Nighthawk at confirmed sites in appropriate habitat in the park. Nests and birds are currently protected by the Canada National Parks Act and the Migratory Birds Convention Act.

Conservation and Recovery Measures:

- Implement measures (e.g. best management practices, seasonal closures if required) to protect known nest sites and known nesting habitat from destruction or disturbance.
- Identify breeding and nesting sites opportunistically, targeting high probability sites, and encourage the public to share observations.

Results

Population Monitoring - Incidental Observations

There are two sources of incidental observations for Common Nighthawk in Banff National Park:

1 Banff National Park Wildlife Observation Master database.

2 eBird Observation database - global

There are two general areas where Common Nighthawk have been sighted over the past 10 years: the urban areas of Lake Louise and Banff in Banff National Park (Figure 3).

Between 2007 and 2017:

- In the Lake Louise area, there was 1 observation reported to eBird.
- In the Town of Banff area, there were 2 observations reported to eBird and 1 observation by Park staff.



Figure 2. Common Nighthawk. Photo by Larry Halverson.

We have not recorded calls from these birds on our acoustic breeding bird transect surveys that form part of our long-term ecological integrity condition monitoring program.

Conservation and Recovery Measures

1 Implement measures to protect known nest sites and known nesting habitat from destruction or disturbance

a We have no data on nesting locations of Common Nighthawk. However, if any nests are found or reported, we will protect these from disturbance and destruction. Outcome – ***Partial***.

2 Identify breeding and nesting sites opportunistically, targeting high probability areas, and encourage the public to share observations.

a We have not communicated widely with regards to status of Common Nighthawk, nor have we encouraged the public to share observations. To date, communication efforts have focused on encouraging Park staff to report observations. Outcome – ***Not Initiated***

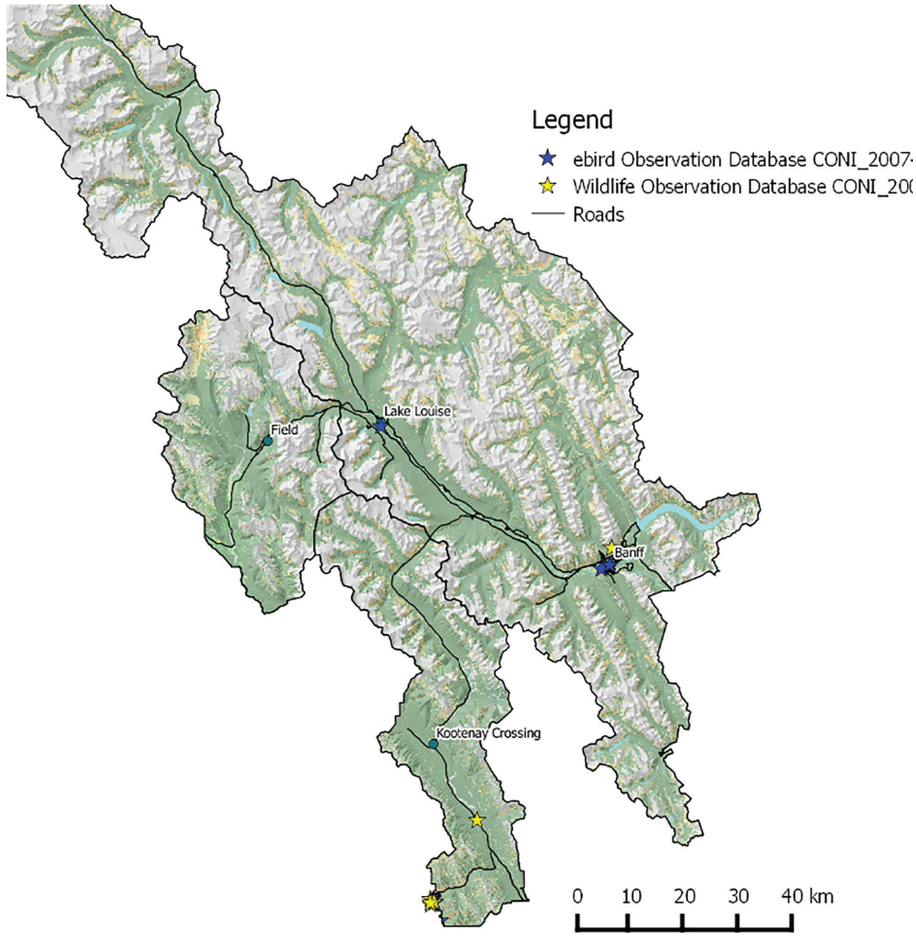


Figure 3. Common Nighthawk observations in eBird Observation Database and Banff, Yoho and Kootenay National Parks Wildlife Observation Database, 2007 – 2017. CONI is Common Nighthawk

Discussion

There is very little known about Common Nighthawk in Banff or Kootenay National Parks, nor are there many reported sightings of these birds. However, we have not done comprehensive surveys in targeted areas. The multi-species action plan commits to three very general approaches to protection and recovery (Banff Multi-Species Action Plan, 2017):

- Opportunistically identify nest sites and bird activity. Focus efforts in areas where nest protection measures may improve nest success.
- Outreach, education and potential seasonal activity restrictions to help prevent accidental nest destruction from off-trail recreation and to limit disturbance in confirmed breeding areas.
- Fire and invasive plant management programs to contribute to enhancing nesting habitat.

Through the Research and Collection Permit system, Banff National Park can facilitate research and monitoring projects initiated by other agencies or through Universities to improve our understanding of this species and the factors affecting its distribution and abundance.

Contact

Anne Forshner, A/Wildlife Ecologist for Species of Concern
Lake Louise, Yoho and Kootenay Field Unit
P: 403-431-1795
E: *Anne.Forshner@pc.gc.ca*

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SARA STATUS:
ENDANGERED

Olive-sided Flycatcher

ABILITY TO INFLUENCE STATUS IN BANFF NATIONAL PARK: LOW

Introduction

The olive-sided flycatcher *(Contopus cooperi)* is a medium-sized, migratory songbird that breeds in Canada's forests. The species nests in open coniferous or mixed-wood forests, often located near water or wetlands with the presence of tall snags (Environment Canada 2016). Olive-sided flycatcher's range for breeding, migrating and wintering extends through much of North, Central and South America (Figure 1, Environment Canada 2016).

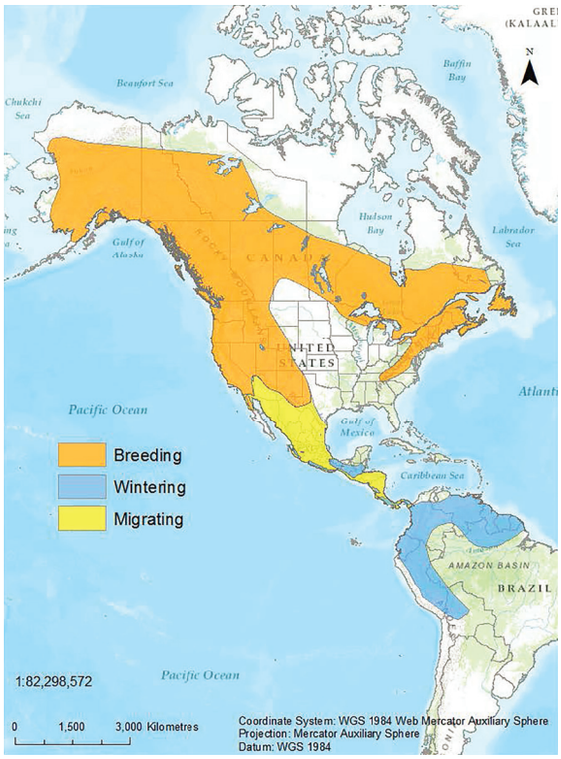


Figure 1. Breeding, migrating, and wintering distribution of olive-sided flycatcher (adapted from BirdLife International and NatureServe (2014), using data from Haché et al. (2014), and eBird (2014)).

The causes of population declines are not well understood, although several possible factors have been identified. Probable threats include reduced availability of insect prey, fire suppression, deforestation and land conversion, forest harvesting and silviculture, energy and mining exploration and extraction, and residential and commercial development (Environment Canada 2016). The significance of each threat varies across the olive-sided flycatcher's geographical range.

Olive-sided flycatcher's (Figure 2) are found throughout Banff National Park during the breeding season, and are monitored through acoustic songbird surveys that are part of the long-term ecological integrity condition monitoring program across the Mountain National Parks.

Objectives

The following conservation targets are outlined in the Banff National Park's Species at Risk Multi-Species Action Plan (Parks Canada Agency, 2017):

Site-based Population and Distribution Objectives

- No objectives established: Nests and birds are protected by the Canada National Parks Act and the Migratory Birds Act. Fire management practices may provide more nesting habitat. Banff is of limited importance to the species national recovery. Nests and birds are currently protected by the Canada National Parks Act and the Migratory Birds Convention Act.

Conservation and Recovery Measures

- No specific conservation and recovery measures are listed other than 'all species' measures that are the same for all listed threatened and endangered species addressed in the document.



Figure 2. Olive-sided flycatcher. Dominic Sherony *learningcommons.org*

Results

Population Monitoring

We surveyed for olive-sided flycatchers and other songbirds using acoustic recording devices from 2007 through 2016. We surveyed 307 sites within Banff National Park, with a median value of 144 sites surveyed per year and 42% of the sites were surveyed for at least 5 years. We detected olive-sided flycatchers at 118 of the 553 sites (21%). We assessed trends for olive-sided flycatchers using a hierarchical occupancy model. Occupancy (distribution) related covariates included landcover type, indices of productivity, year, and random effects for sites. Covariates for detection probability included time since sunrise and sound quality. We modelled detection probability using time-to-first event analyses (Whittington et. al *in prep.*).

Point estimates for the proportion of sites occupied varied from 2008 through 2016 (Figure 4). Overlapping 95% CI's suggest an insignificant change in overall occupancy. Occupancy was positively influenced by temperature. Model covariates indicated that occupancy rates increased with temperature, at southern latitudes, below alpine, and in areas with herbaceous meadows, shrubs, and deciduous forests (Figure 5). Detection probability decreased with time since sunrise and increased when there was little background noise from wind and moving water. The model had good overall fit with a Bayesian p-value of 0.79. Future models could be improved by including fire history and severity data.

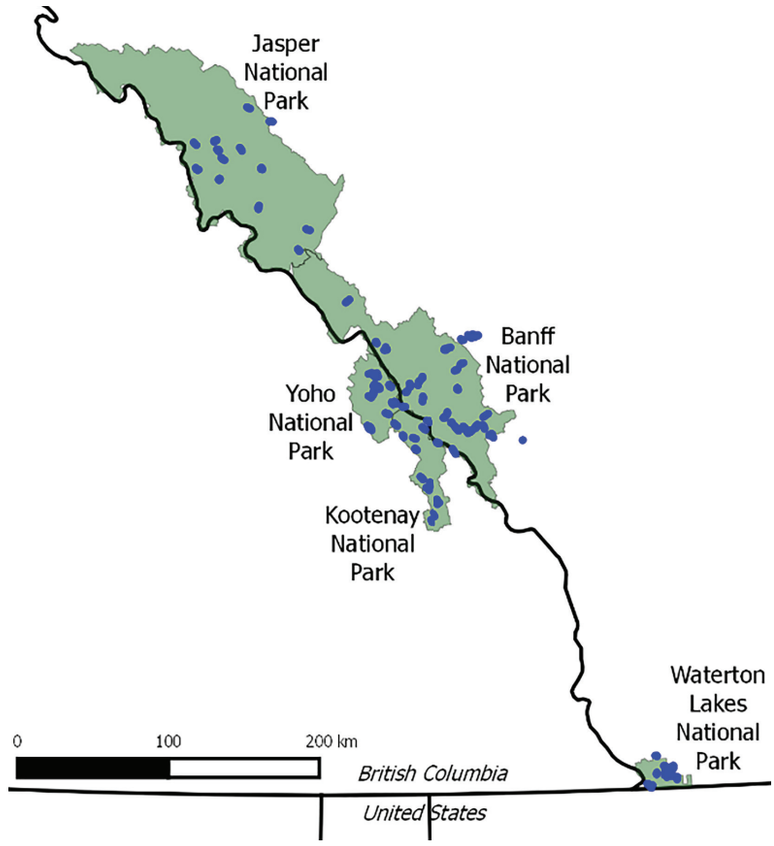


Figure 3. Map showing the distribution of acoustic songbird sampling locations throughout Banff, Yoho, Kootenay, Waterton Lakes, and Jasper National Parks from 2007 through 2017.

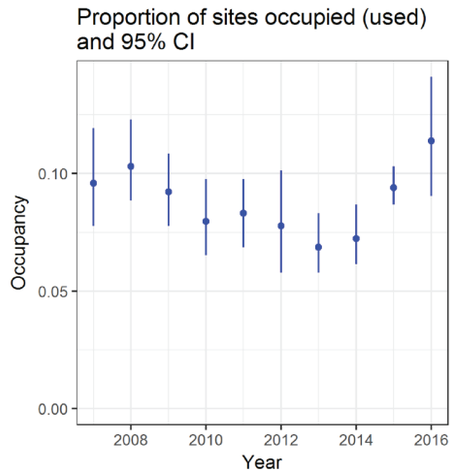


Figure 4. Proportion of sites occupied and 95% confidence intervals for olive-sided flycatchers in Banff, Kootenay, & Yoho National Parks.

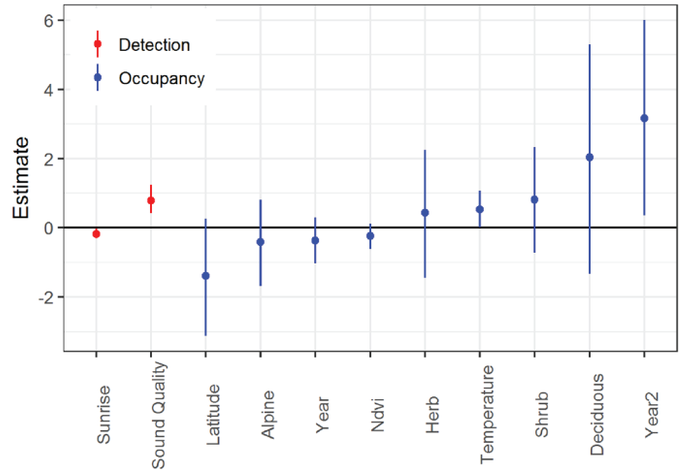


Figure 5. Parameter estimates and 95% confidence intervals for time-to-detection occupancy model for olive-sided flycatchers in Banff, Kootenay, & Yoho National Parks. Parameters for occupancy (psi) and detection probability p are shown in blue and red respectively.

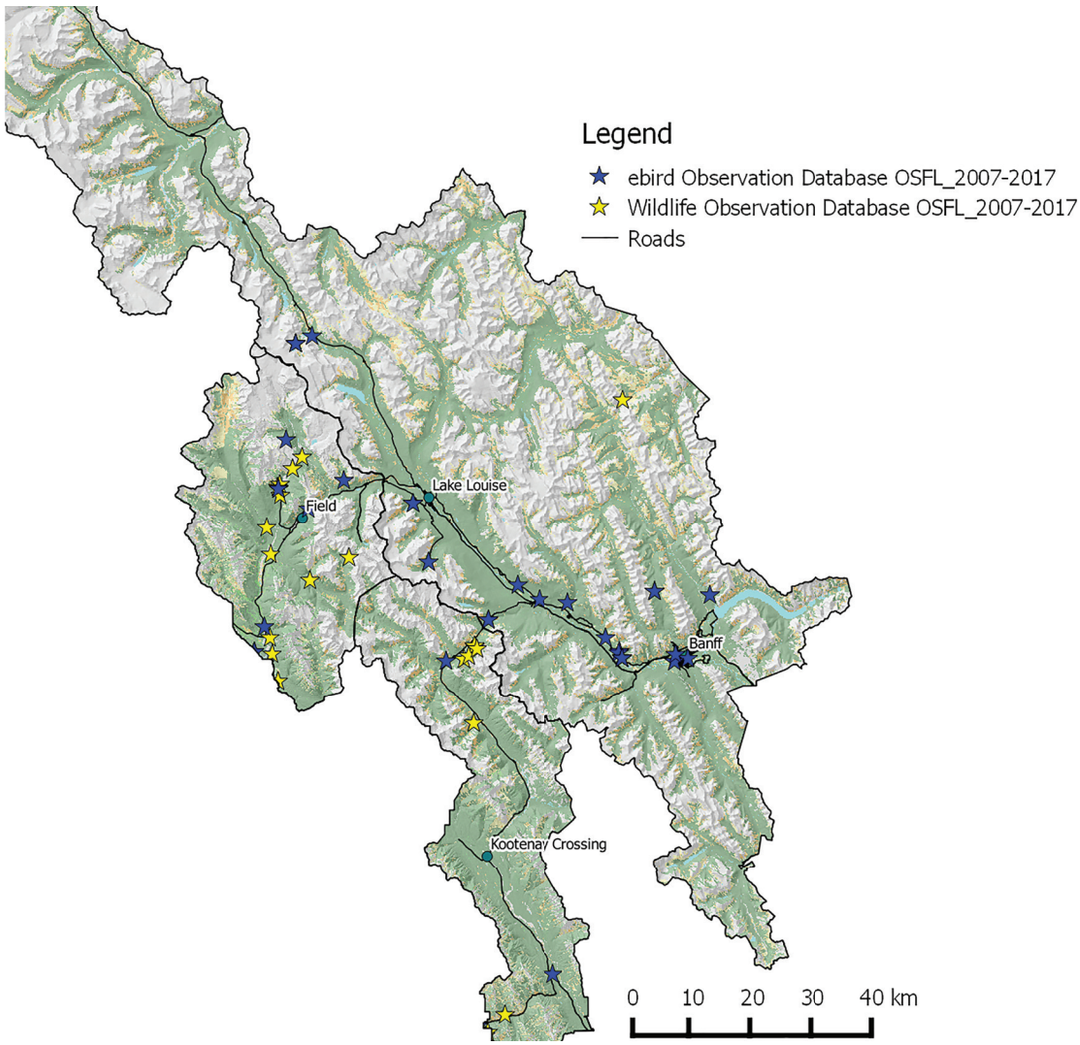


Figure 6. Olive-sided flycatcher observations in eBird Observation Database and Banff, Yoho and Kootenay National Parks Wildlife Observation Database, 2007 – 2017. OSFL is olive-sided flycatcher.

Incidental Observations

There are two sources of incidental observations for olive-sided flycatcher in Banff, National Park:

1. Banff, National Park Wildlife Observation Master Database.
2. eBird Observation Database – global

From these two sources, there are numerous incidental observations of olive-sided flycatchers across Banff, Yoho and Kootenay National Parks (Figure 6). These data could be used in to help identify critical habitat in the future.

Discussion

Site-specific objectives and conservation and recovery measures for olive-sided flycatchers apply to protection measures in place under the Canada National Parks Act and the Species at Risk Act, population monitoring, and habitat maintenance or restoration through existing management regimes in Banff National Park.

For this species, Banff, National Park could take the following actions to contribute to their protection and recovery:

1. Fill information gaps. Develop and identify critical habitat withinBanff National Park as per the proposed schedule of studies within the Recovery strategy (Environment Canada, 2016). Further collaboration with other Mountain National Parks, universities, and agencies could help determine local and regional factors affecting olive-sided flycatcher critical habitat and populations.
2. Active management. Partner with universities to better understand effects of prescribed fire in restoring habitat for this species. Olive-sided flycatcher prefers a mix of live and dead trees within a mosaic of forest patches of different age structure particularly near wetlands. Parks Canada is internationally recognized for leadership in restoring fire through prescribed burning and continues to conduct burns and manage wildfire as part of a national restoration program.
3. Working together. Engage others in the recovery of species at risk through involving Indigenous communities, partnering efforts, visitor experience opportunities, and outreach activities.
4. Understand how to restore and recover olive-sided flycatcher habitat while meeting the habitat requirements of other species at risk.
5. Contribute to larger scale efforts to understand the relative importance of climate change and local versus global factors affecting olive-sided flycatchers.

Acknowledgements/Partners

Anne Forshner prepared this technical summary. Jesse Whittington completed occupancy analysis. Shelagh Wrazej compiled eBird data from Alberta and British Columbia and reviewed this technical summary. Resource Conservation staff from Banff, Yoho and Kootenay National Parks collected the songbird data. Staff collecting data relied on the assistance of the equine program from both field units. Cam Gillies classified songbird recordings.

Contact

Anne Forshner, A/Wildlife Ecologist for Species of Concern
Lake Louise, Yoho and Kootenay Field Unit
P: 403-431-1795
E: *anne.forshner@pc.gc.ca*

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Active Management and Effectiveness Monitoring

Introduction

In cases where ecological integrity is impaired, through the loss of natural species diversity or impacts to natural processes such as flood, fire and predation, Parks Canada develops and implements effective strategies to restore ecological integrity.

Emerging issues are first identified through the condition monitoring program and prioritized through State of the Park Reporting. Key management actions are then identified in the Park Management Plan where these general approaches undergo public review and consultation. Once approved in a management plan, detailed strategies are developed and often undergo additional consultation and review through environmental assessment processes, research and collection permitting and animal care committees. Approved projects are then implemented by cross functional teams, often across field units, and often with the support of various industry and academic partners.

In order to learn from our efforts, most active management projects incorporate some form of management effectiveness monitoring. Ideally this includes a BACI (before vs after and control vs impact) study design or something similar so we can evaluate the impact of our actions on various ecological parameters. This effectiveness monitoring allows us to become more efficient and effective in our restoration efforts. Data collected often supports improved methodologies or provides critical evidence to encourage replication of successful approaches in areas well beyond the boundaries of Banff National Park. Banff led innovations in the use of prescribed fire, wildlife crossing structures to mitigate highway fencing, and the successful removal of non-native fish through mechanical means (without the use of poisons) provide some examples.

The following section describes some of the key active management and ecosystem restoration projects currently underway in Banff National Park and the work we are doing to assess their effectiveness.

Reintroduction of Plains Bison to Banff National Park

Introduction

Bison are a keystone species that was extirpated from the area that is now Banff National Park over 140 years ago. Historically, bison played a critical role in the local ecosystem through grazing, wallowing, trampling, and serving as prey or carrion for a variety of species. Bison were also very important to the livelihood of people in the area. As part of its larger mandate to maintain and restore ecological integrity, Parks Canada is undertaking a 5 year pilot bison reintroduction project to assess the long term feasibility of bison restoration in the region (Figure 1).

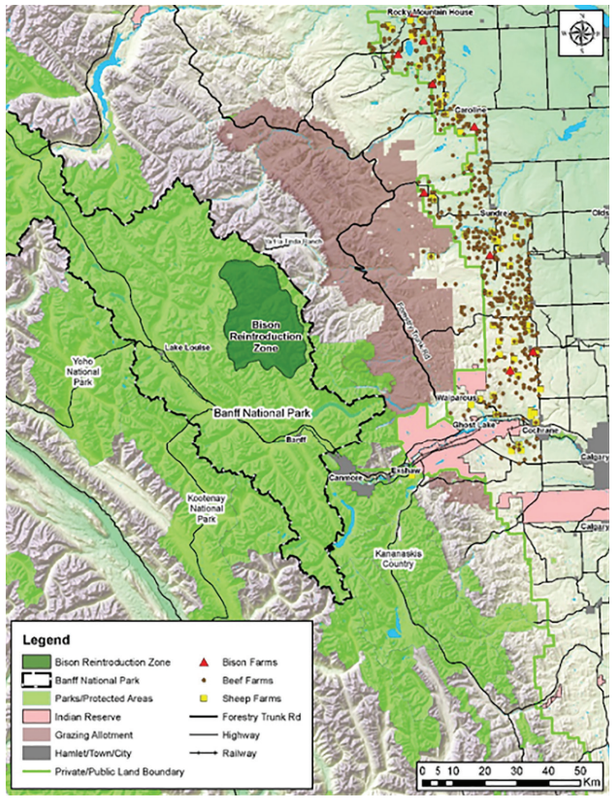


Figure 1. Location of the 1,200 km² Bison Reintroduction Zone in the backcountry of Banff National Park.

Objectives

Reintroduce a breeding population of plains bison to the eastern slopes region of Banff National Park.

Methods

Years of public and stakeholder input resulted in a project design that starts with a small number of animals in a remote section of Banff National Park. Key approaches include:

- Translocating 10 young pregnant females and 6 young bulls from a healthy herd of plains bison in Elk Island National Park to the backcountry of Banff National Park;
- Holding and supporting the animals in an 18 hectare backcountry pasture system in Banff National Park for the initial 16 months to allow them to calve twice and bond to the area prior to being released. This soft-release period will also allow the animals to adjust to local native forage and the steep terrain of their new home;

- Enhancing bison habitat attractiveness through the use of prescribed meadow burning in the reintroduction zone;
- Complementing the natural containment of the reintroduction zone with short sections of adjustable drift fencing that will encourage the bison to stay within the reintroduction zone once they are released.

Results

Translocation

We successfully translocated sixteen plains bison aged 2-3 years old (10 pregnant females and 6 young bulls) via truck and helicopter from Elk Island National Park to a 16 hectare soft release pasture in the middle of Banff National Park's bison reintroduction zone on February 1, 2017.

Soft Release Pasture

We fenced the 18 hectare soft-release pasture in Banff National Park's backcountry Panther River Valley in summer 2016 using a combination of existing posts and rails from an old horse pasture and new posts and 2.5 m-high page-wire.

Once the 16 founder animals arrived in the pasture on Feb 1 2017 we fed them hay and alfalfa pellets for the remainder of the winter and spring. They had access to and fed on natural vegetation in July and August, in a larger summer pasture, and are now being fed again until late spring of 2018.



Figure 2. Nine of the ten calves pictured with three of the bison cows in the soft-release pasture in July 2017 (photo: K. Heuer/Parks Canada).

The ten pregnant females gave birth to 10 healthy calves (7 females and 3 males) in April and May 2017 (Figure 2) and there was evidence of subsequent mating this past summer and fall. More calves are likely to be born prior to the animals' release into the larger reintroduction zone in summer 2018.

Daily health and weekly body condition monitoring, along with fecal parasite testing, shows all 26 animals are healthy and growing with adequate reserves of fat (Figure 3).

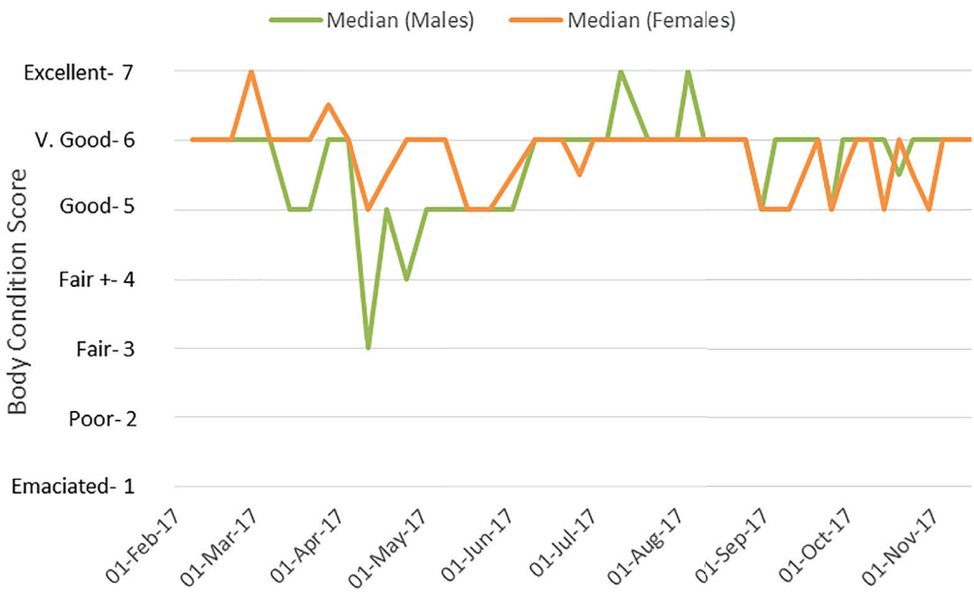


Figure 3. Median body condition scores for 10 female and 6 male bison in soft-release pasture, Feb. to Nov.2017. Based on 45 observations per animal during this period.

Prescribed Meadow Burning

We are conducting low complexity prescribed fires of open grasslands and shrublands, within the bison reintroduction zone, to improve habitat quality and attractiveness for bison before and after their reintroduction. As of fall 2017, we have successfully burned 865 hectares of our 2019 target of 1500 hectares (Figure 4).



Figure 4. Prescribed meadow burning, Panther River Valley, Banff National Park (photo Dan Rafla/Parks Canada).

Deflection Fencing



Figure 5. Elk traverse a test section of drift fencing in the Panther River Valley of Banff National Park.

Two and a half years of fence testing and monitoring with motion-activated cameras have led to the adoption of an adjustable fence design that can be switched from "bison deflection mode" (6' high, 6-wire) to "wildlife permeable mode" (6 wires clumped into 2 bundles). We expect fences to be deployed in wildlife-permeable mode most of the time, which allows for the free movement of all species. We measured crossing rate indices as the percent of time that wildlife crossed versus the number of fence interactions. Crossing rate indices on permeable mode fences ranged from 38% for mule deer to 100% for black bear, with an average crossing rate of 55% for all species from 1586 interactions. The crossing indices underestimated true crossing rates because many animals examined the fence before crossing at an adjacent location. For comparison, we estimated the percent of time any animal crossed a fenced region within 10 minutes. This crossing index ranged from 48% for elk to 100% for moose and averaged 70% across species, but also included animals using the fence line as a travel route.

We will install a total of 5 km of this adjustable drift fencing across 10 sites on the periphery of the reintroduction zone to complement natural containment provided by rock ridges and cliffs. We constructed over 2 km of this drift fencing at 6 of the 10 sites this past fall (2017) and will construct the remaining 4 sites in spring 2018.

Discussion

Parks Canada is on track and on schedule to release a small herd of approximately 30 plains bison into a 1,200 km^2 reintroduction zone in the backcountry of Banff National Park in summer 2018. We will use a number of performance measures to evaluate the feasibility of longer term bison restoration in the region once this five-year pilot project ends in 2022 (see Parks Canada 2017 for a list and description of these performance measures). If we determine that restoration is feasible, beyond the pilot project, we will develop a long-term population target as part of a bison management plan.

Acknowledgements/Partners

Thanks to Saundi Norris, Dillon Watt, Caroline Hedin, Adam Ziervogel and Peter White for their flexibility and hard work on this project. The support and encouragement from First Nations members of the Buffalo Treaty, as well as the not-for-profit group Bison Belong, have been very

encouraging. Many thanks to employees in the Public Lands and Environment and Parks divisions of the Alberta Government for their input and cooperation on this project.

Contact

Karsten Heuer, Bison Reintroduction Project Manager
Banff National Park
P: (403) 431-0599
E: *karsten.heuer@pc.gc.ca*

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Black Swift Monitoring and Management

Introduction

The Black Swift *(Cypseloides niger borealis)* is the largest swift in North America. The *borealis* subspecies occurs only in Canada. It has a specialized diet of flying insects and its range is limited by its requirement to nest near or behind waterfalls, often located in canyons. The female lays a single egg each year and nestlings do not fledge until early or mid-September (Figure 1). This late fledging is extremely unusual and may place Black Swifts at risk from human use impacts that generally occur after most birds have completed nesting in July. British Columbia and southwestern Alberta are home to 81% of the North American population, but only 0.1% of that is found in Alberta. Black Swifts have been documented in Banff, Jasper and Waterton Lakes National Parks in Alberta, and Kootenay National Park in British Columbia. Johnston Canyon is the only confirmed nesting site in Banff National Park.



Figure 1. Black swift nestling exercising wings in advance of fledging in Johnston Canyon, Sept 2017 Photo: Amar Athwal

The species has experienced large population declines in recent decades. Canadian populations have declined by 50% in the last 40 years and 25-50% in the last decade (COSEWIC 2015). In 2015, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended the bird be listed as Endangered in Canada, however it is not listed under the Species at Risk Act of Canada.

Declines may be related to changes in food supply and impacts to waterfall nesting sites, as snowpack and glacial melt shifts with climate change.

Sightings of Black Swifts in Johnston Canyon have been inconsistent and generally declining. Parks Canada staff did not conduct systematic annual surveys from until recently in 2015. It is not clear whether declines in our species records for Banff are related to lack of observations, numbers of birds, or both. However Dr. Geoff Holroyd has systematically surveyed this site and

observed that between 1975 and 1992 up to 12 pairs of Black Swifts nested in Johnston Canyon. From 1993 to 2017, he has only observed 1 – 3 pairs in the same section of canyon (Holroyd *pers. comm.* 2018).

The impetus to begin annual surveys for Black Swifts in Johnston Canyon was driven by the 2015 COSEWIC status report, a gap in knowledge about the species in Banff National Park (particularly over the last 20 years), periodic catwalk and railing maintenance and rock scaling work in the Canyon, and increasing visitation to one of the most popular day use areas in the Park. Anthropogenic disturbance of nest sites is critical to avoid. If hikers stay on the trail, only a handful of nest sites are potentially impacted, but if visitors leave the trail, they can potentially disturb or displace nest sites of birds that have presumably sought out a secluded site.

Annual surveys at nesting sites in Banff National Park are vital to gaining a clearer picture of breeding phenology, the number of active nests and evaluating trends of Black Swifts in Johnston Canyon and throughout the Mountain Parks.

Objectives

- Establish a standardized survey protocol and maintain a long-term monitoring program
- Monitor Black Swift nesting colony attendance and conduct nest counts
- Identify a long-term (10 year) trend of Black Swifts in Banff National Park
- Collect ancillary data on phenology, nesting success and productivity
- Identify other potential nesting colonies in Banff National Park
- Collaborate with Jasper and Kootenay National Parks in establishing annual standardized surveys, identifying other potential nesting colonies, and assessing trends

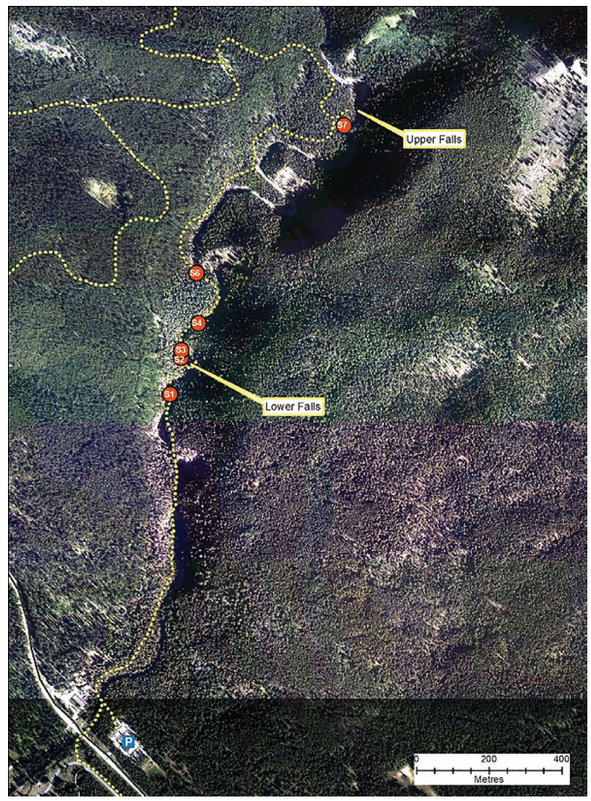


Figure 2. Active and historic nest sites (orange dots) in Johnston Canyon 2017

Methods

In 2015, we identified and recorded historic nest sites in Johnston (Figure 2), and starting in 2016, conducted annual counts of active nests observed in Johnston Canyon during the breeding season from June through September. Observers conduct an initial survey in mid-late June to identify the

number of active nest sites. We then complete three to four subsequent evening surveys, timed to coincide with hatch dates and post-hatch dates (based on latitude and elevation) to observe the breeding adults attending to the egg or hatchling, and to collect data on breeding phenology, success and productivity of the colony. Johnston Canyon is unique in that it is ideally suited to observe nests and hatchlings because the nests are predominantly located directly across from trails and boardwalks at or slightly above eye level. However, unlike some other sites Johnston Canyon lacks an elevated vantage point to observe and conduct point counts of flying individuals. Point counts of the number of individuals seen flying or roosting on nesting cliffs should be conducted at sites like Marble Canyon in Kootenay National Park where viewing of nests is difficult or impossible.

Results

Complete survey data is limited to 2016 and 2017 breeding seasons. In 2016, we observed no Black Swifts during surveys (n=0). In 2017, two nests were active and the maximum individuals observed during surveys was 4 adults and 2 nestlings (n=6). We first observed adults on nests on June 29, in Johnston Canyon. Hatching date occurred on July 28 (incubation=27-30 days). The fledging date for one nest was September 9 (fledging=44 days), and we last saw a nestling in the second nest on August 28 (nestling phase=32 days). Mean fledging in Black Swifts occurs at 48 days (Hirshman et al. 2007). It is unknown if the nestling from the second nest fell out of the nest, was preyed upon, or the nest was subject to human disturbance, but we considered it a nesting failure. The second nest was located directly across and within 5 metres of the boardwalk. Together, the 2017 nest success rate was 50% in Johnston Canyon.

Discussion

COSEWIC recommended that black swifts be listed as Endangered and are scheduled to be assessed by 2018. This status highlights the need to collect baseline data throughout the Mountain Parks for this specialized aerial insectivore. At a minimum, we should conduct tri-annual surveys in Johnston Canyon. A census for the number of active nests sites will provide a broader picture of colony attendance over time and valuable data for the evaluation of long-term trends. We should also collect data on the timing of egg-laying, as well as hatching and fledging success. Assessing reproductive success requires a greater time investment, with repeated visits at the beginning of the egg-laying period, and again near hatching and fledging. We could utilize the Parks Canada volunteer program to provide additional support to capture data on reproductive success.

In addition, we should periodically assess other potential nesting sites in Banff Yoho and Kootenay to determine whether swifts are colonizing other sites. Finding suitable montane waterfall habitat may be possible along the Bow Valley Parkway, in the Minnewanka/Stewart Canyon area, along the Icefields Parkway or more remote waterfall canyons in the backcountry. Nesting habitat is characterized by presence of running water, high relief for entering and exiting

nests at foraging altitudes, inaccessibility to terrestrial predators, darkness or no direct sunlight on nests, a flyway free of obstructions, and nest platforms (Levad *et al.* 2008).

In Jasper National Park in 2017, staff identified 18 potential additional nest sites with high habitat suitability and identified two new active nesting sites at Athabasca Falls and Pleckaitis Canyon for a total of 4 actives colonies including Maligne Canyon and Two-Valley Canyon (St-Amand 2017). One prospective site along the North Saskatchewan River Canyon was surveyed and is within the Lake Louise, Yoho, Kootenay field unit. Staff will conduct a follow up survey as a joint effort in 2018 between the Banff and Jasper field units.

Although Black Swifts have been officially monitored for only 2 seasons to date by Banff National Park staff, discrepancies between database records and accounts from local naturalists and ornithologists suggest observations of the species are underreported and the colony size has decreased. Records of Black Swifts in the Banff Yoho Kootenay Observation Database date back to 1972. Gaps exist where no observations were recorded (Figure 3). Black Swift site fidelity is generally high, with birds returning to the same colonies consistently over time (Levad *et al.* 2008). What factors have influenced an apparent decline of the swift colony in Johnston Canyon?

The requirement for continuous running water flowing late into the summer, leave swifts particularly vulnerable in years with low snowfall and insufficient summer rain. Over 11 years of monitoring, Hirshman *et al.* (2007) reported that nesting success at Box Canyon Falls in southwestern Colorado, was lowest in years with the most severe drought, with only one exception. A warming climate affects the temporal and spatial patterns of local water flow, which can in-turn impact the phenology and spatial patterns of the swarming insects that are the primary prey of Black Swifts (Wiggins 2004, COSEWIC 2015). Other threats to prey abundance and diversity may be correlated with decreasing variation in forest stand age structure due to forest management practices, and air-borne pollutants. Pesticides, such as neonicotinoid insecticides and DDT have been linked to declines in insectivorous bird populations (COSEWIC 2015).

Air-borne pollutants and climate change are identified as having the highest and most pervasive impacts to Black Swifts and other aerial insectivores (COSEWIC 2015). Impacts from recreational activity is considered low, although any direct disturbance to nests or nesting sites can affect nesting success and should be assessed and mitigated. The Parks Canada Johnston Canyon trail counter data for the summer of 2016 tallied a total of 212,841 visitors walking the Canyon between June 03 and September 9. In the fall of 2015/2016 crews conducted rock scaling work to address hazards associated with loose rock, and railing was amended along the boardwalks in the Canyon. In June of 2016 a large wind event downed thousands of trees along the Bow Valley Parkway and in Johnston Canyon. Parks crews and contractors cleared downed and hazardous trees. Any one of these activities has the potential to disrupt or destroy nests. Site photos, UTMs and bearings of nesting areas have been documented to prevent accidental nest destruction. The Black Swift Observation protocols should be referred to in advance of activities in Johnston Canyon and work near nest sites should not occur between May 1 and September 15.

Sections of the canyon, that are used by Black Swifts, away from the official hiking trail, may benefit from a seasonal area closure (June to September, inclusive) to ensure nest sites are

not disturbed by off-trail users. Several sites show evidence of illegal fires and nocturnal party activity which could negatively impact nest success.

Black Swifts should be considered a high priority for conservation. Although not yet added to schedule 1 of the Species at Risk Act, data collected on swifts in Banff will be valuable in supporting recovery strategies on possible critical habitat identification and will support park management decision-making.

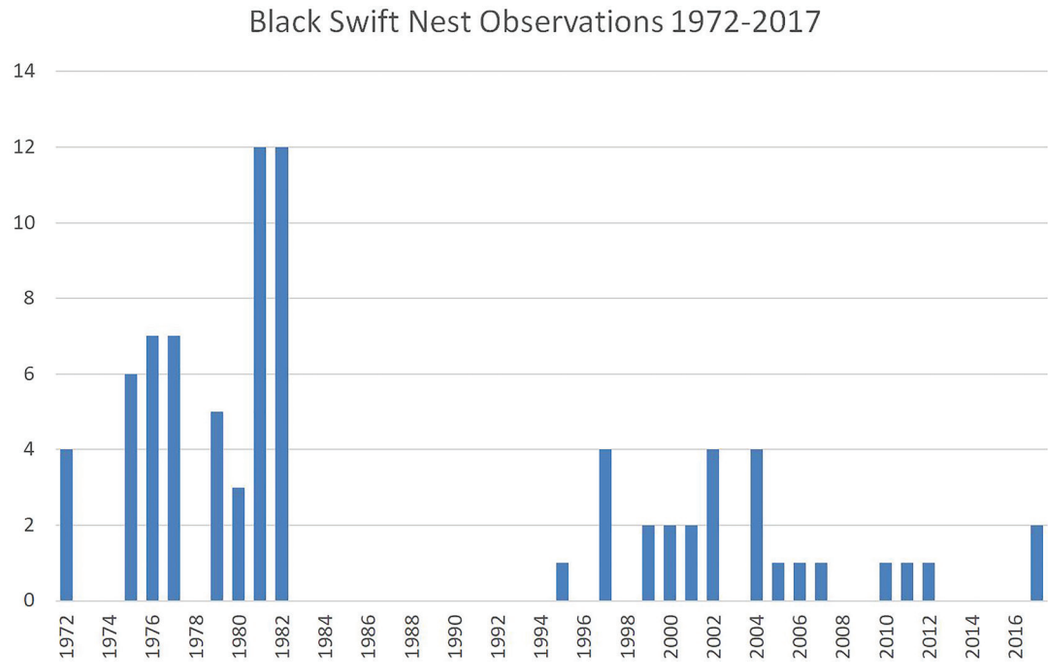


Figure 3. Observation Database Records for Black Swifts

Acknowledgements/Partners

Prepared by Jennifer Reimer. Jennifer Reimer organized and implemented nest surveys. Geoff Holroyd, Jason Rogers and Amar Athwal are recognized for their contributions in providing valuable information on historic nest sites, previous research efforts, observation records and photographs.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403)-763-8865
E: *jesse.whittington@pc.gc.ca*

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Bow Valley Parkway Travel Restriction

Rationale

The Bow Valley Parkway is a scenic drive that bisects rare montane habitat important for wildlife. Many wildlife species den, calve, and feed their young in the area because of this rare high-quality habitat and because it greens up earlier than snow-covered habitat at higher elevations. The parkway is also an important area for visitors who hope to catch a glimpse of the park wildlife.



Figure 1. *Grizzly Bear crossing the Bow Valley Parkway, 2016.*

Human activity has the potential to displace wary animals from high quality habitat (e.g. Hebblewhite and Merrill 2008), which in turn can affect predator-prey dynamics and ecological processes (Hebblewhite et al. 2005, Muhly et al. 2011). Species like grizzly bears and wolves generally avoid roads with high levels of human use (Gibeau et al. 2002, Whittington et al. 2005, Northrup et al. 2012). These displacement effects can be exacerbated where wildlife movements are further constrained by rugged topography, water, and railways.

Reductions in human use can increase habitat quality and wildlife use of movement corridors (Duke et al. 2001, Shepherd and Whittington 2006). Seasonal closures can be used as a conservation tool to reduce the effects of human activity, particularly during sensitive periods throughout the year (Figure 1). Temporal closures that close an area for a portion of the day have potential to improve habitat quality and security for wildlife while minimizing effects on visitors, however no other studies have tested the effectiveness of temporal closures.

Parks Canada implemented a mandatory seasonal travel restriction on the Bow Valley Parkway starting in spring 2014 to improve habitat quality and security for wildlife. The restriction applied to a 17 km section of the parkway from March 1 through June 25 and between the hours of 8 pm to 8 am. Parks Canada selected the timing and duration of the restriction to both minimize impacts to visitors and to provide wildlife with increased security during dawn and dusk throughout the spring when wildlife are more active.

Objectives

To assess how wildlife use of the Bow Valley Parkway changed as a result of the temporal travel restriction.

From 2014-2017, we monitored the effectiveness of the travel restriction using a combination of:

- Remote Cameras
- Road Surveys
- Movement data from GPS collared grizzly bears

Results from this analysis have been submitted for publication as *Temporal road closures improve habitat quality for wildlife (Whittington et al. 2019 in review).*

Methods

Remote Cameras

We compared wildlife detections on ten road-based cameras to detections on 54 cameras distributed throughout the Bow Valley (Figure 2). The reference cameras included 18 cameras on trails and 36 cameras on highway crossing structures that were a subset of Parks Canada's broader remote camera network. We selected data from 2014 to 2017 between March 1 and June 25 to coincide with timing of the temporal closure. We compared hourly detection rates one hour before and after the road opened in the morning and one hour before and after the road closed at night. We used logistic regression with a random effect for camera location to assess hourly detection rates. Covariates included Treatment Area (0 = reference sites on trails, 1 = road sites), Closed Time (0 = 0800 to 2000 hours; 1 = 2000 to 0800), the interaction between Treatment Area and Closed Time, days since May 1, and time since sunrise in the morning and time to sunset at night. Here and below we compared all combinations of covariates and selected the model with the lowest AIC_c value as the most parsimonious model.

Road Surveys

Our staff surveyed the Bow Valley Parkway from Five-Mile Bridge in the east through to Castle Junction in the west (Figure 2). Surveys started approximately 1 hour prior to road opening in the morning or closing at night. Staff waited until the status of the road changed and then re-surveyed the same section of roadway in the opposite direction. During surveys all wildlife observations, scat, and tracks were recorded for every 1 km interval. Staff also conducted surveys before March 1 and after June 25. Reference data consisted of surveys 7 km west of the travel restriction between Johnston Canyon and Castle Junction and surveys conducted when the road was open all day and night. For each survey and road section we determined whether wildlife were detected. We analysed the data using logistic regression with a random effect for survey. Covariates affecting probability of detection included Treatment Area (0 = permanently

open road west to Castle Junction; 1 = restricted section of road), Closed Time, the interaction between Treatment Area and Closed Time, time to sunrise/sunset, and days since May 1.

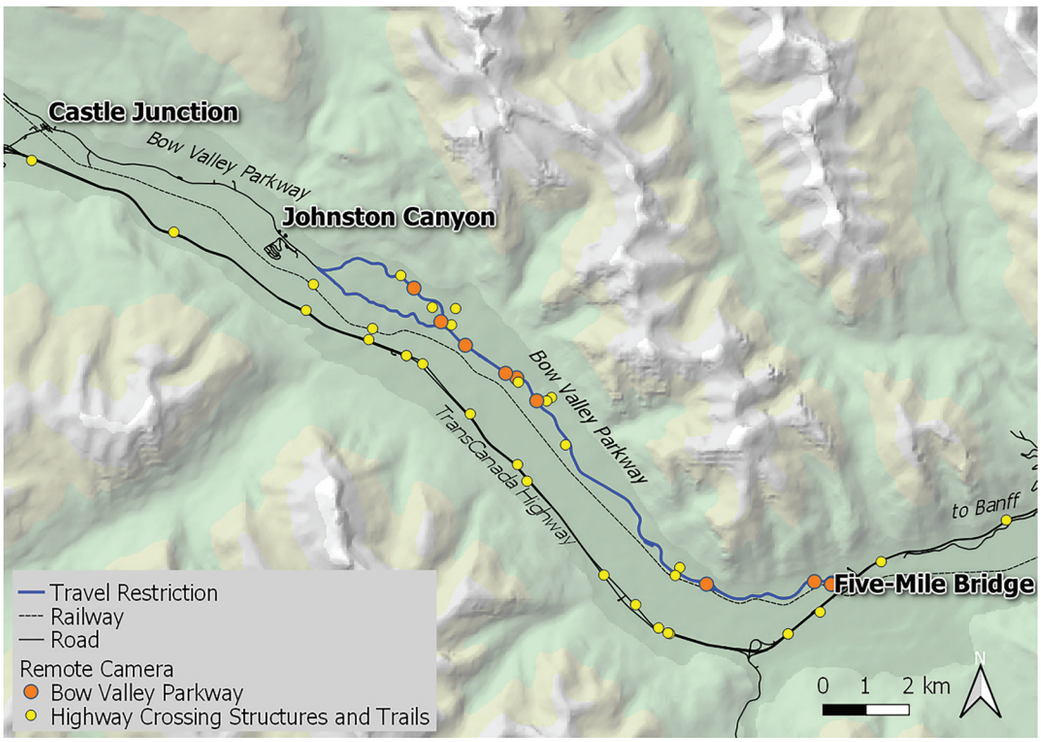


Figure 2. Bow Valley Parkway study area within Banff National Park. Wildlife detection rates on the restricted section of the road were compared to detection rates at reference sites. The study used data from remote cameras, road-based observation surveys, and GPS collared grizzly bears.

Grizzly Bear GPS Movements

From 2012 - 2016, Parks Canada collaborated with the Canadian Pacific Railway and the University of Alberta to collect grizzly bear GPS data to understand root causes of grizzly bear mortality on the railway. We used these data to examine how the probability of grizzly bear use of the Bow Valley Parkway changed with the implementation of the travel restriction. We selected GPS data from 11 grizzly bears that used the restricted section of the Bow Valley Parkway from 2012 to 2017. We selected all grizzly bear locations that were within 3.0 km of the Bow Valley Parkway because 3.0 km was the 95th percentile of 2 hour movements and the Bow Valley Parkway was thus available to the bears. Our response variable was whether each GPS location was within 30 m of the Bow Valley Parkway. We analysed the data using logistic regression with a random effect for animal. Covariates included Treatment Year (0 = 2012 - 2013; 1 = 2014 - 2017), Closed Time, the interaction between Treatment Year and Closed Time, days since May 1, and hour of the day (sine and cosine transformed). We compared all combinations of covariates and selected the model with the lowest AIC_c value as the most parsimonious model.

Results

Remote Cameras

The 10 roadside and 54 reference cameras operated for 2,756 and 13,312 camera sampling days, respectively. The roadside and reference cameras recorded 171 and 1686 detections of wildlife. Deer, elk, and wolves were the most prevalent species (Figure 3). Species varied in their responses to road opening, with wolves, deer, and elk showing the strongest negative response. Grizzly bear detections increased when the road opened, but sample sizes were likely too small to be statistically significant.

Probability of detecting wildlife on remote cameras increased at lower elevations, throughout the spring, and at highway overpasses and open span bridges. Wildlife detection rates doubled during the temporal closure on the restricted section of the Bow Valley Parkway ($p < 0.001$) but remained unchanged at reference locations. (Figure 4).

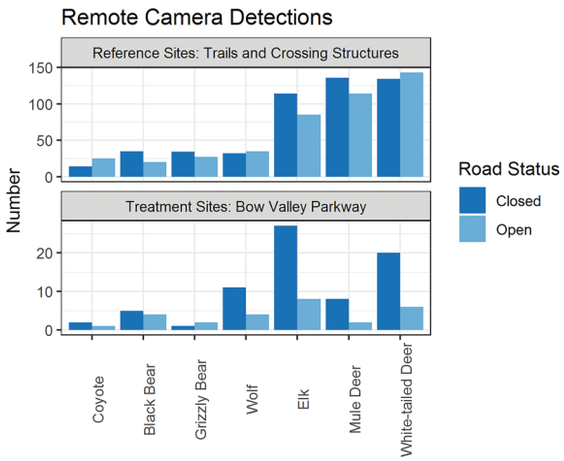


Figure 3. Remote camera wildlife detections within one hour of the temporal closure opening in the morning and closing at night.

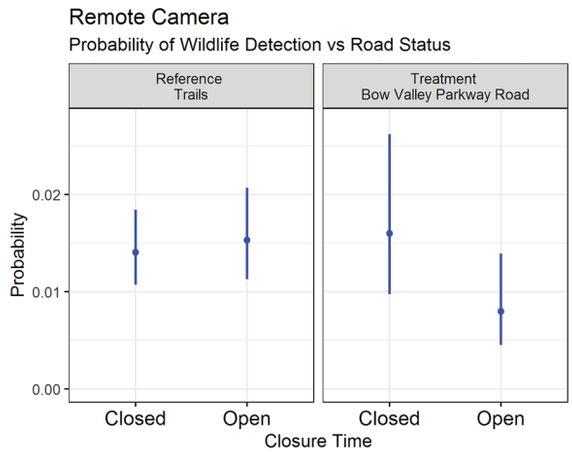


Figure 4. Hourly probability of detecting wildlife and 95% CI's on remote cameras as a function of treatment area and closure time.

Road Surveys

We conducted 67 road surveys for wildlife. Seven surveys occurred prior to March 1, 59 surveys occurred from March 1 through June 25, and 1 survey occurred after June 25. Four of the surveys occurred in the evening and 63 occurred during the morning. We recorded 140 observations of wildlife including 4 grizzly bear, 6 black bear, 15 wolf, 49 deer, and 58 elk; most detections of wildlife occurred when the Bow Valley Parkways was closed (Figure 5).

Probability of detecting wildlife on road surveys increased during the spring and peaked in min-May. Wildlife detection rates more than doubled during the temporal closure in the treatment area (restricted section of road; $p = 0.066$) but remained unchanged in the reference area (permanently open road) (Figure 6).

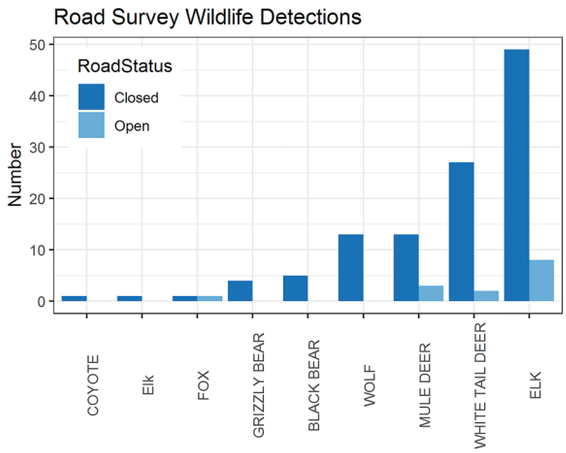


Figure 5. Number of wildlife observations along the restricted section of the Bow Valley Parkway when the road was closed versus open.

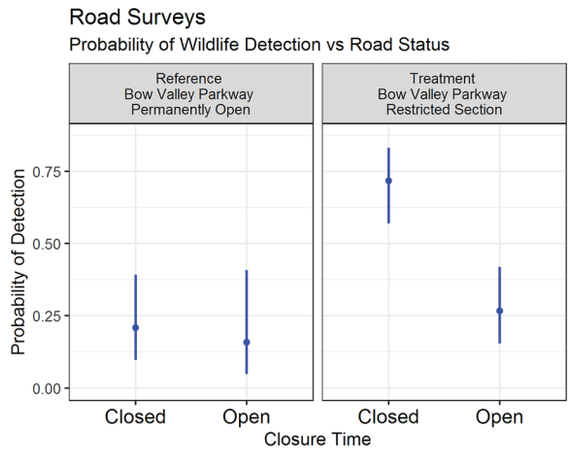


Figure 6. Probability of detecting wildlife and 95% CI's on the Bow Valley Parkway as a function of treatment area and road status (open vs closed) and season.

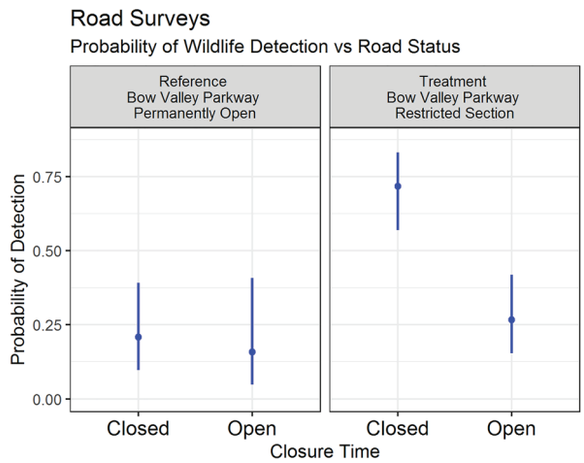


Figure 7. Probability of detecting wildlife and 95% CI's on road-based observational surveys as a function of treatment area and status of the temporal closure.

Grizzly bear GPS Movements

Our analysis used GPS data from 11 grizzly bears that used the restricted section of the Bow Valley Parkway including 7 bears from 2012 - 2013 and 6 bears from 2014 - 2017. Two of the bears had GPS data from both time periods. Seventy one of the 2471 locations occurred within 30 m of the parkway. Grizzly bear selection for the road increased through the spring. Selection for the road depended on time of day for the during the treatment years (2014 - 2017), but not during the reference years (2012 - 2013). Probability of detection doubled when the road was closed during treatment years (p = 0.032, Figure 7).

Discussion

Wildlife detection rates on the Bow Valley Parkway more than doubled when it was closed to vehicle traffic in all three analyses. These results suggest that temporal closures can substantially improve habitat quality and security for wildlife with minimal effects on people. This is the first study to examine the effectiveness of temporal closures. While they may not be as effective as full closures, the current restrictions provide an opportunity for wildlife to use important montane regions without disturbance from traffic. These results support management objectives committed to in BNP's 2010 management plan, including reducing wildlife disturbance and improving habitat security for wildlife.

While activity of large carnivores such as wolves, grizzly bears, and black bears was generally low during both road closures and normal vehicle activity periods, this was expected given their low density and large home ranges. The numerous detections of elk and deer suggests that the montane ecoregion along the Bow Valley Parkway provides important high quality habitat for both ungulates and carnivores. The area likely provided increased access to early vegetation succession (grass and forbs communities) associated with open areas adjacent to the parkway.

The study was limited to a sample size of one temporal closure on one section of road. The closure was also applied to one period of the day, which could be correlated with diurnal activity patterns. We addressed this limitation by using before after control impact type study designs, three parallel data sets, and spatial and temporal covariates that could influence wildlife detection rates. Future research could examine how species differ in their responses to temporal closures and how habitat quality, configuration, and timing of the closure affect wildlife use. Our results are consistent with the growing body of research that suggest wildlife avoid areas with high levels of human activity and that many species are becoming more nocturnal in areas of high human use to avoid encounters with people (Hebblewhite and Merrill 2008, Gaynor et al. 2018).

Effectiveness of the travel restriction will require continued education, compliance, and monitoring to ensure all vehicles exit the Bow Valley Parkway in a timely manner when the gates are closed in the evening. More information could be provided to visitors regarding the reasons for the closure and these positive results to date to emphasise the importance of the Bow Valley Parkway and the surrounding area for wildlife in Banff National Park. Providing wildlife with safe and predictable habitat at night may increase wildlife use of the area and could increase opportunities for visitors to see wildlife during the day. Increased wildlife activity along the Bow Valley Parkway, during the travel restriction, may also help reduce the frequency of wildlife mortality along the nearby railway, by offering an alternative, energy efficient, travel route for wildlife, and safe access to forest-edge vegetation that provides important forage species for bears and ungulates.

Visitors travelling at night, to businesses and campgrounds between Johnston Canyon and Castle Junction, are able to access all of these facilities via the TransCanada highway at Castle Junction during the travel restriction. Mitigations include improved signage on the TransCanada Highway and Bow Valley Parkway, public education (including on Parks Canada websites and social media), news media articles, and staff presence. Therefore we have successfully improved habitat security for wary wildlife while having little to no impact on visitor access.

Acknowledgements/Partners

Prepared by Jesse Whittington, Petah Low, Bill Hunt, Genevieve Perkins, & Mark Benson. Parks Canada Resource Conservation staff collected remote camera and roadside survey data. Dan Rafla designed the road survey study. GPS collaring of grizzly bears occurred in collaboration with Canadian Pacific Railway and the University of Alberta.

Contact

Jesse Whittington, Wildlife Ecologist,
Banff Field Unit
P: (403)763-8865
E: *jesse.whittington@pc.gc.ca*

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Carcass Management and Distribution

Introduction

Wildlife mortality and wildlife conflict frequently occur along transportation corridors and near developed areas. Wildlife use of these areas can increase, especially in early spring, when natural foods are scarce or are concentrated in the valley bottoms near areas with people. For example, grizzly bears often forage on grain spilled along the railway or emergent vegetation adjacent to roads and rails and risk being killed by collisions with trains or vehicles. Strategic dispersal of carcasses on the landscape has potential to reduce wildlife conflict and mortality for carnivores. Wildlife killed from other causes such as vehicle or rail collisions can be stored in a freezer throughout the year and then re-distributed away from developed areas. Carnivores feeding at carcass sites should spend less time in risky areas and thus have lower mortality and conflict rates (Figure 1).



Figure 1. Wolverine detected at Hillsdale carcass site location through use of a remote camera.

Carcass management programs, also referred to as diversionary feeding, have been used by many organizations to manage the human-wildlife interface on public lands (Kubasiewicz et al. 2016, Garshelis et al. 2017). Redistributing carcasses can be an effective tool during times when natural foods are scarce, and wary carnivores may be enticed to areas with higher risk of conflict, provided the redistributed food is located outside of potential conflict areas or known mortality areas, and is more attractive than alternatives near human use areas. This allows critical biomass to remain within the ecosystem, rather than being removed to incinerators or landfills.

Objectives

The objectives of the carcass management program are:

- Reduce the probability for transportation corridor (rail, road) mortalities;
- Reduce the probability of human/wildlife conflict encounters ;
- Retain and recycle an important source of protein within the park; especially during spring and fall when caloric intake for carnivores and scavengers is critical.

Methods

Since 2015, whenever park staff could not move a railway or road-killed mammal (elk, deer, coyote, sheep etc.) at least 500m from human use areas and/or 100m from transportation corridors, our protocol is to collect these carcasses and store them in a refrigerated cargo container. In early spring, and again in late fall, we distribute these carcasses back on the landscape at sites selected based on core goals and guiding practices (see below). When possible we deployed infrared-based remote cameras at the site to determine species type, number and duration of feeding (Figure 2).

Visitor Safety: We selected carcass drop-sites that exceed our carcass management guidelines with a minimum of 500 m from nearest human use area and 100 m from transportation corridors. We consulted Parks Canada visitor safety specialists to ensure that sites did not overlap with ski touring, ice climbing or mountaineering objectives or any formalized trails.

Ecological Considerations: We avoided low elevation drop-sites for several reasons. Carcasses dropped at accessible valley bottom locations could increase wolf population numbers and density. Increased wolf density could lead to increased predation risk of ungulates (Hebblewhite et al. 2007). As well, carcasses located in important spring female grizzly bear denning and rearing locations could lead to increased probability for male bears to be drawn to these areas. Female grizzly bears avoid infanticide from males by selecting for medium quality habitat in isolated areas to birth and raise their young. Depositing carcasses near female denning areas could affect survival rates of juvenile grizzly bears. Thus, we selected carcass sites with the following core ecological goals:

- Carcasses are not accessed by wolf populations.
- Carcass management does not interfere with female grizzly bear emergence and spring habitat selection strategies to avoid male grizzly bears and associated infanticide.
- Carcass management will emulate natural mortalities as closely as possible.

The core goals will be achieved by the following guiding practices that were developed in 2017:

- We will not place carcasses in core wolf habitat as determined by GPS data 2009-2017, with the goal of no wolves gaining access to the carcasses.
- We will not place carcasses in areas known to be den emergence sites for female grizzly bears and/or core female grizzly bear spring habitat as determined from GPS data 2009-2017.
- We will place carcasses in avalanche path run-out zones to emulate natural avalanche wildlife mortalities (Figure 2).
- We will limit the number of carcasses dropped at a site, to the approximate size of a moose, to limit competition among animals visiting the site.

We used a helicopter to drop carcasses near the bottom of avalanche paths and secured each carcass to a tree (<10 cm dbh) with natural fibre manila rope to prevent carnivores from moving the carcass and impeding camera monitoring efforts. We deployed remote cameras and pre-programmed them to reduce the number of photos of corvids (e.g. jays, ravens, etc).

Results

A review of the 2015 and 2016 carcass drop locations showed the following trends. Wolves (both the Bow Valley and Fairholme packs) commonly consumed the majority of the valley bottom carcasses (Table 1 and 2). The alpine sites in 2016 had significant female grizzly bear activity compared to other sites (Table 2), with the majority of female bear activity occurring at the Pilot Alpine site. The majority of the carcass consumption can be attributed to scavengers (corvid spp., eagle spp., red fox and marten). The sites that had the highest species diversity were Hillsdale Meadows in 2015 and 2016 (Table 1) followed by Ink Pots North and Sundance Alpine in 2016 (Table 2).

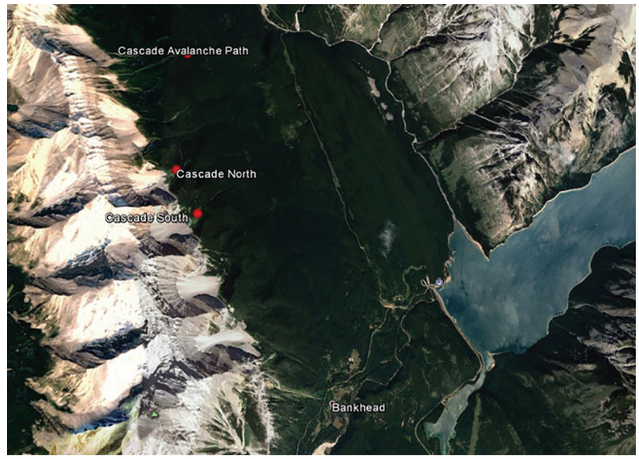


Figure 2. A selection of 2017 alpine carcass site selections

Table 1. Species diversity and carcass consumption time at 2015 fall site locations

Site location	Species observed	Time *
Fairholme Bench West	golden eagle, wolves (FHP), marten, red fox, corvid	26
Healy Pit	bald/golden eagle, wolves (BVP), marten, coyote,corvid	8
Hillsdale Meadow	golden eagle, wolves (BVP),marten,wolverine,grizzly bear (#136),corvid	14
Morisson Coulee	bald/golden eagle,wolves(BVP),coyote,red fox ,raven	7
Pilot Alpine	marten, wolverine	n/a
Sundance Alpine	deer,red fox, marten, corvid	n/a
Inkpots North Alpine	golden eagle,marten,red fox,wolverine,corvid	14

* Consumption time is in days
n/a due to snow depth
FHP - Fairholme Pack
BVP - Bow Valley Pack

Table 2. Species diversity and carcass consumption time at 2016 spring site locations

Site location	Species observed	Time *
Fairholme Bench East	grizzly bear(2 unmarked),wolves (FHP),marten, corvid	n/a
Fairholme Bench West	wolves (FHP), corvid	3
Hillsdale Meadow	black bear, wolves(BVP),red fox, cougar, golden eagle, bald eagle, marten, corvid	35
Morisson Coulee	red fox, cougar, golden eagle, bald eagle, corvid	15
Pilot Alpine	grizzly bear (F130&3YOY,F148,F160,M137,2 unmarked), black bear, marten, wolverine	55
Sundance Alpine	grizzly bear (F148), red fox, golden eagle, marten, corvid	70
Inkpots North Alpine	black bear, coyote, red fox,bald eagle, marten, wolverine	32

n/a camera malfunction

We altered drop locations in 2017 to minimize consumption by wolves and female grizzly bears with offspring. The spring 2017 drop cycle was hindered by inclement weather and remote cameras were deployed at only two of six sites. We hope to complete image classification and analysis of 2017 remote camera data in 2018. Preliminary analysis suggests golden eagle, bald eagle, marten and red fox visited the Sundance Canyon site. Corvids, bald eagle, golden eagle, marten, coyote, grizzly bear, and black bear visited the Sundance Middle site. Female grizzly F160 consumed the majority of this carcass and spent 5 days at the site feeding and defending the carcasses from other scavengers. We detected a black bear passing through the area twice after the carcasses was consumed. Overall the revised approach we adopted in 2017 seemed

to achieve the core goals of limiting wolf access and avoiding placement of carcasses in core female grizzly bear denning and spring cub rearing habitat.

Discussion

Key issues regarding carcass management in the Banff Field Unit are:

1. Male grizzly bears monopolizing sites;
2. Avoiding carcass drops in female grizzly denning areas and spring cub rearing habitat;
3. Limiting the probability of wolves consuming the majority of the carcasses at lower elevations sites;
4. Reducing times carnivores spend in close proximity to human use areas and transportation corridors, which may reduce mortality strikes and human-wildlife conflict.

Current strategies to address these issues include dropping smaller amounts of carcasses at multiple sites to prevent a single dominant male grizzly bear from monopolizing all sites. We analyzed GPS data from grizzly bears from 2009 to present to avoid denning sites and spring cub rearing habitat, therefore reducing the risk of intraspecific competition and infanticide.

Preliminary results from 2017 show we were successful, as none of the sites had females with offspring. In 2017, we chose higher elevation sites to emulate natural avalanche paths and to avoid core wolf habitat. Wolves were not detected at sites in 2017, which helped minimize the effects of diversionary feeding on population sizes and pup survival. Total consumption times (days) varied by site but results indicate that, in spring and fall when natural food sources are limited, grizzly bears and black bears may be drawn away from human use areas or transportation corridors towards remote carcass sites.

The effectiveness of diversionary feeding at reducing conflict and wildlife mortality is variable (Kubasiewicz et al. 2016, Garshelis et al. 2017). In southwestern Alberta diversionary feeding sites were used predominantly by a relatively small number of male bears and did not result in decrease wildlife-conflict incidents (Morehouse 2016). Similarly, individual variability in bear behaviour and dominance can outweigh population level effects of diversionary feeding (Steyaert et al. 2014). While the amount of meat in grizzly bear diets has been correlated with body size, reproductive rates, and population density (Hilderbrand et al. 1999), large-scale diversionary feeding programs could inflate population carrying capacity and bear dependence on carcasses (Morehouse 2016). Similarly, carcass sites could increase disease transmission and likelihood of juvenile mortality (Derocher et al. 2013). Wolf feeding at diversionary feeding sites could increase the population of wolves, which could then increase predation risk of ungulates, especially those like caribou or perhaps moose that are susceptible to wolf-mediated apparent competition (Hurd 1999, Hebblewhite et al. 2007). Our 2017 decisions to emulate natural processes in carcass distribution increased the likelihood of program success. We distributed smaller volumes of carcasses to more sites along avalanche slopes and avoided known female denning areas. Carcasses could not be monopolized by a few dominant grizzly bears and were inaccessible to wolves. Conceptually, diversionary feeding returns valuable protein to the landscape and may reduce the amount of time carnivores spend near transportation corridors. Reduced time near developed areas could reduce mortality risk and human-wildlife encounters at time when natural food resources are scarce.

Next Steps – in future we will investigate the potential of smaller scale diversionary feeding to increase carnivore use of newly restored wildlife routes that will provide energy efficient travel paths for wildlife as an alternative to travelling along roadways and railways where mortality risk is elevated.

Acknowledgements/Partners

Prepared by Chris Groves, Dave Garrow, Laura Rance, Laura Nicholson, & Jesse Whittington. Other individuals involved with this project included: Simon Ham, Eric Knight, Steve Michel, Blair Fyten, Emma Carroll, David Laskin, Mike Grande, Mark Benson, & Bryan Macbeth.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: 403-763-8865
E: *jesse.whittington@pc.gc.ca*

Dave Garrow, Resource Management Officer
Banff Field Unit
P: 403-431-2288
E: *dave.garrow@pc.gc.ca*

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Cascade Creek Restoration

Introduction

Westslope cutthroat trout (WSCT-*Oncorhynchus clarkii lewisi*) are listed as threatened under Alberta's Wildlife Act and the federal Species at Risk Act (2013). Historically abundant throughout the Canadian Rockies, westslope cutthroat trout are now absent from more than 95% of their original range. Part of this range included the lower Cascade River in Banff National Park.



Figure 1. A team of Aquatic Technicians use electro-fishing to capture and remove non-native brook trout from Cascade Creek in Banff National Park, June 2013.

The majority of water exiting the Lake Minnewanka reservoir is diverted through Two Jack Canal, to create hydropower at the TransAlta Cascade Generating Facility. However, a small regulated amount of water flows through the riparian valve beneath the Lake Minnewanka dam, where it creates a stream known as Cascade Creek. The creek flows in the historic Cascade River channel, but has significantly reduced flows compared to the original river (8 m^3/s reduced to 0.3 m^3/s; Figure 2) and the channel has been further impacted by gravel extraction at Cascade Pits and Cascade Ponds. As a result, the lower half of Cascade Creek is dewatered, year round, and no longer connects with the Bow River. Parks Canada historically stocked brook trout (*Salvelinus fontinalis*) throughout the region for sport fishing opportunities. As a result of hydrological changes (flow regime and connectivity), and competition with brook troutbrook trout, westslope cutthroat trout have been extirpated from Cascade Creek.



Figure 2. Historic Cascade River at Bankhead 1904-1922.

Objectives

1. To remove all non-native fish from Cascade Creek.
2. To restore habitat (flow regime and connectivity) by constructing a smaller, more incised channel within the historic Cascade River bed.
3. To re-establish a population of pure native westslope cutthroat trout in Cascade Creek.

Methods

- Parks Canada conducted extensive electrofishing to remove brook trout (Figure 1).
- The emergency spillway release during the 2013 flood, scoured away huge amounts of fine sediment that had accumulated in the channel over many decades.
- We used hydrologic modelling to design a smaller channel within the original Cascade River channel based on the constraints of reduced flow.
- We will use an articulated backhoe to incise a smaller channel within the historic channel and establish a barrier to upstream movement of fish at the bottom end of this reach, just above the confluence with the tailrace which contains non-native fish.
- Once the channel and flow regime are restored, Parks Canada hopes to re-introduce genetically pure westslope cutthroat trout into this newly isolated and restored section of Cascade Creek.

Results

- From November 2011-2016, Parks Canada technicians removed 23,280 brook trout from Cascade Creek. The number of fish captured per minute decreased from 1.85 fish/minute in 2011 to 0.0026 fish/minute in 2016 (Figure 3).
- We completed 19.5 hours/km of electrofishing in late summer of 2016 to validate the complete removal of fish. Zero brook trout were caught during that electrofishing effort.
- The section of Cascade Creek along the Trans-Canada Highway has been narrowed and incised within the historic Cascade River channel to facilitate hydrological connectivity.
- Channel and flows are being designed for the remaining sections.
- Restored channel will be constructed during the spring and summer of 2018 and 2019.

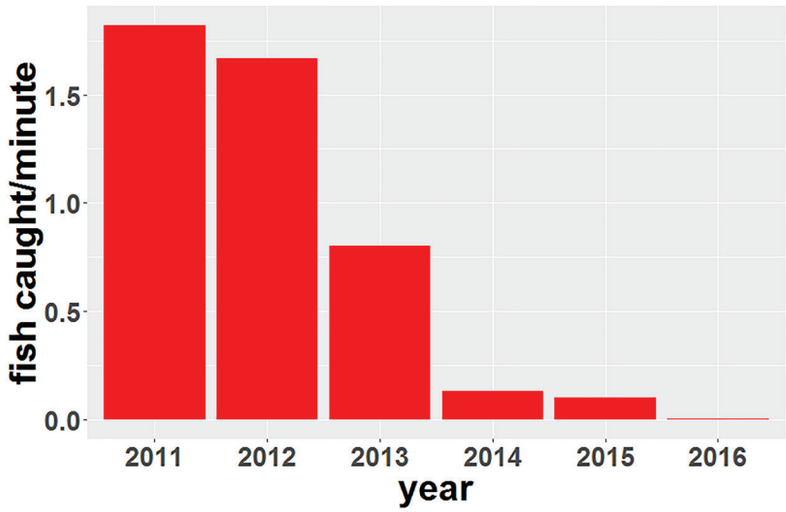


Figure 3. Standardized catch rates (# fish caught/min) for the removal of non-native brook trout in Cascade Creek, within Banff National Park, since the project began in 2011.

Discussion

To successfully restore Cascade Creek we needed to remove all brook trout. Non-native brook trout are generally able to outcompete native westslope cutthroat trout when the two species occur in sympatry (Peterson et. al. 2004, Peterson and Fausch 2003). Incomplete removal of the invasive species can contribute to unsuccessful reintroductions of native trout (Harig et. al. 2000). We expended tremendous effort removing brook trout from Cascade Creek; dedicating over 678 electrofishing hours over six years. As reaches were confirmed fishless (numerous repeated passes of catching zero fish) we isolate the reach with a barrier to prevent immigrating fish. Employing this isolation technique allowed technicians to focus efforts on other sections of Cascade Creek still containing fish. We targeted known brook trout spawning habitats throughout the removal project and disturbed gravels and cobbles with rakes, and shovels to destroy or displace any eggs that may have been laid.

The emergency spill release in 2013 flushed out decade's worth of accumulated silt from the pools and runs of Cascade Creek. To prevent future sediment accumulation and provide a more natural flow regime, an artificial annual maintenance flow will coincide with the natural spring freshet. To restore connectivity of Cascade Creek with the Bow River, Parks Canada is working with Dr. Robert Newbury to design an appropriate channel and flow regime.

To ensure this reach of stream remains accessible only to native fish species, we will first work with TransAlta to construct a fish barrier at the downstream end of Cascade Creek, at the confluence with the power plant tailrace on the lower Cascade River. The barrier will prevent fish from moving upstream from the Bow River into the restored Cascade Creek channel. Harig et. al. (2000) identified that along with incomplete removal of non-native salmonids, failed

artificial barriers were the main causes of non-native trout re-colonization. This barrier will be located in a regulated flow regime, below the Minnewanka reservoir, and therefore protected from spring flooding.

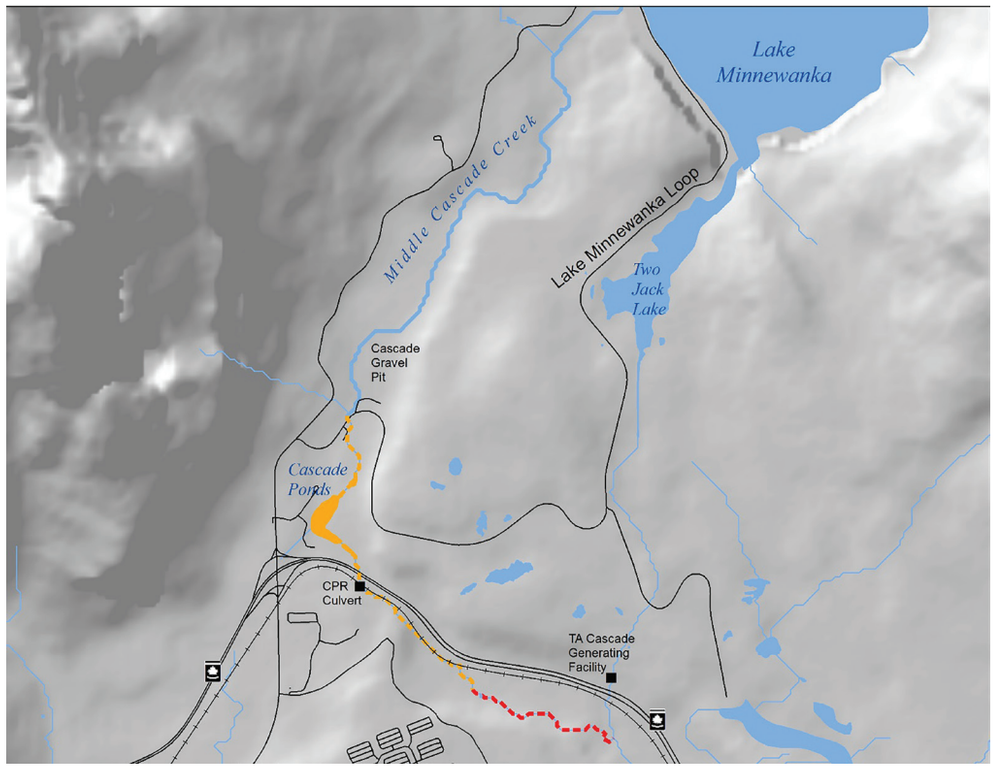


Figure 4. Map of Cascade Creek in Banff National Park, showing diminishing flows downstream of Cascade Ponds day use area (orange), and dried creek bed upstream of the power plant tailrace (red).

With the discovery of whirling disease in Banff National Park in 2016, extensive sampling of fish occurred throughout the park. A few remaining book trout from Cascade Creek were found to be infected with the myxosporean parasite *Myxobolus cerebralis*, the causative agent for whirling disease. However, with the complete removal of brook trout from Cascade Creek, Parks Canada eliminated one of the hosts of the disease from that closed system. Nehring (2014) suggests three years after the removal of infected fish, triactinomyxon spores (the type of spore released by the *Tubifex tubifex* oligochaete worm) will no longer be released, and the *Myxobolus cerebralis* parasite may be removed from the system. Since all brook trout have been removed from Cascade Creek, there is a possibility that over time all evidence of whirling disease may be eliminated from that system. Before the introduction of pure westslope cutthroat trout, Parks Canada will sample the water from Cascade Creek attempting to detect eDNA of *Myxobolus cerebralis*.

When completed, Parks Canada will have restored approximately 9 km of previously impaired and dewatered stream channel, by restoring flows, removing non-native species and establishing a new population of native westslope cutthroat trout in the heart of Banff National Park.

Acknowledgements/Partners

Parks Canada
TransAlta
Trout Unlimited
Canadian Pacific Railway
Fisheries and Oceans Canada

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: 403-762-1418
E: *mark.taylor@pc.gc.ca*

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Fisheries Restoration of the Upper Cascade River

Introduction

Native westslope cutthroat trout (*Oncorhynchus clarki lewisi*) are now absent from more than 80% of their historic range due to over-exploitation, habitat degradation, and hybridization or competition with non-native trout (Fisheries and Oceans Canada. 2013). Three of only ten remaining pure populations, in all of Banff National Park, are in the Cascade River watershed (e.g. Sawback Lake, Elk Lake, and Cuthead Creek). However, these pure populations are threatened by headwater populations of non-native fishes. For example, non-native rainbow trout (*Oncorhynchus mykiss*) in Rainbow Lake had compromised westslope cutthroat trout genetics by way of downstream movement and interbreeding (Figures 1 and 2). Another headwater lake, Badger Lake, contributes non-native Brook Trout (*Salvelinus fontinalis*) to the entire Cascade watershed.



Figure 1. Rainbow Lake (4.3 ha and 2,200m elevation) at the headwaters of the Cascade River was historically stocked with non-native Rainbow Trout. Sawback Lake, a "core" population for threatened Westslope Cutthroat Trout, can be seen in the distance (top right of photo).

Starting in 2011, we actively removed non-native or hybridized fish from the upper Cascade watershed. We entirely eradicated Rainbow Trout from Rainbow Lake (2011-2013), the source population that was causing rainbow trout-x-westslope cutthroat trout hybrids in the Upper Cascade Watershed. We also selectively removed rainbow trout and their hybrids from Sawback Creek, effectively creating a new pure population. Brook trout still remain in Badger Lake as well

as some brook trout in the upper Cascade River and Sawback Creek (See stream fish occupancy measure).

Goal and objectives

The goal is to restore native genotypes to the upper Cascade watershed via the following objectives:

1. To remove non-native rainbow trout from Rainbow Lake and Rainbow Creek.
2. To use mark/re-capture and genetic analysis to selectively remove hybrids from the Upper Cascade River.
3. To introduce a population of westslope cutthroat trout into Rainbow Lake from pure source populations.
4. To identify and remove non-native fish from other headwater lake populations in the Cascade Watershed.

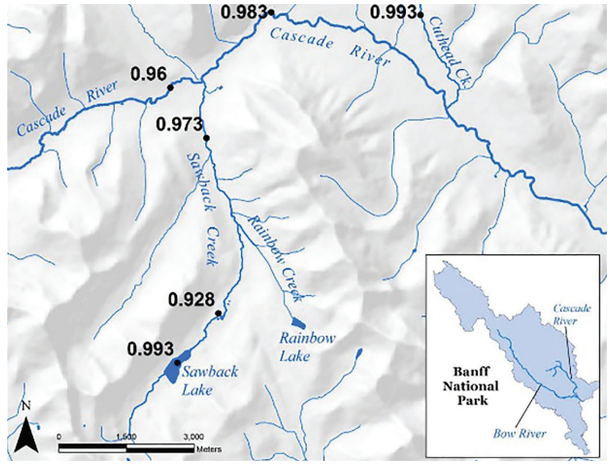


Figure 2. Map of restoration area showing Sawback Lake and Rainbow Lake. Numerical values indicate genetic purity of Westslope Cutthroat Trout sampled prior to restoration efforts. Populations must be in native waters with genetic purity ≥ 0.990 to be considered "core".

Methods

We removed rainbow trout from Rainbow Lake (4.3 ha at 2,200m asl) primarily by trapping at spawning grounds, gill netting (summer and winter), and shoreline electrofishing (2011-2013). We selectively removed non-native fish in the streams of the Upper Cascade watershed by electrofishing (2011-2013). To do this we individually marked fish and collected a tissue sample (adipose fin) from each fish, for DNA analysis. We then removed all known hybrids by re-capturing fish the following seasons. In 2015, we captured westslope cutthroat trout from a pure source population (Sawback Lake) and released them into Rainbow Lake. Brook trout will be removed from Badger Lake using the same methods as we used in Rainbow Lake.

Results

- From September 2011 to September 2013, we removed 532 rainbow trout from Rainbow Lake (Fig. 1) and 141 rainbow trout from Rainbow Creek.
- We caught no fish in Rainbow Lake the following year (September 2013 – September 2014), proving we removed all the non-native rainbow trout. Therefore, we eliminated the downstream propagation of rainbow trout alleles.

- In 2015, we worked with a group of volunteer anglers to capture one hundred genetically pure westslope cutthroat trout from Sawback Lake and released them into Rainbow Lake to provide additional pure genes to areas downstream.
- In Sawback Creek (Upper Cascade River), we successfully removed enough hybridized fish that this population is now genetically pure with Q values > 0.990 (Fig. 3).
- The last remaining headwater source of non-native fish in the Cascade River watershed is brook trout in Badger Lake, and we are currently completing planning and approvals to remove them.

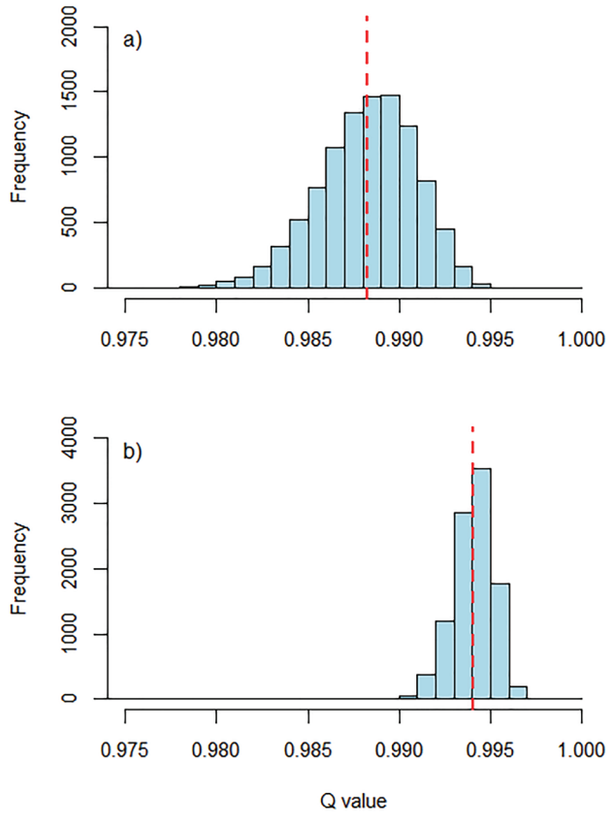


Figure 3. The genetic purity of the Westslope Cutthroat Trout in Sawback Creek, before (a) and after (b) the removal of hybrids.

Discussion

Freshwater fishes are some of the most imperiled taxa worldwide as evident by the number of threatened and endangered species (Strayer and Dudgeon 2010). For example, the Alberta population of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) has been assessed as "threatened" provincially and nationally (Fisheries and Oceans Canada 2013). This species is also listed as "threatened" under the federal Species at Risk Act (Fisheries and Oceans Canada 2013). In Banff National Park, native westslope cutthroat trout populations area absent from almost 80% of their range. The remaining, genetically pure native populations (believed to be 10 in Banff National Park) persist as severely fragmented, remnant headwater populations.

Threats to westslope cutthroat trout, and inland fisheries in general, can be broadly classified as habitat degradation, invasive species, water pollution, nutrient loading, flow modification and fragmentation (Dudgeon et al. 2006). Because Banff National Park is a protected area, some of these threats are non-existent. However, decades of historic stocking of non-native species has resulted in brook trout being found in every watershed in Banff National Park. Parks Canada has demonstrated leadership in the active management of this threat. To date, we've eradicated brook trout from over 30 ha of lakes and 4.5 km of stream habitat using mechanical methods such as gill netting and electrofishing (Pacas and Taylor 2015). Many more headwater lakes in Banff National Park contain non-native trout and Parks Canada will continue with strategic control efforts.

In addition to the threat of non-native trout, there are larger scale threats caused by warming shifts in precipitation and runoff (Richter et al. 1997; Dudgeon et al. 2006). Indeed, US fisheries scientists have modeled the predicted effects of climate change on cutthroat trout abundance and distributions (e.g., Williams et al. 2009; Al-Chokhachy et al. 2013; Wenger et al. 2011). Warmer water, changes in stream flow and increased frequency and intensity of other disturbances (e.g. flooding, drought) are among the factors associated with climate change that have been shown to effect cutthroat trout populations directly. Indirectly, westslope cutthroat trout may become more vulnerable to non-native trout because many non-native species have higher thermal tolerances. Indeed, Muhlfield et al. (2014) have demonstrated that accelerated hybridization between westslope cutthroat trout and rainbow trout were strongly linked to climate drivers. Therefore, Parks Canada may need to step up our control efforts. Prioritizing restoration projects based on thermal regimes would provide the best chance at mitigating the effects of climate change and ensuring that restored population have the best chance at survival. New and innovative techniques will also have to be developed whereby non-native fishes can be eradicated more quickly and easily.

Through this work in the upper Cascade Drainage, we've successfully removed a key threat, by eliminating rainbow trout from Rainbow Lake, and repopulating this impacted waterbody with native westslope cutthroat trout. Normally, we would restore an historically fishless lake by removing non-natives and leaving it fishless, but in this case we felt the Rainbow Lake food-web had already been affected by stocking, and it was important to attempt "genetic swamping" in an effort to maintain pure populations downstream. Additionally, by restoring genetic purity of >0.990 to Sawback Creek, which is native waters for westslope cutthroat trout, we have now added an 11th "core" population of threatened westslope cutthroat trout to Banff National Park. This represents the first successful restoration effort for westslope cutthroat trout anywhere in Canada.

Acknowledgements/Partners

Trout Unlimited

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: 403-762-1418
E: *mark.taylor@pc.gc.ca*

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Restoring Bull Trout Connectivity in Forty Mile Creek

Introduction

The Forty Mile Creek Dam was constructed between 1916 and 1949 to supply drinking and fire protection water to the Town of Banff. The infrastructure had not been used since the mid-1980's, yet it continued to block connectivity between the Bow River watershed and the Forty Mile Creek watershed. In 2014, Parks Canada and the Town of Banff cooperated to remove a portion of the dam and restore natural flows to this system. This restoration of natural alluvial processes is significant, as the dam had almost completely filled with sediment; robbing areas downstream, of important spawning gravels. A second key objective of the partial dam removal project was to restore connectivity for fish. We intended the newly created passage through the dam to act as a natural fishway; allowing native bull trout to move upstream. Fishways are rarely tested for their effectiveness, and we were concerned that a flat concrete apron, remaining on the substrate near the dam structure, may impede fish movements during low flows. To mitigate this, we installed metal baffles to break up the laminar (flat) flow over this artificial substrate.

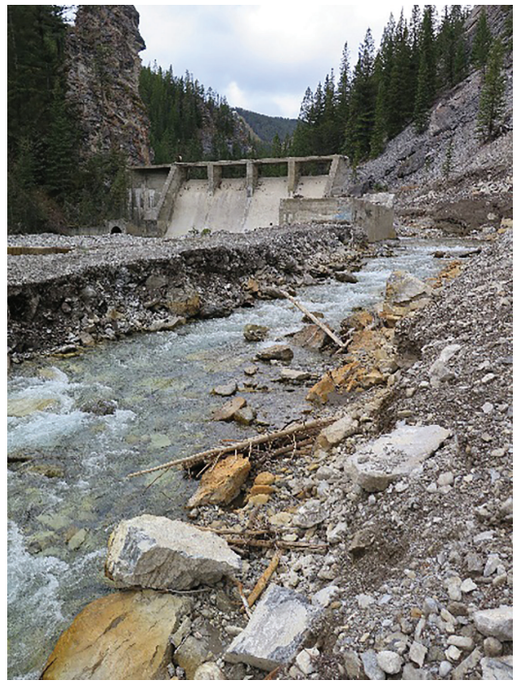


Figure 1. Nature-like fishway following the partial removal of 40 Mile Dam.

The success of this restoration project required validation, through effectiveness monitoring, if we hoped to consider the project successful and to contribute to the body of knowledge related to dam removals. Documenting passage of bull trout at the Forty Mile dam site would provide evidence that these fish are finally able to access the high quality headwater habitat found further upstream, for the first time in 65 - 100 years.

Objectives

1. Determine the probability of bull trout approaching the fishway (i.e. do they want to move up and/or downstream of the dam?)
2. Determine the probability of bull trout passing the fishway (are they capable of passing the dam, given they were attracted to it?
3. Determine the environmental characteristics that predict approach and passage probabilities.

Methods

Parks Canada aquatics specialists collaborated with M.Sc. student Brittany Sullivan of Carlton University to complete this monitoring project. We captured 136 bull trout from below and above Forty Mile dam (68 upstream and 68 downstream). We held bull trout captured from upstream of the dam in aerated tanks and moved them downstream to the tagging/release site. This experimental downstream release of bull trout, caught above the dam, was important for sample size as more bull trout occur upstream of the dam. We surgically implanted transmitters in each fish following Parks Canada's Best Practices for Fish Handling (McLean et al. 2015). To track movements of bull trout, we placed a receiver at the dam, and spaced two more receivers upstream and downstream, respectively. We pointed receiver antennas at the dam site, up and downstream of the fishway, to determine attraction efficiency. One antenna was pointed directly at the constriction in the fishway to determine which individuals were actually successful at passing the site. We used mixed models to test for probability of bull trout approaching the dam, passing the dam, and passage probability.

Results

The probability of translocated bull trout approaching the dam was low (37%), but equalled the probability of non-translocated fish approaching the control receiver. This means that translocated fish moved upstream at the same rate as non-translocated fish.

- For those fish that did approach the dam, the probability of them passing was high (78%; Figure 1) meaning that the fishway is permeable.
- The probability of passage was 0.30 higher at night compared to during the day suggesting possible predator avoidance (Figure 1).
- Passage duration was not significantly related to any of the environmental variables tested. However, individual bull trout spent 5 minutes to 13 days in the fishway suggesting the used the fishway for foraging as well as movement.

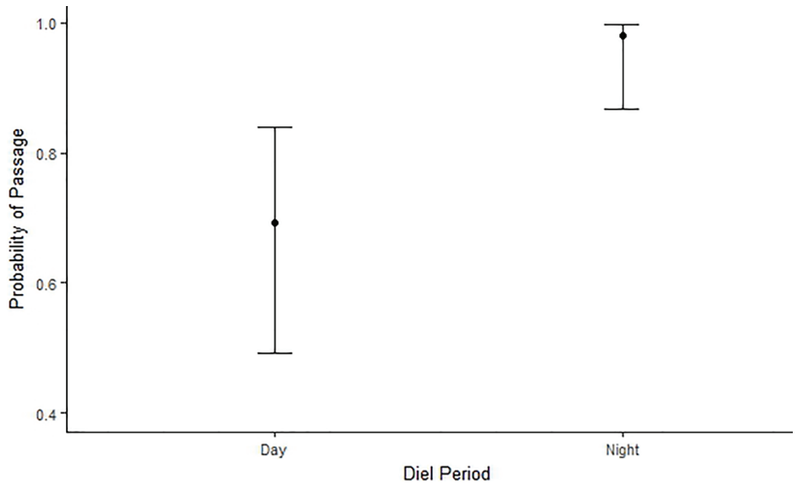


Figure 2. Probability of passage was 78% overall. However, at the mean water level, the probability of bull trout to pass the fishway increased by 0.30 at night.

Discussion

Forty Mile Dam prevented any upstream movement of fish for at least 65 years. Longitudinal connectivity in fluvial ecosystems is important for gene transfer, nutrient cycling, and population persistence (Wiens 2002; Pringle 2003). This research confirms that we have restored upstream movement of bull trout by partially removing the Forty Mile Dam. Improving aquatic connectivity was a goal in the last management plan (Parks Canada 2010) recognizing how dispersal can play a pivotal role in genetic structuring of natural populations (Slatkin 1987; Waters et al. 2000). The continued blockage of upstream movement in bull trout in Forty Mile Creek may have contributed to the long term genetic extinction risk and excluded bull trout from preferred habitats.

Not only has fish passage been restored, but the downstream movement of sediment has also been restored. Until the partial removal, only fine sediment in suspension would have travelled downstream past the Forty Mile Dam (de Scally 1999). Since the partial removal, large sediment can now move downstream which will help restore the alluvial fan and provide important materials for spawning fish. Alluvial fans affected by floods and debris flows promote the growth and maintenance of clone stands of trembling aspen (de Scally 1999). In the absence of this disturbance, aspen will be succeeded by coniferous species such as white spruce and Engelmann spruce in < 100 years. For example, the Forty Mile Creek alluvial fan is currently covered in stands of over-mature aspen which are being replaced by coniferous species (de Scally 1999). This role of alluvial fans has become especially important given the major decline of aspen stands over the years as a result of the park's fire suppression activities (de Scally 1999).

Unfortunately, in the case of Forty Mile Creek, alluvial fan restoration is further hindered by an historic dumpsite and the Trans Canada Highway (TCH). Parks Canada has recently needed to

constrain alluvial processes upstream of the highway to prevent erosion into this historic contaminated site and to ensure the wetted channel aligns with the TCH bridge. Fortunately these impacts do not impede the downstream migration of gravels, which were previously captured behind the dam, and will now be available to diversify spawning habitat.

We have identified and even restored a number of other barriers to connectivity associated with road-stream crossings. However, the effects of the remaining Minnewanka Dam (Cascade River) and Canyon Dams (Spray River) persist until Parks Canada can develop innovative ways to mitigate the negative impacts of this hydropower infrastructure. By confirming the successful restoration of connectivity for native bull trout in Forty Mile Creek, Parks Canada has proven the effectiveness of a novel approach, (partial dam removal) which may be applied in other areas of North America, where full dam removal is not feasible.

Acknowledgements/Partners

Brittany Sullivan, Cooke Lab, Carleton University, Ontario.

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: (4030) 762-1418
E: mark.taylor@pc.gc.ca

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Bow Valley Elk Management

Rationale

Elk are an important component of Banff National Park's ecosystem because they can exert strong grazing pressure, are an important prey species for wolves, grizzly bears, and cougar, and are inspiring to visitors. Many elk seek refuge in the Banff town site to reduce predation risk and can be aggressive towards people especially during calving and breeding seasons. Elk management in the Bow Valley currently focusses on reducing elk-human conflicts and monitoring population trends, migration rates, and predator-prey dynamics (Banff Elk Management Strategy 1999, 2007).



Figure 1. Seasonal elk safety information (Parks Canada).

Objectives

- Monitor the population size and recruitment rate of Bow Valley elk;
- Mitigate detrimental effects of excessive elk herbivory by maintaining an elk density conducive to vegetation recovery (target of ≤ 2 elk/km^2);
- Monitor migrant vs. resident strategies in a portion of the Bow Valley population, in support of the goal of increased migration;
- Reduce habituation and human-elk conflict by at least 75% from 1990's levels;
- Facilitate access to elk by predatory species by preventing elk from seeking refuge in built-up areas such as the town site;
- Disseminate information on elk behavior, safety, and management actions.

Methods

As they relate directly to each objective listed above:

- Spring (April) and fall (November) ground surveys to monitor calf-recruitment and spring aerial surveys to monitor population trends; aerial surveys were last conducted in 2014.
- Remove aggressive and habituated "resident elk" (those that spend more time in the town). Removals are undertaken in the context of other sources of mortality and population targets of 150-300 for the Bow Valley, with 116 in the central zone;
- Radio-collar and monitor a subset of the Bow Valley population. This included 28 individuals at the start of the 2017 calendar year.
- Consistent hazing of elk from Banff town site area, and tracking human-elk conflicts through the national occurrence tracking system (Incident Event Management);
- Maintain/restore habitat security of wildlife corridors, and monitor for trends in carnivore activity (see Wildlife Corridors report);
- Post seasonally-specific, newly designed elk safety information during calving (spring) and rut (fall), while continuing to reinforce key public messaging, including removal of potential entanglements etc.

Results

The Bow Valley elk population has been relatively stable for the last 13 years (Figure 2). Ground counts in fall 2017, found 229 individuals while the spring count found 158 individuals. Calf-cow ratios have been much more variable over time, but have been relatively stable the last 5 years. The fall 2017 calf-cow ratio was 26% while the spring ratio was 20%. Moderate recruitment rates indicate the continued capacity for steady growth in the Bow Valley population. Detection of collared animals during the classified ground counts helped to determine roughly what percentage of the elk may have been missed during the survey. We have flown yearly aerial counts each spring from 1985 - 2014. An aerial survey is planned for the spring of 2018 to get a better estimate of the Bow Valley elk population.

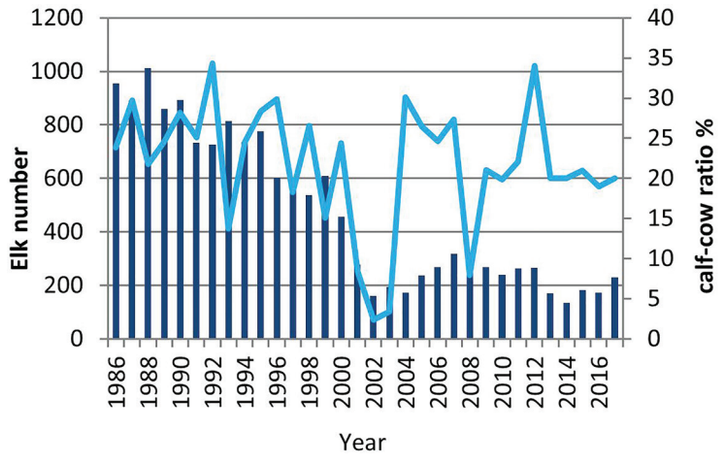


Figure 2. Spring elk count (bars) and calf-cow ratio (line) of 11 month old calves, Bow Valley, 1986-2017; 2015 to 2017 elk counts were based on ground rather than aerial surveys.

In the last 10 years elk have migrated from Banff town site to Bryant, Lake Louise, Minnewanka, and the Cascade Valleys. In 2017, VHF telemetry monitoring indicated that 13 of the 28 collared elk migrated. These results correspond exactly to the migration rates found on Parks Canada's YaHa Tinda Ranch by Hebblewhite & Merrill (2014). Of the 13 Banff migrants 10 returned near the town of Banff by November 2017.

In addition to some predation and human-caused mortality (e.g. railway strikes), Resource Management Officers have removed 109 habituated resident elk since 2007. Early removals focused on female elk. The focus more recently has been on aggressive bull elk around the town of Banff who frequent the town site despite continual hazing. To date we have removed 5 bull elk over the past 3 years; including 3 in 2017. Most contact charges in 2017, stemmed from incidents with bull elk (Figure 3). Even with wolves frequenting the area around the town, the elk calf-cow ratio has remained steady around 20% over the past 4 years.

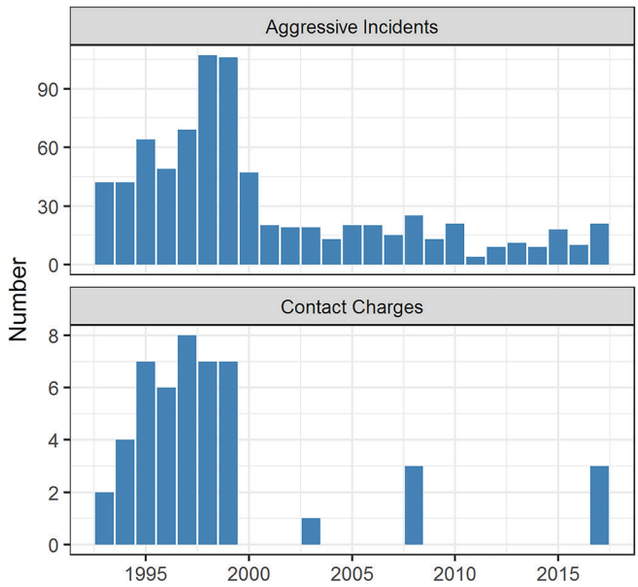


Figure 3. Aggressive elk incidents and contact charges in Banff National Park 1993 to 2017.

Park staff also historically deployed temporary wood-rail fencing across specific highway crossing structures to hold a portion of the central herd in the areas of their winter range that are more accessible to predators (e.g. Cascade Corridor). These rails were not deployed over the past two winters as the wolves were accessing elk on both sides of the highway.

Instances of human-elk conflict remain well below the prescribed target. The number of aggressive incidents increased from 10 in 2016 to 21 in 2017 (Figure 3). There were also 3 contact charges in 2017 but prior to this there have been none since 2008. Most of the aggressions have been related to the bull elk frequenting the town site. Ongoing active management practices, including systematic hazing efforts, will continue to increase elk wariness and reduce town site habituation.

Discussion

We will continue to monitor the Bow Valley elk herd to track population trends and calf recruitment with a target of ≤ 2 elk/km² which is conducive to vegetation recovery. Aerial surveys have higher detection probability and are more accurate than ground surveys. Flying aerial surveys at least every three years will provide accurate population estimates, which are important

because the elk population and associated conflict can quickly increase (e.g. 2004 - 2007). We will continue to manage elk around the town site to reduce levels of habituation and human-elk conflict. Proactive education helps reduce conflicts so we continue to communicate safety messages to residents and visitors in a timely manner and to remove aggressive habituated elk; if the population grows beyond ≤ 2 elk/km^2 in the core area then additional culling may be necessary. Indigenous People have, and will continue to be, involved in elk removals depending on the population size and number of elk to be removed. Effective wildlife corridors continue to be an important tool to provide predators with access to elk so that they can naturally regulate the elk population.

Acknowledgements

Prepared by Blair Fyten and Sarah Fassina.

Contact

Blair Fyten, Wildlife Conflict Specialist
Banff Field Unit
P: (403) 760-5688
E: *blair.fyten@pc.gc.ca*

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Ya Ha Tinda Elk Population

Rationale



Figure 1. Cow elk with young of the year (S. Fassina)

Through a collaborative research program between the University of Alberta, University of Montana, Parks Canada, and other research and conservation organizations we are investigating how changes in the Ya Ha Tinda elk population are affected by abiotic factors such as climate and biotic factors such as predation, seasonal habitat quality, and human use. Research on predator-prey dynamics in the Ya Ha Tinda ecosystem started in 2000 and is one of the longest running elk studies in the world. The focus has been on understanding the changing migratory behavior of elk, the trophic interactions between predators, prey, vegetation, and long-term grassland dynamics (http://www.umt.edu/yahatinda). These elk utilize large portions of north Banff - overlapping with recently reintroduced plains bison in Banff, and support predator populations that occupy portions of Banff National Park, so it is important to understand factors affecting Ya Ha Tinda elk populations.

Objectives

Major objectives of the research nearing completion include

1. Continued long-term monitoring to estimate pregnancy rates, adult female survival/mortality, migratory behaviour, population size, and grassland productivity.
2. Monitor calves to determine survival and cause-specific mortality. Determine the effects of migratory behaviour and habitat selection on calf survival. Capture and ear-tag new born calves with radio-transmitters to assess causes of mortality.
3. Conduct scat surveys using scent detection dogs to determine relative diets between the large carnivores and to evaluate multi-predator predation risk on elk survival.

Major objectives of future research just getting under way include

1. Continue monitoring population trends of the Ya Ha Tinda elk herd by monitoring pregnancy rates, mortality, and migratory movements of collared female elk, focusing on the migratory habits and switching behaviour of individually marked females.
2. Monitor the predator community that preys on the Ya Ha Tinda elk herd and the effect of predation and predation risk on the elk population.
3. Monitor habitat quality by using combinations of field data and remote sensing across the study area to create dynamic models of forage quality and forage biomass.
4. Monitor endoparasites in the Ya Ha Tinda elk herd and the impact that different migratory strategies have on parasite species composition and abundance.
5. Monitor male elk mortality, movements, and migratory behaviour to understand male elk cause-specific mortality, age structure, survival, and population dynamics.

Methods

Parks Canada staff and researchers captured and radio-collared over 225 adult female elk and tracked their resource selection, movements, survival and migratory patterns. From 2013-2016, 184 female elk were captured and monitored throughout the summer to determine migratory status and calf survival. In addition during February and March of 2017, 20 additional elk were free-ranged darted from horses, immobilized and subsequently collared. Female elk were palpated for pregnancy and fitted with a vaginal implant transmitter if determined to be pregnant. These transmitters are ejected during birthing and allowed researchers to locate and radio-eartag calves immediately after being born, to assess causes of mortality. This study design assumed that researcher handling of young calves did not affect predation rates. Researchers investigated mortality signals of VHF collars as soon as possible to determine cause of death.

Moving forward we will continue to collar approximately 60 female elk, and 35 bull elk, to track migration strategies and mortality rates and will continue to monitor reproduction using population and individual-level-approaches. We will also continue to monitor a camera grid that covers the full extent of the Ya Ha Tinda elk population range and to measure local predator activity to investigate how elk respond to these patterns. We will continue to monitor vegetation plots across the Ya Ha Tinda grasslands to estimate grassland biomass. To assess differences in endoparasite abundance and diversity between resident elk and eastern and western migrant elk we will collect ungulate pellets from May through October at the Ya Ha Tinda and in July and August on the Ya Ha Tinda Ranch and in Banff National Park. All samples will be analyzed to determine parasite abundance and diversity.

The scat-based predation risk study systematically searched for scats across the study area using specially-trained dogs. Students collected scat samples of wolves, black and grizzly bears, coyotes, cougars, and lynx. They then linked predictive models of scat distribution to elk mortalities to understand the relative importance of each predator on elk survival.

Results

The Ya Ha Tinda elk population peaked at over 2000 individuals in the early 1990's. This population may have been elevated due to predator control on provincial lands. Since then the population steadily declined, but has stabilized for the last four years at around 360 animals. Part of this stabilization may be driven by higher calf survival of elk migrating east of the winter range (Berg et al. 2016). The elk population has been driven primarily by constant density-independent predation (Ahrestani et al. 2016).

On average 36% of the elk population migrated, either west from Ya Ha Tinda into Banff National Park as far as Lake Louise and Bow Summit, or east towards Sundre. The benefits of migration included higher quality forage, higher pregnancy rates, and higher calf weights (Hebblewhite and Merrill 2011). The trade-off for migrating included increased predation risk compared to residents that lived in larger groups close to people. However, 15% of individuals switch migration strategies each year (Eggeman et al. 2016). This switching of migratory behaviour had not been observed elsewhere in the world. The probability of a resident switching to migratory behaviour increased with wolf density, elk population size, and age, and decreased when the previous summer had high precipitation.

Elk pregnancy rates were high ranging from 91-97%, but calf recruitment remained low (Berg et al. 2016). Based on known locations (n = 153), 12% of cows gave birth in Banff National Park, 19% of cows gave birth north of Ya Ha Tinda, (mostly in the Bighorn Creek cut blocks and along Scalp Creek), 27% of cows gave birth to the east of Ya Ha Tinda, 37% of cows gave birth in the vicinity of the ranch, and 4% gave birth to the south of the ranch. Known birth dates ranged from 9 May to 11 July.

Calf mortality was primarily caused by bears (Figure 1), although calves died from a wide variety of causes. Note that unknown, unknown predator and failed/dropped tags accounted for 39% of the sample. Approximately 50% of the elk calves (n = 105) in the Ya Ha Tinda elk herd died before the age of 10 days (Figure 2). Handling newborn calves during tagging, may have differentially impacted causes of mortality, but should not affect comparisons between groups. Preliminary analysis suggests the difference in survival of calves from eastern migrants (n=79) as compared to western migrants (n=33) was statistically significant with calves born to the east of the YaHa Tinda Ranch having a greater chance of surviving (Berg et al. 2016).

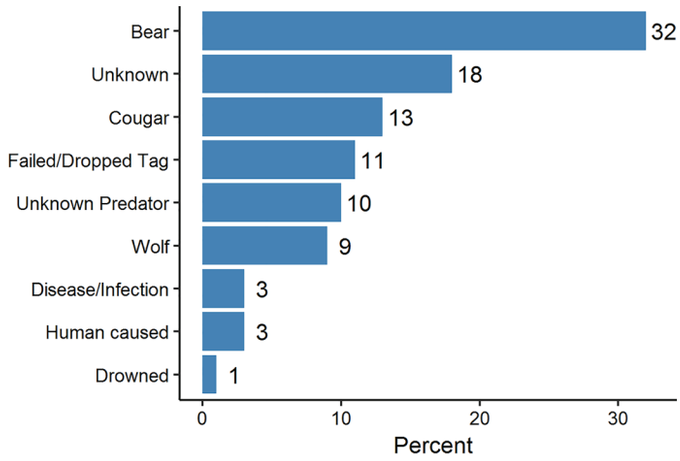


Figure 2. Causes of death of marked elk calves (2013-16).

Of the 1,300 carnivore scats collected over 1,000 km of survey routes there is ongoing analysis to determine what prey species are in the scats and to identify where different prey are being killed and what predators are doing the killing.

Researchers used long term elk GPS data to determine the location and timing of elk migrations (Killeen et al. 2015). On average 79 elk migrate into Banff National Park each year and 105 migrate east of Ya Ha Tinda (2011-2014). The percent of elk migrating into Banff National Park has declined steadily over time while the percent of elk migrating eastward has increased from 3% to 26%. Of the elk migrating into Banff National Park, 17% travelled through core bison range in the Panther Valley and 43% migrated through the bison expansion area in the Red Deer Valleys. Most (75%) of elk started their spring migration by June 20 and fall migration by October 20. Individuals used similar migration routes in spring and fall.

Discussion

The Ya Ha Tinda elk herd has declined over the past 20 years from a count of ~2,200 individuals in the early 1990's to ~390 individuals in winter 2016. As the population declined, the number of elk remaining near the Ya Ha Tinda ranch year-round increased and the number of elk migrating westward to Banff National Park decreased. Additionally, a new migration pattern developed in the late 2000's where increasing numbers of elk migrated eastward to take advantage of high forage quality caused by timber harvest and the Dogrib fire that burned 10,200 ha in 2001. From 2011-2014, 27% of marked elk have followed this eastern migration. Increasing numbers of elk summering on the Ya Ha Tinda grasslands has potential to damage rough fescue, which can sustain grazing pressure in winter more so than summer.

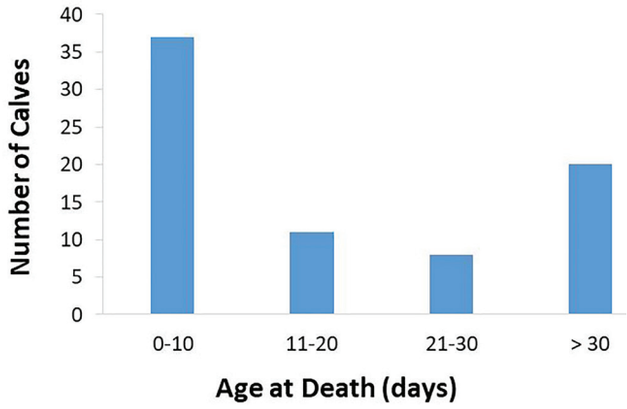


Figure 3. Age at death for 105 elk calves (2013-2016).

Understanding the dynamics of these migratory segments of the elk herd is main goal of this project. Recent research shows a switching rate of ~15% per year between migratory strategies which may be dependent on intrinsic factors, such as age, or extrinsic factors, such as forage quality or predation risk. This switching behavior may have caused changes in the ratios of migrants and residents in this system resulting in the population dynamics observed over the last 15 years. Understanding the causes and consequences of changing migratory behavior is a major applied focus of this research.

The long-term collaring and monitoring program that has been occurring for over 16 years will help us understand what causes conditional dependence in switching between migratory strategies and evaluate the consequences of switching to population dynamics. This research will help us understand how and why the Ya Ha Tinda elk population has declined with changes

to its migratory patterns, with a key outcome being understanding the effect that declining elk migration into the National Park has on predators in Banff National Park. In addition, male elk will be included in the study design for the next 3 years to understand the ecology and population dynamics of male elk in the Ya Ha Tinda ecosystem. Hunting is allowed on the Ya Ha Tinda ranch and these data will provide valuable information about survival, migration, and cause-specific mortality of adult males in this population and their importance to predators in Banff. Research will answer these questions through the understanding of individual trade-offs between predation risk and forage which are the overriding drivers of large herbivore life history and ecology as well as understanding switches in predator diet and distribution. We have used an extensive camera trapping grid for multi-species occupancy models; successfully estimating grizzly bear, wolf, and cougar distribution across the study area (Steenweg et al. 2016, Steenweg et al. online early view). In addition to these occupancy models, wolf collaring efforts have provided valuable information about wolf distribution, numbers, and habitat selection used to develop spatially explicit predation risk models.

The main objective of the research continues to be the monitoring of population dynamics of the Ya Ha Tinda elk herd by monitoring pregnancy rates, mortality, parasite load, and migratory movements of collared elk, focusing on the migratory habits and switching behavior of individually marked elk.

Acknowledgements/Partners

Prepared by Blair Fyten, Sarah Fassina, and Jesse Whittington. Principle investigators Mark Hebblewhite from the University of Montana and Evelyn Merrill from the University of Alberta. The Alberta Conservation Association, Alberta Environment and Parks, National Science Foundation, Natural Sciences and Engineering Council of Canada. Rick Smith and Ya Ha Tinda staff. Parks Canada Resource Conservation staff.

Contact

Blair Fyten, Wildlife Conflict Specialist
Banff Field Unit
P: 403-762-1438
E: *Blair.Fyten@pc.gc.ca*

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: 403-763-8865
E: *jesse.whittington@pc.gc.ca*

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Fire Management Program

Introduction

With the creation of the first national park, Parks Canada took on the responsibility of fire management within its boundaries. Like most agencies, Parks Canada began with a strategy of complete fire suppression. This culture reduced the amount of fire on the landscape, increasing fuel loading, encroachment and heterogeneity.

Increased understanding on the role of fire as a necessary ecological process has resulted in a shift in fire management practices within national parks including the implementation of the first prescribed fire in 1983 (Two Jack Canal, Banff National Park).



Figure 1. Verdant creek wildfire, just west of Sunshine Meadows area in Banff National Park, in August 2017

Outlined in the National Parks Act and under the direction of the Parks Canada Agency National Wildland Fire Management Directive (2017), national parks are responsible for fire management including the reduction of wildfire risk and promoting ecological integrity as per the Parks Canada mandate.

Further to the directive and mandate, the Banff National Park management plans (Parks Canada, 2010), outlines requirements for strategic documents to achieve objectives as they relate to fire management in Banff National Parks. This includes the creation of a fire management plan (Parks Canada, 2016) to outline fire management actions. From this plan, prescribed fire, vegetation, fuel management guiding documents have been developed.

This framework provides tools for fire managers to meet objectives as they pertain to the management of fire and fire risk in Banff National Park (Figure 1).

Objectives

Objectives of the fire management program as they relate to fuel management, prescribed fire and wildfire risk:

1 Continue to improve and build on fire management projects which align with the protection of communities, infrastructure and public safety. This includes fuel management, prescribed fire and managed wildfire.

Prescribed fires are generally planned to meet multiple objectives. These include ecological and risk reduction components. Commu-nity protection and wildfire risk reduction through prescribed fire is used to reduce the risk wildfire to the communities and infrastruc-ture within and adjacent to park boundaries.

2 Continue to deliver on the parks mandate of ecological integrity.

As per the park management plan (2010), there is a long term goal to restore fire as a natural process based on historical data, except where limited by safety considerations and the protection of park facilities and neighbouring lands. A quantitative target for the restoration of fire through prescribed fires and unplanned fires of 50% of the estimated long-term fire cycle has been adopted. This amounts to an annual area burned goal of 1400 ha for Banff National Park.

3 Develop and update strategic documents to continue to provide guidance for fire management implementation.

The fire management plan will identify areas where efforts will be concentrated over the next ten years and the manner in which these targets will be achieved (e.g. prescribed burning and/or managed wildfire).

Methods

Prescribed fire

Setting priorities for prescribed fire is based on a number of factors, including but not limited to: wildfire preparedness and values at risk protection (e.g. Prescribed fire in the wildland urban interface or to serve as landscape fuel breaks); ecological objectives and priorities (eg. Bison, grassland restoration etc); landscape level fire restoration objectives (50% fire cycle restoration objectives) and management of boundary lands. Aerial and ground ignition methods are used under prescriptive conditions to meet multiple objectives with low to moderate risk.

Fuel Management

In areas where prescribed fire results in too high risk or impacts to public safety and values, other fuel management techniques can be used including:

- fall and burn operations
- brushing
- fall and salvage
- mechanical removal (logging)

Wildfire Management

Through management zoning, agreements with adjacent stakehold-ers, prescribed fire planning, the management of unintended fires allows for greater flexibility in reaching both objectives of values protection and ecological integrity. In managing wildfires, Parks Canada personnel can establish safer boundaries for resources, encourage fire growth into receptive fuel types and improve fire breaks for future fire incidents. This can be achieved through the monitoring of wildfires, implementation of burn operations and/or control line construction and artificial boundaries to fire growth.

Results

Table 1. Area burned by various causes between 2008 and 2017. The term "incendiary" refers to accidental human caused fires (e.g. discard-ing cigarette) whereas "recreation" includes illegal camp fires.

Year	Recreation	Lightning	Incendiary	Unknown	Railway	Other Industry	Prescribed Fire	Total Area Burned (ha)	Total Number of Fires
2008					0.7		1315.7	1316.4	8
2009	1.3	5730.5		0.1	0.1	0.3	1528.5	7260.9	12
2010	0.6	0.6	0.1					1.3	10
2011	0.1		0.3	<0.1				0.4	3
2012						0.1		0.1	1
2013			0.1				57.7	57.8	2
2014	0.1	2287.7				<0.1	1607.9	3895.8	12
2015	0.3	703.0		1.0			680.1	1384.4	26
2016	0.1	<0.1					41.0	41.1	14
2017	0.7	<0.1	0.2	<0.1				1.0	33
Frequency	75	15	5	5	2	4	16	-	121
Total Area	3	8,722	1	1	1	0	5,231	13,959	-

Over the past 10 years, we have conducted approximately 5,231 ha of prescribed fire operations, and have managed 8,728 ha of wildfires, in Banff National Park, for a total of 13,959 ha burned. This is very close to our annual area burned target of 14,000 ha over 10 years (Figure 2).

Despite this success, the past century of fire suppression has resulted in an overall condition measure that is rated as "poor" (see Area burned by Condition Class measure for the Forest Condition Indicator). It is important to differentiate between these two measures of success. The burn target (MEM) shows that recently we have been very successful in Banff, at applying fire, but the Condition Measure shows that the overall condition remains poor, because of ecosystem effects of over a century of fire suppression.

Table 2. Major wildfires and prescribed fires (> 100 ha) in Banff National Park between 2008 and 2017.

Year	Fire Name	Area (ha)	Cause
2008	Mount Nestor	491	Prescribed Fire
2008	Panther River	446	Prescribed Fire
2009	Spray 16/Nestor	862	Prescribed Fire
2011	Red Deer	862	Prescribed Fire
2014	Sawback	724	Prescribed Fire
2014	Spreading Creek	2286	Lightning
2015	Dormer	305	Prescribed Fire
2015	Snarl Peak	703	Lightning
2015	Panther Valley	375	Prescribed Fire

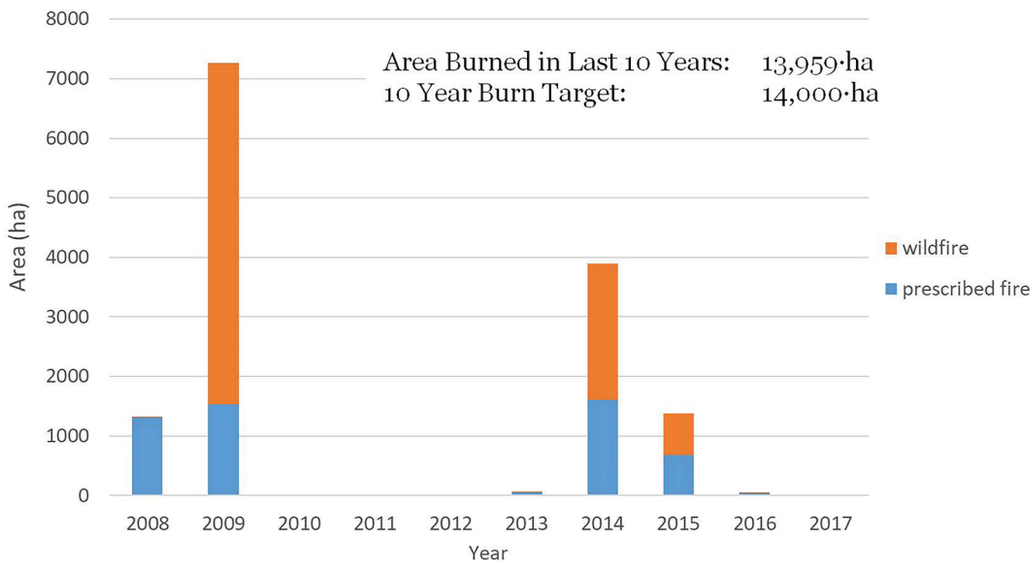


Figure 2. Hectares burned in Banff National Park since 2008 by prescribed fire and wildfire (total = 13,959 ha).

It is also important to note the success of our initial attack efforts, in which the vast majority of wildfires (all categories in Table 1 except Prescribed Fire) are quickly suppressed before growing larger than 1 ha. We have successfully suppressed, or managed, 105 wildfires in the past decade.

In some areas of the park, we allow wildfires proceed naturally, and simply work to manage them on the landscape (e.g. Snarl Peak) whereas in most frontcountry areas, we work to immediately suppress any unplanned fires.



Figure 3 Fuel management work conducted in the Fenlands day use area, in Banff National Park, November 017.

Area burned targets will not be met with prescribed fire alone, but rather through a combination of prescribed fire and managed wildfire. Prescribed conditions for prescribed burns (weather, risk, wildfire situation, personnel requirements) vary yearly and thus yearly analysis is not beneficial in analyzing long term success.



Figure 4. An example of fuel management work being completed by Parks Canada crews at the Fenlands Day Use Area.

Since 2008, we have completed a total of 1500 ha of fuel manage-ment within Banff National Park. We monitor completed areas to assess maintenance requirements and to help us in designing future projects, regarding risk factors. A number of factors will contribute to the implementation of future management in all areas including but not limited to risk analysis, weather, funding, resources and timing.

Discussion

Key Issues and Opportunities

1 Stakeholder Engagement and Understanding

While public perceptions of fire management have evolved, in part through various Parks Canada led education and awareness programs and as a result of successful fire preparedness

and management, some members of the public still express concerns or opposition to prescribed fire and fuel management projects. The continuous turn-over of residents and new park visitors necessitates proactive public communication and ongoing consultation to retain public support.

2 Multi-Agency Collaboration

In order to better utilize resources, manage large projects, and work near boundaries, we often collaborate with local structural fire departments and other fire management agencies, as well as research agencies. This helps facilitate the improvement of models and predictions, assists in implementing newer technology, reduces cost, improves opportunities and provides cross-training opportunities for staff.

3 Wildland Urban Interface

This will continue to be an area of focus and while communities within park boundaries may have set footprints, communities outside of the park have the ability to expand and increase the amount forest-community interface. This provides new challenges in the management of fire risk. Education on FireSmart activities, and the shared responsibility of home owners, is an opportunity that increases as fire management plays a larger role in the interface. Parks Canada will continue to implement fuel management activities both directly adjacent to communities as well as at the landscape scale.

Acknowledgements/Partners

With regards to fire management and prescribed fire operations, fuel management and reduction of wildfire risk, Banff National Park works with a number of partners and contributors.

Contributors include Town of Banff, Town of Canmore, Village of Lake Louise, and the hamlet of Harvie Heights. Outside agencies include BC Ministry of Forests, Lands and Natural Resources Operations and Rural Development, BC Parks, Alberta Parks, Alberta Agriculture and Forestry as well as the Canadian Forest Service.

Contact

Erin Tassell, Fire Management Officer
Banff Field Unit
P: 1-403-762-1422
E: *Erin.tassell@pc.gc.ca*

Charlie McLellan, A/Fire Management Officer
Lake Louise, Yoho and Kootenay Field Unit
P: 1-250-347-6174
E: *Charlie.mclellan@pc.gc.ca*

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Forest Insects and Disease

Introduction

Many forest insects and diseases contribute to natural processes within Banff National Park. Native insects contribute to forest succession and decomposition processes, helping to create heterogeneous landscapes that are more resilient to disturbances over time. However, decades of effective fire suppression have altered forested land cover throughout much of the mountain national parks; resulting in an overabundance of over-mature forests, falling outside the range of historic variability in stand age composition.

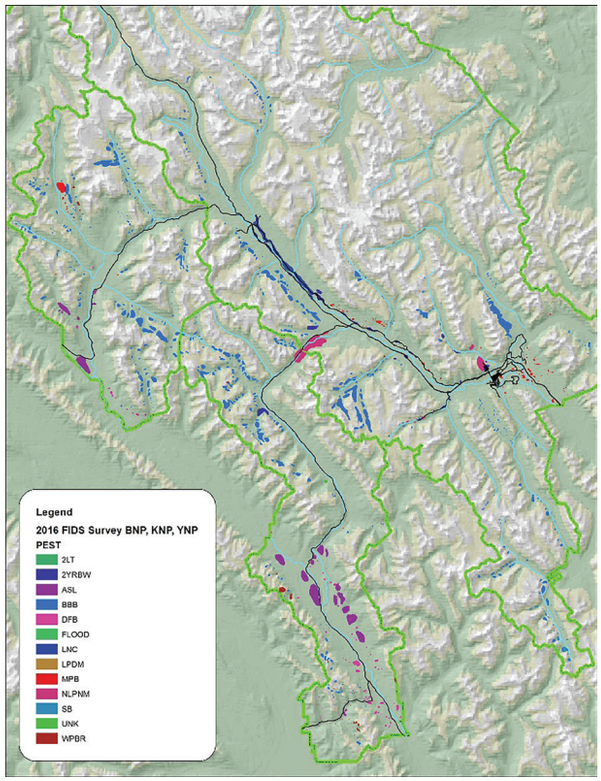


Figure 1. Map showing extent of major forest insects and diseases in Banff, Kootenay and Yoho National Parks. FIDS abbreviations found in Table 1.

Parks Canada policy on natural processes states that *"National park ecosystems will be managed with minimal interference to natural processes. However, active management may be allowed when the structure or function of an ecosystem has been seriously altered and manipulation is the only possible alternative to restore ecological integrity"* (Parks Canada, 1994).

Furthermore, policy states that manipulation of natural processes such as insects and disease may take place when 'no reasonable alternative exists' and when monitoring has indicated that without limited intervention there will be adverse effects on neighbouring lands.

As such, Parks Canada has entered into a Memorandum of Understanding (MOU) with the Canadian Forest Service in order to monitor the status of forest insects and diseases (Parks Canada, 2012). Through continued monitoring of several species of forest insects and disease appropriate management actions can be undertaken if ecological integrity, facilities, public health and safety, or neighbouring lands are threatened by altered insect and disease populations.

Table 1. List of common forest insects and diseases in Banff, Kootenay and Yoho National Parks.

Abbreviation	Common Name	Latin Name
2LT	Aspen 2-leaf tier	*Enargia decolour*
2YRBW	2-year Budworm	*Choristoneura biennis*
ASL	Aspen serpentine leaf miner	*Phyllocnistis populiella*
BBB	Western balsam bark beetle	*Dryocetes confuses*
DFB	Douglas-fir beetle	*Dendroctonus pseudotsugae*
FLOOD	Flood damage	*NA*
LNC	Lophodermella needle cast	*Lophodermella concolor*
LPDM	Lodgepole pine dwarf mistletoe	*Arcuethobium americanum*
MPB	Mountain pine beetle	*Dendroctonus ponderosae*
NLPNM	Northern lodgepole needle miner	*Coleotechnites starki*
SB	Spruce beetle	*Dendroctonus rufipennis*
UNK	Unknown	*NA*
WPBR	White pine blister rust	*Cronartium ribicola*

Objectives

- To allow fluctuating populations of native forest insects and disease, while considering the impacts of these populations on overall ecosystem health and adjacent jurisdictions.
- To prevent the establishment of non-native insects and diseases.

Methods

Strategies

- To monitor the status of forest insects and diseases to ensure they fall within the natural range of variability and do not adversely impact neighbouring lands.
- Only manipulate native insect/disease under the strictly defined conditions outlined in Parks Canada policy.
- Control or eliminate, where practical, populations of non-native forest insects/disease.
- Inform the public and raise awareness and appreciation of the important role that forest insects and disease play in ecosystem health.
- To maintain forest resilience through the management of natural processes such as fire and insect disturbances within historic norms.

Tactics

- Conduct annual surveys in conjunction with the Canadian Forest Service (CFS) to determine the population and distribution status of forest insects and disease.
- Conduct long term monitoring of diseases such as White Pine Blister Rust to ensure the health of rare and/or endangered species (e.g. Whitebark pine).
- Adaptively manage populations of insects and disease according to Parks Canada policy.
- Develop communication material (key messages, fact sheets etc) to inform the public about the role of insects and disease in a healthy forest.
- Implement prescribed fire and other vegetation management actions to increase forest heterogeneity and resilience to future outbreaks of forest insects and disease.

Results

Table 2. Occurrence and extent of major forest insects and disease within Banff, Kootenay and Yoho National Parks between 2008-2017. Data collection methods vary depending on extent of population and are recorded either in hectares or by number of trees. Data are collected by the Canadian Forest Service, as per a memorandum of understanding, to monitor key forest insects and disease annually. Please note that trends noted are based on observations and are not statistically valid due to varying data collection methods.

Pest Name	Year	Area (ha)	# Trees	Overall 10 yr trend
Mountain Pine Beetle	2008		10690	Increasing – Endemic population growth
	2009		20150	
	2010		40000	
	2012		600	
	2013	51		
	2014	142		
	2015	189.8		
	2016	434		
Lodgepole Needle Miner	2013	80		Variable
	2014	4639		
	2016	0		
Lophodermella Needle Cast	2014	93		Decreasing
	2014	37.2		

Pest Name	Year	Area (ha)	# Trees	Overall 10 yr trend
Western Balsam Bark Beetle	2008		2400	Increasing
	2009		1000	
	2010		8300	
	2012		700	
	2013	490		
	2014	1640		
	2015	1961.7		
	2016	4954		
Whitepine blister rust	2013	0.6		Increasing but minor amounts
	2014	1.3		

Discussion

National Park policy indicates that Parks Canada will allow natural processes such as forest insects and disease to go unimpeded unless there are significant threats to neighbouring jurisdictions.

Parks Canada will continue to work with neighbouring agencies to monitor and manage forest insects and disease considering neighbouring jurisdictional values (e.g timber values). Any changes to management actions as a result of potential impacts to neighbouring jurisdictions will be done in consultation with regional internal (e.g. neighbouring field units and other national parks) and external partners (e.g. Canadian Forest Service, provincial and municipal agencies).

Parks Canada will continue to work closely with the Canadian Forest Service to collect data on the status of key forest insects and disease through a long term memorandum of understanding.

The main tool that Parks Canada will use to increase forest resilience to forest insects and disease will continue to be prescribed fire and the restoration of historic vegetation patterns and forests with stand age distributions within the natural range of variability

Acknowledgements/Partners

Banff Field Unit – Fire and Vegetation Management Section

LLYK Field Unit – Fire and Vegetation Management Section

Canadian Forest Service – Northern Forestry Centre – Roger Brett – Forest Health Supervising Technician

Contact

Jane Park, Fire and Vegetation Ecologist
Banff Field Unit
P: 403-762-1417
E: *jane.park@pc.gc.ca*

Jed Cochrane, Fire and Vegetation Ecologist
Lake Louise, Yoho and Kootenay Field Unit
P: 250-347-6161
E: *jed.cochrane@pc.gc.ca*

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Glaciers

NOTE – MONITORING OF GLACIERS IN BANFF NATIONAL PARK IS CONDUCTED THROUGH PARTNERSHIPS WITH EXTERNAL EXPERTS. WE THANK DR. MIKE DEMUTH FOR THE FOLLOWING CONTRIBUTION

Introduction

The presence of glaciers influence a wide variety of natural processes and mountain heritage attributes [1]. Foremost is their provision of water and aquatic services, particularly when other seasonal sources of water are in decline (snowmelt) or absent outright (rain). Glacier runoff and its promotion of often severe hydraulic conditions aids in the development and maintenance of habitat for numerous aquatic species adapted to cold, turbulent waters [2]. Glaciers provide travel corridors for wildlife, connecting regions that are seasonally sought out for preferential habitat and climate conditions.

Objectives

The formal observation and analyses of glacier fluctuations usually concerns itself with glacier mass change because seasonal and annual mass changes are a direct result of changing precipitation, air temperature and cloudiness - that is, weather and climate [3]. Changes in the dimensions and extent of the glacier occur after the delayed and complex process of dynamic readjustment to mass changes.

From a recent milestone study considering the fluctuation of reference monitoring glaciers around the world, it has been determined that: *"The rates of early 21st-century mass loss are without precedent on a global scale, at least for the time period*

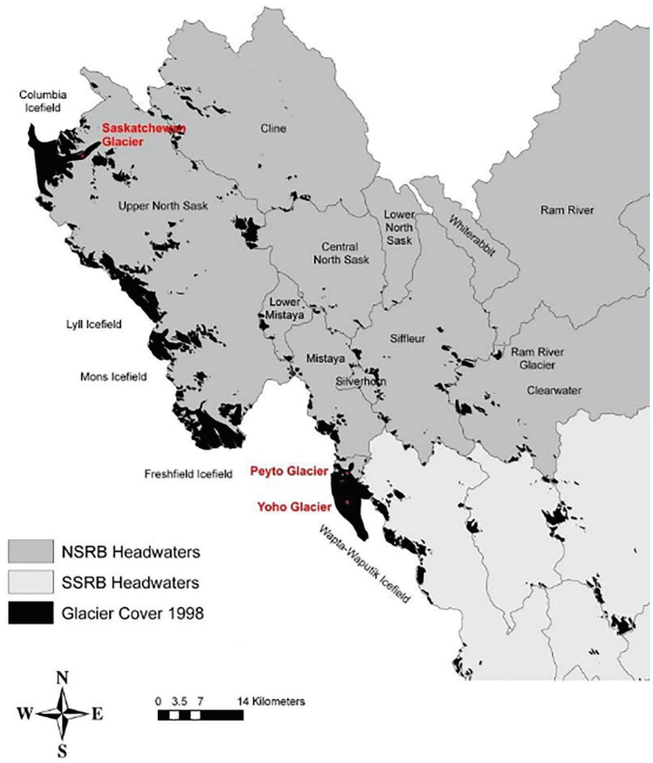


Figure 1. Location map of reference observing glaciers in the Lake Louise / Yoho / Kootenay region. The headwaters of the North and South Saskatchewan River Basins are also delineated. The Yoho Glacier is in the Upper Kicking Horse catchment of the Columbia River Basin.

observed [more than a century] and probably also for recorded history, as indicated also in reconstructions from written and illustrated documents. This strong [negative] imbalance implies that glaciers in many regions will very likely suffer further ice loss, even if climate remains stable" [4].

Numerous glaciers in Canada are part of this internationally coordinated effort, including many in Canada's Mountain National Parks. The Lake Louise-Yoho-Kootenay Field Unit (LLYK) contains numerous glaciers, particularly in the upper Bow, Kicking Horse and North Saskatchewan River Basins (Figure 1); along the continental divide - as upland icefields drained by outlet valley glaciers. Isolated mountain glaciers and cirque type glaciers are also common [5, 6].

Methods

Several of these glaciers are subject to systematic and coordinated observation of their mass balance, dimensions and extent, and include Saskatchewan Glacier (draining a portion of the Columbia Icefield), Peyto Glacier and Yoho Glacier (draining portions of the Wapta Icefield) (see Appendix A in [1]). These studies are conducted by NRCan's Geological Survey of Canada with support from the Parks Canada Agency and with contributions from various federal government-academic consortia (f.ex., *www.CCRNetwork.ca*).

Several recent site and regional analyses confirm the matter that Canada's glaciers are in a state of negative mass imbalance fuelling unprecedented glacier thinning and retreat generally [5, 7, 8]. There is also evidence that year-to-year variability is increasing in some regions [4, 9].

Results

Peyto Glacier (Banff National Park of Canada-Lake Louise)

Latitude = 51.6766667° N; Longitude = 116.5466667° W; WGMS[1] ID = 57

The long-term (1966-2016) annual mass balance[2] of Peyto Glacier is <*Bn*>1966-2016 = – 671 mm W.E. a-1 reflecting in particular the negative mass imbalances that manifested after the mid-1970s with only two instances of mass gains since then: 1996 and 2000 (Figure 2).

From Figure 2 it is clear that the inter-annual signal contains a substantial amount of noise with some extreme mass losses and gains exceeding the 10-year moving standard deviation by a significant amount. Most notable are record mass losses recorded for 1998, 2006 and 2015, the latter being the largest mass loss on record. The largest mass gain on record occurred in 2000. Increases in regional and site inter-annual variability over the last few decades reported by [4] and [9] are also reflected in the Peyto Glacier record.

1 World Glacier Monitoring Service

2 Unless otherwise noted, the mass balance data reported herein are derived from an application of the traditional glaciological method. See [1] for details.

Figure 2 also illustrates the long-term annualized mass balance over a centenary scale, <*Bn*>LIA (i.e., since the maximum expression of the Little Ice Age Cavell Advance: 1841 CE). This long-term estimate utilizes a parameterization of the glacier's longitudinal profile change; see [9] for methodological details. Notably, mass losses over the last several decades are approximately thrice that of this centenary average. Moreover, the mass loss in 2015 was more than four times more negative.

Yoho Glacier (Yoho National Park of Canada)

Latitude = 51.6068280° N; Longitude = 116.5492160° W; WGMS ID = n/a

Mass balance observations over the Yoho Glacier were initiated in 2007 as part of an effort to broaden the regional representativeness of GSC's reference observing system at the icefield scale. For a variety of reasons and circumstances, measurements have been sporadic, and as such none of the data are described herein. The measurement is conducted adjunct to that for the Peyto Glacier but remains logistically difficult under certain environmental conditions.

Geodetic or topographic methods (see [1] for details) using aircraft-mounted LiDAR and small Unmanned Aerial Vehicle (sUAV) photogrammetry have been applied over the Yoho Glacier in a research mode: the former, to estimate the net and seasonal balances (personal communication, B. Menounos); the latter, to assess topographic and climate controls over field-scale winter mass balance variability (personal communication, Eleanor Bash). While these efforts are integrated with the GSC's observing framework, inter-comparison work has not yet matured.

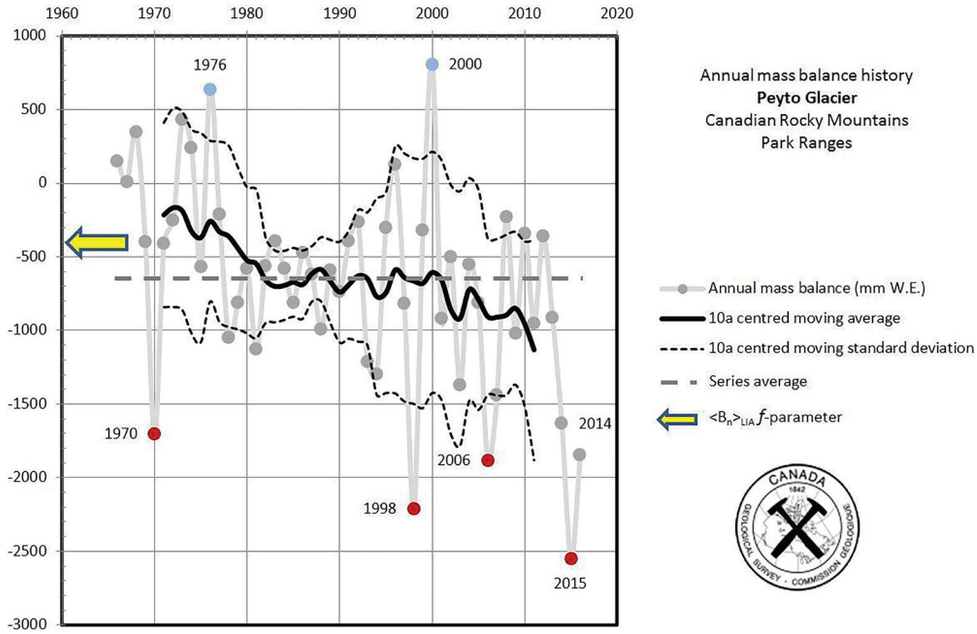


Figure 2. Centenary, decadal and annual mass balance fluctuations for Peyto Glacier, updated and adapted from [1]. The arrow defines the annualized centenary value (since 1841 CE) as compared observations borne out of the instrumental era for Peyto Glacier (i.e., since 1966).

Never-the-less, the long term diminution of the Yoho Glacier is illustrated by estimating (as for Peyto Glacier, Figure 2) its long-term annualized mass balance over a centenary scale using the aforementioned longitudinal profile change parameterization: Yoho Glacier $\langle Bn \rangle$LIA ≈ – 210 mm W.E. a-1.

As traditional glaciological and geodetic measurement program outputs mature, this long-term value will place more contemporary measurements in context.

Saskatchewan Glacier (Banff National Park of Canada-Lake Louise)

Latitude = 52.1371900° N; Longitude = 117.2143980° W; WGMS ID = 8

Mass balance observations over the Saskatchewan Glacier were initiated in 2010 as part of an effort to broaden the regional representativeness of GSC's reference observing system at the icefield scale; and specifically as part of a joint GSC-PCA investigation of the Columbia Icefield as a whole [10, 11] and adjunct to a complimentary effort [12].

Similar to the situation posed by the Yoho Glacier, difficult environmental conditions have contributed to a sporadic observational time series, though recent analytical and reporting efforts for the Saskatchewan and Athabasca glaciers [13] and one particular study examining the decadal and centenary-scale changes of a diverse set of glaciers in Jasper National Park of Canada/Columbia Icefield region [9] have accelerated the production of perspectives important for assessing landscape/ecosystem integrity in this portion of the Mountain National Parks.

For the Saskatchewan Glacier specifically, recent measurements reported in [13] estimate the 2014-15 and 2015-16 annual balances as – 1,220 and – 840 mm W.E. a-1 respectively (dashed vertical fiducial in Figure 3). Reduction of the annual data collected prior to these two years is underway, though sporadic measurements over the upper reaches of the source accumulation region (Columbia Icefield) pose a major challenge.

As noted in [9], the contemporary state of the Saskatchewan Glacier's lateral moraines precluded a confident parameterization of the glacier's longitudinal profile change. Never-the-less, it is notable that the study glaciers in [9] reflect an unweighted regional $\langle Bn \rangle$LIA of approximately – 230 mm W.E. a-1 (Figure 3). Notably, the contemporary annual and decadal mass change values are three or more times more negative than this 170 year mean. Data in Figure 3 strongly suggest increasing and possibly accelerating negative glacier mass imbalance.

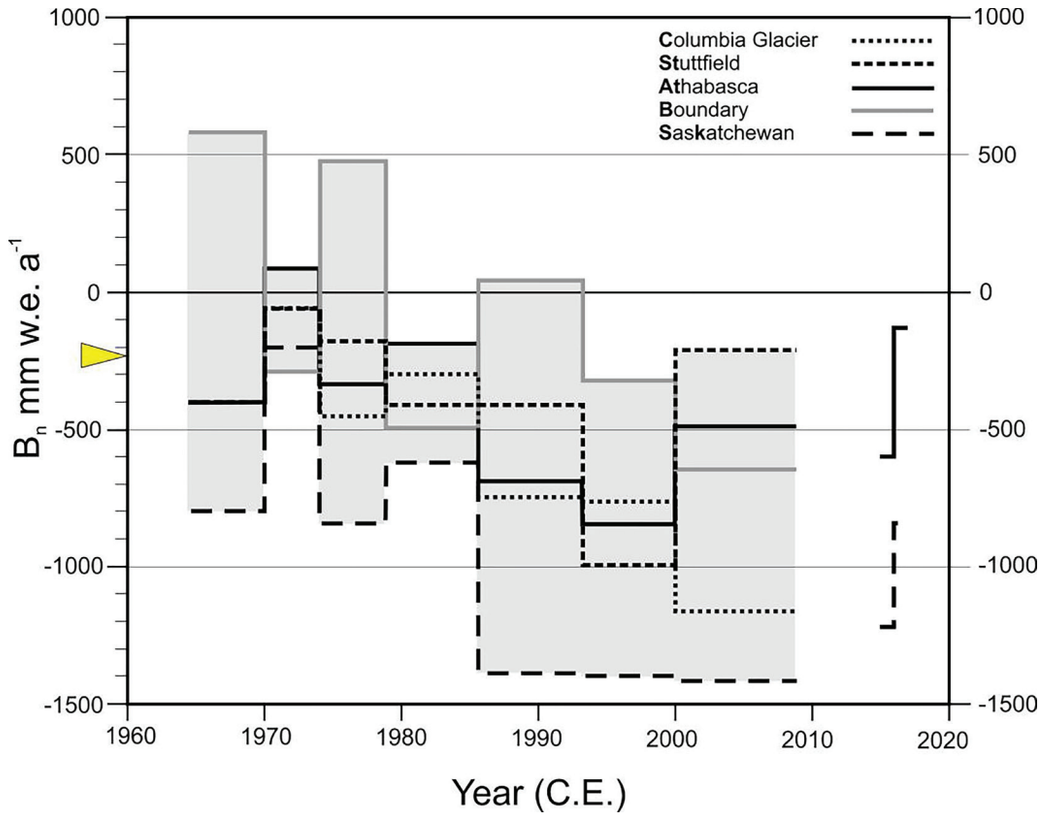


Figure 3. Centenary and decadal-scale mass changes for glaciers in the Columbia Icefield and Jasper National Park of Canada region (adapted from [9] and with reference to Table G1).

Table 1. Annualized centenary mass change values for glaciers in the Columbia Icefield and Jasper National Park of Canada region (adapted from [9] and with reference to Figure G3).

Glacier	Post 1841, <**Bn**>LIA, mm W.E a-1
Brazeau	-220
Parapet	-160
Mastadon	-280
Simon	-200
Coleman	-280
Dome	-290
Gong	-190
Stutfield	-240
Charlton	-210
mean	**-230**
stdev	**42.9**

Discussion

The information presented strongly suggests that the glaciers in the LLYK region are in a state of strong, negative mass imbalance, particularly when comparisons are made to the low-pass filtering effect of the derived 170-year long-term average annual mass balance for several of the regions' glaciers.

As it concerns more recent variability, it is well documented that the post-1976 shift in the Pacific Decadal Oscillation (PDO) from a cold phase to a warm one manifested a significant modulation of the Pacific-North American (PNA) atmospheric circulation pattern. This had a demonstrable effect on the magnitude of end-of-winter season snow depths, SWE and winter glacier mass balances (i.e., lower) throughout the southwestern Cordillera (see [5, 14] and references therein). Never-the-less, summer conditions appear to have prevailed overall in terms of controlling the region's annual mass balances [4].

Interestingly though, increased variability in the region's glacier mass balances since the late 1980s [4, 9] appears to be linked to a higher frequency variation in the PDO metrics rather than the simple notion of a decadal binary cold or warm configuration prior to this period [15, 16].

Glacier mass balance signals integrate the impacts of both climate change (i.e., enhanced greenhouse gas radiative forcing leading to synchronous warming of the atmosphere) and climate variability (f.ex., the effects of the El Niño Southern Oscillation or ENSO [17]). Teasing out the exact impact of these constituents on hydro-climatic phenomenon like glacier mass balance is difficult. Some general commentary, however, is possible and is directed particularly at the situation presented over the period 2014-2016 during which unprecedented mass losses and firn pack depletion occurred in the region.

Ocean-Atmosphere conditions in the Northeast Pacific Ocean during 2014-15 and 2015-16 conspired to build the so-called "2014-2016 El Niño "event" [18], with the 2014-15 El Niño characterized as "rivalling" those that occurred in 1982-83 and 1997-98 ([18]; see also Figure 4.

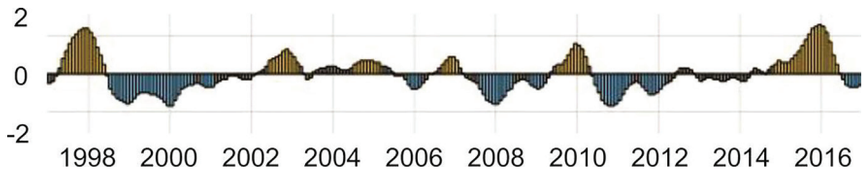


Figure 4. The Oceanic Niño Index (ONI) reflecting the magnitude of average sea surface temperature in the east-central (≈120-170°W) equatorial Pacific Ocean – the Niño -3.4 region. Positive index values reflect the warm cycle - El Niño, and negative values, the cold cycle - La Nina (adapted from NOAA Climate.gov, last accessed 2017-12-02).

El Niño, the warm cycle of ENSO, primarily influences atmospheric circulation in the hemisphere of winter (i.e., stronger Hadley Cell circulation because of the equatorial-winter hemisphere temperature contrast). Generally speaking, under El Niño conditions, winters in northwestern North America will be warmer than average. How this manifests itself in terms of hydro-climatological

impacts has more specific details beyond the scope of this work, but one particular ocean-atmosphere phenomenon that developed during the 2014-2016 period event was something colloquially called the "Blob" – a large region of warm water off northwestern North America produced as a result of complex ocean-atmosphere coupling [19].

Between the winters of 2013-14 and 2014-15, during what many have described as a strong North American drought, the northeastern Pacific Ocean experienced the *"largest marine heatwave event ever recorded"* [20]:

> *"...teleconnections between the North Pacific and the 2014-15 El Niño linked the atmospheric forcing patterns of this event. These teleconnection dynamics from the extratropics to the tropics during winter 2013-14, and then back to the extratropics during winter 2014-15, are a key source of multi-year persistence of the North Pacific atmosphere. The corresponding ocean anomalies map onto known patterns of North Pacific decadal variability, specifically the North Pacific Gyre Oscillation (NPGO) in 2014 and the Pacific Decadal Oscillation (PDO) in 2015. A large ensemble of climate model simulations predicts that the winter variance of the NPGO- and PDO-like patterns increases under greenhouse forcing, consistent with other studies suggesting an increase in the atmospheric extremes that lead to drought over North America."*

In essence, when an accumulation of heat content was manifested in the tropics in 2014, it acted to intensify tropical–extratropical interactions and, as such, extended the 2015-16 El Niño longer than any of the previous El Niño events recorded within the observational period [19] [3]. America during this period, a strong upper-level ridge manifested a large region of warmer than average mid-level air temperatures extending into the British Columbia interior/western Alberta and northward into the Yukon and western Nunavut. Taken together, the 2014-2015 period in the southern Cordillera was characterized by exceptional warmth in summer (f.ex., [21]) but, in addition, generally poor antecedent glacier nourishment in terms of winter mass balance.

The contemporary decline that LLYK and other region's glacier observations suggest in terms of mass change fuelling dramatic thickness losses, facies configuration changes and area reductions has wide-ranging impacts. In the Canada's Mountain National Parks, for instance, water resource [5, 7] and ecosystem integrity considerations [1, 2] must contend with the loss of Little Ice Age "bonus water" [22] which may have given the impression of water "abundance" during the early 20th century [23]. Most notably, by 2017, many glaciers and icefields in the Lake Louise-Yoho-Kootenay region lost all or nearly all of the accumulated firn pack in their upper reaches - in effect, new ice was not being generated. Given the outlook generated by recent modelling studies [7, 24] continued tracking of the region's aquatic resources will be critical for assessing current and future vulnerabilities under the influence of climate change and the complex ocean-atmosphere processes that control climate variability.

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[3] A thorough, plain language summary of [19]: *http://environmentalresearchweb.org/cws/article/news/69828*

Acknowledgements/Partners

We thank the Geological Survey of Canada – Cryosphere Geoscience Section for their ongoing monitoring and reporting of glacier status in Banff and Yoho National Parks. We especially thank Dr. Mike Demuth (Geological Survey of Canada – Cryosphere Geoscience Division; University of Saskatchewan – Centre for Hydrology – Coldwater Laboratory; University of Victoria – High County and Northern Weather Impacts Laboratory) for his submission of all content for this State of Park Report.

Contact

Derek Petersen (Park liaison), Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: 250.347.6171
E: *derek.petersen@pc.gc.ca*

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Grizzly Bear Habitat Security in Banff National Park

Introduction

Grizzly bears are a management concern in Banff National Park because of their status as 'Special Concern' under the Canadian Species at Risk Act (Schedule 1), and their provincial listing (in Alberta) as threatened due to habitat loss and human-caused mortality. Grizzly bears are widely accepted as an indicator of health and diversity of mountain ecosystems. Parks Canada's goal is to maintain a stable to increasing healthy population of grizzly bears and to provide bears with safe access to available habitat (Parks Canada, 2010). Grizzly bear habitat is secure when bears have a low probability of encountering humans and can forage with little human-caused disturbance, maintaining their wary behaviour, a trait considered desirable (State of the Park Report, 2008). The status of grizzly bear habitat security is a measure of sustainable land use practices and an indicator of ecological integrity in Banff National Park.



Figure 1. Grizzly Bear 64 and her offspring, Banff National Park.

Objectives

- Revise the 2010 grizzly bear habitat security model using current human use data.
- Report the current condition of habitat security in each of the 27 Banff National Park land management units (LMU).
- Report on the overall change in secure land base (2010 to 2018) and evaluate the current condition based on a management threshold of minimum 68% secure habitat.

Methods

Secure habitat areas are defined as areas that are below 2500 m elevation, vegetated, greater than 500 m from high human use and having continuous (non-fragmented) habitat equal to or greater

than the 9 km² average daily feeding area for a female grizzly bear (Gibeau et al. 2001).

We compiled a progression of GIS models for secure area analysis following methods established by Gibeau et al. (2001). We removed areas from the landscape that were unsuitable for bear foraging (e.g. rock and ice) and defined an elevation of 2500 m as the upper limit of useful grizzly bear foraging. Combining a vegetated cover map with the 2500m elevation cut, identified vegetated lands below 2500 m considered for security areas.

Next, using the most recent and accurate human use spatial data for motorized and non-motorized access, we buffered high human use features by a 500 m zone of influence and imposed on the map of available/unsuitable lands. We defined high use as receiving >100 human visits during the month of August, a midpoint in the active foraging season of bears. We estimated human use of trails using trail counters and/or wildlife remote camera data. For trail segments without counters or cameras, we based estimates on surrounding trails where data was available.

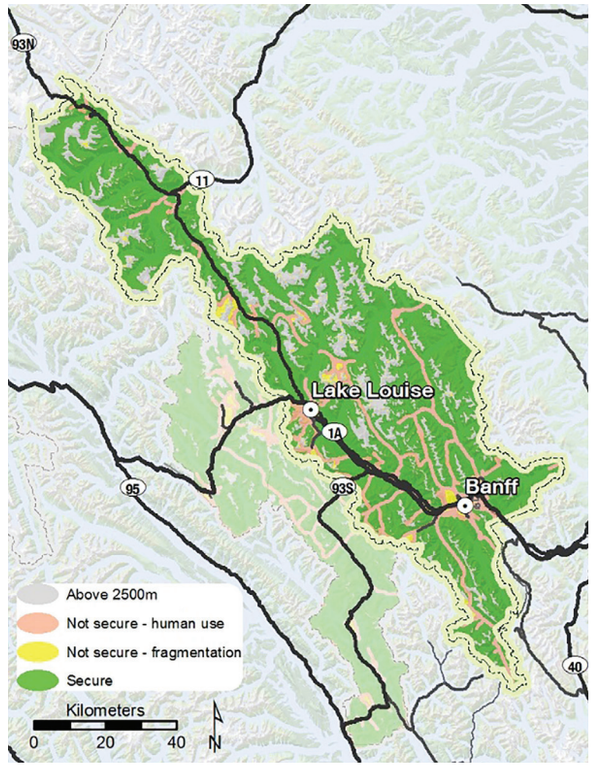


Figure 2. Grizzly bear habitat security model, 2018.

After removing unsuitable lands and lands within 500 m of high human use, we removed all remaining polygons smaller than 9 km², resulting in the final secure habitat model for 2018 (Figure 1). From this model, we tabulated results into 3 categories: (1) non-secure due to human use, (2) non-secure due to fragmentation (<9 km²), (3) and secure habitat.

Habitat security is reported by land management unit (LMU) in Banff National Park (Figure 3). LMU's each approximate the size of an adult female grizzly bear home range and were delineated on the basis of current knowledge of grizzly bear distribution and use and typically encompass watersheds (Eastern Slopes Grizzly Bear Project 1998). This division of the landscape primarily identifies contiguous habitat that meets the yearly foraging needs of grizzly bears and helps prioritize areas for management needs (Eastern Slopes Grizzly Bear Project 1998).

Results

Banff National Park is 6,858 km² and 19% of this land base is unsuitable habitat for grizzly bears primarily because it is rock and ice (above 2500m elevation). The 2018 habitat security model for Banff National Park identified an average of 77% of available land across 27 LMU's as secure habitat.

Twenty of 27 (74%) land management units exceeded the minimum management target of 68% secure area (Table 1). The lowest percent secure habitat occurred in the Banff Townsite (36%) and Lake Louise (39%) land management units. The Siffleur had the largest area of secure habitat (99%), closely followed by the Clearwater, Howse, and Upper Red Deer management units, each with 98% of secure habitat (Table 1).

An average of 21% of the land base across all LMU's was not secure because of high human use. Logically, the largest percent land base in the zone of human influence occurred in the Banff Townsite (59%) and Lake Louise (58%) management units (Table 1). Excluding these two LMU's that contain urban centres, Skoki and Sunshine/Egypt LMU's have the least secure habitat in Banff National Park at 52% and 54%, respectively.



Figure 3. Land Management Units in Banff National Park.

The percent land base not secure because of habitat fragmentation averaged 2% across all LMU's. However, Bryant and Skoki LMU's have the highest area (9 and 8% respectively) unsecure habitat due to fragmentation (Table 1).

Since 2010, 14 of 27 (52%) LMU's have increased in their area of secure habitat by an average of 3% (Figure 3). Management units with the greatest increase in secure habitat, between 2010 and 2018, were Minnewanka (9%) and Panorama (8%).

Five of 27 LMU's remained unchanged in their total area of habitat security and 8 LMU's saw a decline (average 5%) in their secure habitat over the past seven years (Figure 3). Management units with the greatest loss of secure habitat were the Lower Red Deer (11%), Bryant Creek (9%) and Baker Creek (8%).

Despite the Banff Townsite and Lake Louise management units having the lowest percent secure habitat that was far below the management target of 68%, they both saw a small increase in secure habitat since 2010. Banff Townsite LMU had a 6% increase in secure area and Lake Louise had a 1% increase (Figure 4).

Table 1. Grizzly bear habitat security by LMU in 2018. Security values above 68% meet the management target for grizzly bear habitat security.

Land Management Unit	NON-SECURE* (%)		SECURE* (%)
	Human Use (>100 visits/mo)	Fragmentation (< 9km2)	< 100 visits/mo and >9km2
Alexandra	8	1	92
Baker Creek	22	0	78
Banff Town	59	5	36
Brewster Creek	20	0	80
Bryant	30	9	61
Cascade	27	1	72
Clearwater	1	2	98
Cuthead	15	0	85
Howse	0	2	98
Lake Louise	58	3	39
Lower Red Deer	11	0	89
Massive	31	0	69
Middle Spray	5	0	94
Minnewanka	6	0	94
Mistaya	23	5	72
Panorama	30	4	66
Panther	5	0	95
Pipestone	16	2	82
Saskatchewan Crossing	10	0	89
Sawback	37	1	62
Siffleur	0	1	99
Skoki	40	8	52
Sunshine / Egypt	43	3	54
Upper Bow	21	1	79
Upper North Saskatchewan	21	2	77
Upper Red Deer	0	2	98
Upper Spray	25	0	75

* Areas > 2500m elevation were excluded

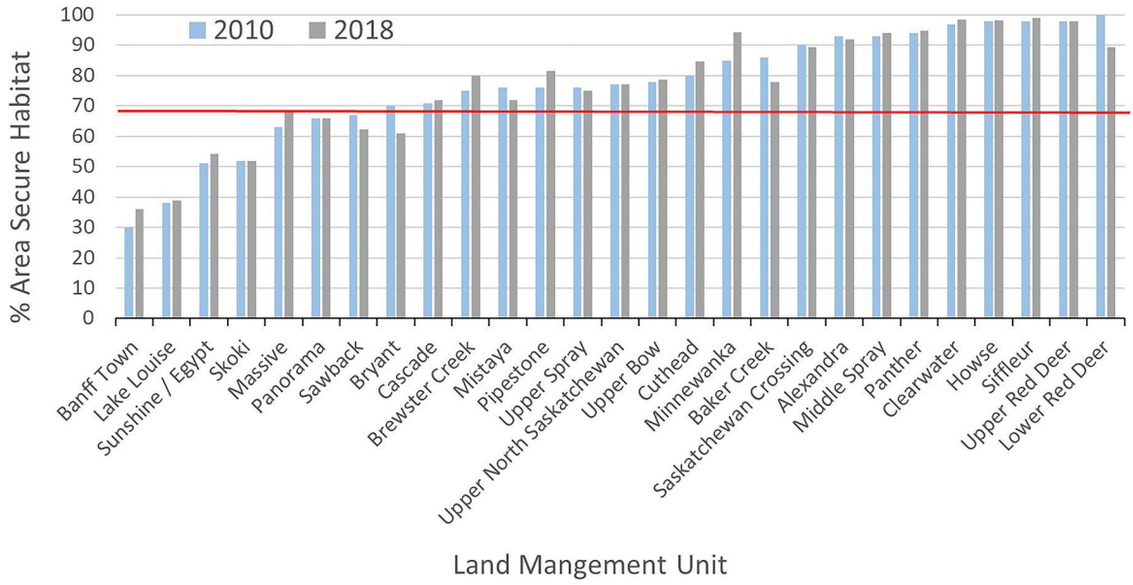


Figure 4. 2010 and 2018 comparison of grizzly bear habitat security by LMU. Those above the red line have met the grizzly bear habitat security target of 68% secure.

Discussion

Banff National park uses grizzly bear habitat security targets as a key decision-making tool in managing human use levels/developments and is committed to maintain or improve habitat security in each of the 27 landscape management units (Parks Canada 2010).

The 2018 habitat security model incorporated the most current and accurate human use data available, providing managers the best analytical tool for assessing current landscape condition and changes in secure area over time. This model is a metric for tracking human disturbance relative to available habitat (not physical quality of habitat) for bears and ultimately many other wildlife species.

The minimum target for secure grizzly bear habitat in Banff National Park is 68% within each land management unit (a target also used by several other jurisdictions). In some areas such as the Banff and Lake Louise town sites, the 68% target may not be achievable given the level of human activity. In these units, a more important target is to see improving trends.

Long term grizzly bear research in Banff Park has identified the most important core reproductive areas for grizzlies in the following watersheds:

- Pipestone/Baker/Skoki
- Upper Cascade/Cuthead
- Red Deer/Panther
- Middle Spray/Bryant

The Banff National Park Management Plan (Parks Canada 2010) considered these a priority for management to optimize wildlife access to all available habitat within. Three of these nine priority management units; Bryant Creek (-9%), Red Deer (-11%) and Baker (-8%) saw a loss of secure habitat since 2010. Two of these declining LMU's are below the 68% threshold (Bryant = 61% and Sawback = 62%). While we cannot determine if these declines are statistically significant, they alert us to consider future management actions in at least 8 LMU's:

- **Lower Red Deer** (-11 to 89%) Mistaya (-4% to 72%)
- **Bryant (-9 to 61%)** Upper Spray (-1% to 75%)
- **Baker Creek** (-8 to 78%) Saskatchewan Crossing (-1% to 89%)
- **Sawback (-5% to 62%)** Alexandria (-1% to 92%)

Modelling grizzly bear habitat security areas provides useful information for planning and implementing mitigations such as seasonal closures, facility relocations or trail re-alignments. Minimizing the influence of human disturbance in secure wildlife habitats will help maintain healthy wildlife populations and conserve natural ecological processes.

Acknowledgements/Partners

Prepared by Saundi Norris. Josh Keitel and Alison Buckingham produced the 2018 Grizzly Bear Habitat Security GIS Model and extracted comparison data for the 2010 to 2018 analysis.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403) 763-8865
E: *jesse.whittington@pc.gc.ca*

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Grizzly Bear Population Trends: Density, Reproduction Index, Human-Caused Mortality

Introduction



Figure 1. Grizzly bear 64 and 2 offspring

Grizzly bears are of management concern in Banff, Yoho and Kootenay National Parks because of their status as 'Special Concern' under the federal Species at Risk Act, and their Alberta and British Columbia provincial status. In Alberta, grizzly bears are provincially listed as threatened because of habitat loss and human-caused mortality, and in BC, grizzly bears are listed as vulnerable. Human caused mortality is the principle concern in Banff National Park where grizzly bears have some of the lowest reproductive rates in North America (Garshelis et al. 2005). Parks Canada's goal, and the goal of Alberta and British Columbia, is to maintain a stable to increasing, healthy population of grizzly bears in the Rocky Mountains.

Objectives

Report on key grizzly bear monitoring projects

- Population Density
- Reproduction Index
- Mortality

Grizzly bear are also monitored as part of the large mammal occupancy measure in the Parks Canada's ecological integrity "Condition Monitoring" program for the mountain parks (see *Wildlife Occupancy - Remote Cameras*).

Methods

Population Density

Grizzly bear density was first estimated by applying spatial capture-recapture models to hair-based DNA surveys from 2006 – 2008. This study encompassed 2,246 km^2 centred within 14 km of the Bow Valley (Sawaya et al. 2012, Whittington and Sawaya 2015). We estimated density from 2012 - 2014 by applying newly developed generalized spatial mark-resight models to a combination of remote camera and GPS data from radio-collared bears. This study encompassed 4,050 km^2 and included portions of Banff, Kootenay, and Yoho National Parks (Whittington et al. 2018).

Reproduction Index

We used remote cameras and observations from both the public and staff to determine the minimum number of grizzly bear family groups and the minimum number of female grizzly bears with young of year cubs (YOY) throughout Banff, Kootenay, and Yoho National Parks. Recruitment (births) and juvenile survival rates can strongly influence population trends.

Human-Caused Mortality

We summarize data on human-caused mortality from our wildlife mortality database: railway mortality, highway mortality and management mortality from 2007 – 2017. Historic data are summarized in (Parks Canada 2016).

Mortality Threshold

The Banff National Park Management Plan target for grizzly bear mortality is to maintain the annual number of adult female bears killed, due to human-related activities, to less than 1.2% of the grizzly bear population based on a 4-year moving window (Parks Canada 2010). The mortality rate was calculated as the mean number of females killed over the 4 previous years (the reproductive interval) divided by the estimated population size (N_{Total} = 65).

The definitions used for the mortality target were: bears that died due to human-related activities and management removals (i.e., bears translocated out of the ecosystem that were not known to have returned, translocated bears that died in other jurisdictions and bears placed in zoos); independent females included known female grizzly bears, of any age, that were not accompanied by their mother.

This threshold is similar to other jurisdictions (Team 2003) and has been subjected to significant public and management scrutiny in Banff National Park (Bertch and Gibeau 2010).

Results

Population Density

We recorded 2,061 grizzly bear detections out of 56,552 remote camera sampling days from 2012 to 2014. We recorded 614 detections of marked and identifiable bears, 93 detections of marked, unknown bears (discarded), and 1,354 detections of unmarked bears. The 2012-2014 grizzly bear density estimate was 12.4 grizzly bears per 1000 km² (95% CI = 9.7 - 15.6). The 2012-2014 density estimates were similar to the 2006 to 2008 estimates, which suggests the population was relatively stable (Figure 2). These results are corroborated by occupancy estimates that grizzly bears and grizzly bear family groups occurred at 86% and 47% of sites respectively, across Banff, Kootenay, and Yoho and that occupancy estimates changed little since 2011.

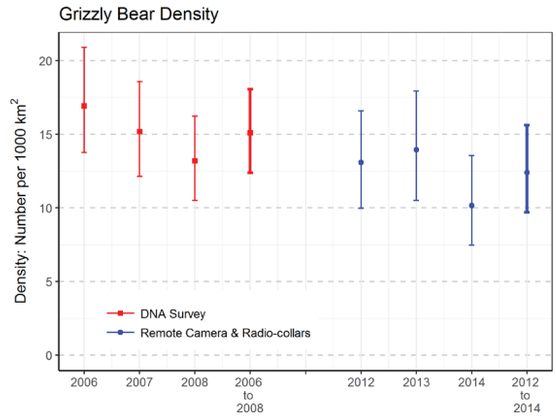


Figure 2. Grizzly bear densities and 95% confidence intervals.

Reproduction Index

We detected on average 20 family groups and 5 females with YOY throughout Banff, Yoho and Kootenay National Parks (Figure 3). We may not detect some wary females with YOY until their offspring become yearlings.

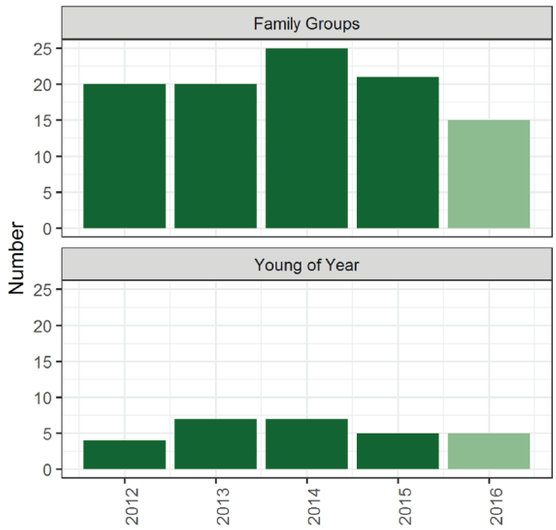


Figure 3. Number of grizzly bear family groups and females with young of year in Banff, Yoho and Kootenay National Park

Human-Caused Mortality

Sixteen grizzly bears died from human causes from 2007 through 2017 in Banff, Yoho and Kootenay National Parks, including 9 on the railway, 6 on highways, and 1 management removal in 2005 (#8) (Figure 4).

In 2017, female #148 travelled out of Banff National Park to Canmore and was translocated by the province of Alberta. She was then lawfully harvest in British Columbia.

The data exclude railway and highway strikes, reported to us, because of uncertainty around the bear fates. Between 2007 and 2017, Parks Canada recorded 8 railway strikes and 1 highway strike.

Between 2012-2016 we radio-collared 26 grizzly bears as part of a GPS collaring study, to understand root causes of grizzly bear mortality on the railway. From 2012 through 2016, 7 of 26 radio-collared grizzly bears died, (3 of natural causes and 4 from human causes), 8 of 18 juveniles died before reaching 4 years old, and 3 of 7 sub-adults (all males) died before reaching 6 years old.

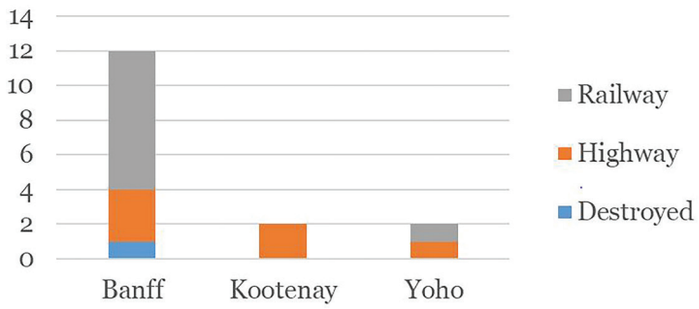


Figure 4. Human-caused mortality of grizzly bears in Banff, Kootenay and Yoho National Parks, 2007 – 2017.

Mortality Threshold

In Banff National Park, the proportion of female grizzly bears that died from human-caused mortality was below 1.2% of the total grizzly population from 2014 - 2017 (Figure 5). Prior to 2014, the female mortality rate was at or above the 1.2% threshold. Total numbers of adult females and other bears that died are shown in Figure 6.

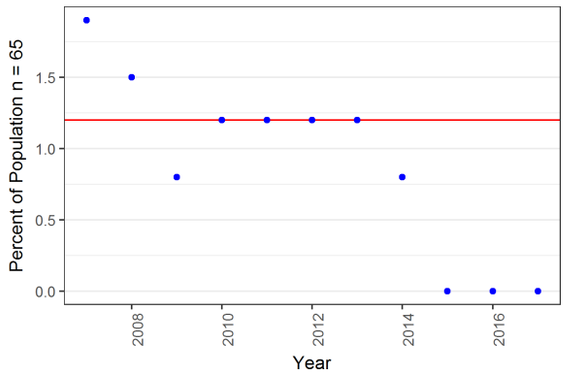


Figure 5. Human-caused mortality of grizzly bears in Banff National Park, 2007 – 2017. The line represents the 1.2% management threshold we strive to stay below.

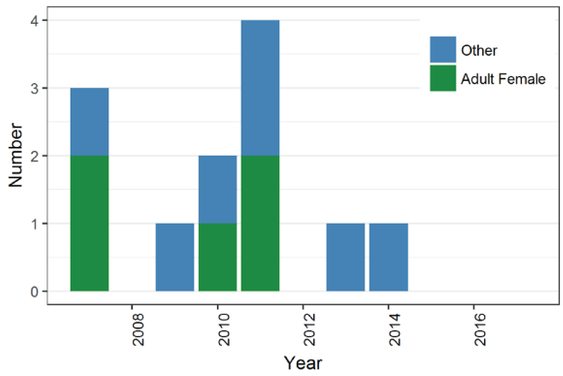


Figure 6. Human-caused mortality of grizzly bears in Banff National Park, 2007 – 2017.

Discussion

Grizzly bears are an iconic focal species for conservation, an umbrella species to protect species diversity range (Carroll et al. 2001), and an important keystone species in many parts of their range (Helfield and Naiman 2006). They are also a key species many visitors hope to see when they come to visit the Mountain National Parks. Few species can match the grizzly bear as an emblem of Canadian wilderness, yet this icon faces an uncertain future based on federal and provincial listing in all portions of their western range (Wilkinson et al. 2008, Festa-Bianchet 2010). In 2012, COSEWIC scientists identified grizzly bears as species of "special concern" and recommend they be added to the official List of Wildlife Species at Risk (Schedule 1) under the Species at Risk Act. On 29 May 2018, grizzly bear (Western Population) was added to Schedule 1 of SARA as "Special Concern"; triggering the need for a formal "Management Plan".

Population density and trend

By developing and applying new and innovative spatial mark-resight models to estimate density, we determined that the grizzly bear population in Banff, Yoho and Kootenay National Parks was stable. Density estimates had coefficients of variation less than 15%, which means the camera-collar based methods using existing data had high statistical power to detect changes in density. For this approach we assumed density was constant throughout the study area, whereas both the Eastern Slopes grizzly bear study (Herrero 2005) and the more recent GPS collaring study found that grizzly bears concentrated their activities in productive valleys.

Next steps are to:

- Include the effects of habitat quality on density so that density and corresponding population estimates can be extrapolated to the rest of Banff, Yoho and Kootenay National Parks.
- Determine how many years after a radio-collaring study finishes that researchers can obtain reliable density estimates from generalized spatial mark-resight models.
- Develop integrated population models that combine data from multiple sources (cameras, collars, reproduction) to estimate density, survival, recruitment, emigration, and immigration rates (Zipkin and Saunders 2018).
- The field of wildlife population monitoring is rapidly advancing. The next grizzly bear population survey should strive to use efficient and robust survey techniques that include multiple sources of data.
- Collaborate with other agencies and adjacent jurisdictions on large scale population monitoring and grizzly bear management.

Reproduction index

The minimum number of females with young and the number of females with young of year were surprisingly stable given that grizzly bears are pulse breeders and typically have cubs every 4 years. The reproduction index provides a course measure of grizzly bear reproduction, but

large decreases in the index would signal concern and could trigger additional research into factors affecting changes in reproduction. Moreover, the reproduction data could potentially be incorporated into spatial capture-recapture models to estimate the density of breeding females with associated levels of uncertainty. Understanding reproduction and productivity is important because grizzly bears in Banff National Park have some of the lowest reproductive rates in North America and juvenile and sub-adult grizzly bears continue to have relatively high mortality rates (Garshelis et al. 2005).

Human-caused mortality

Human-caused mortality is important to monitor because grizzly bears incur high mortality rates in developed areas (Nielsen 2004). Thus, monitoring cause-specific mortality (e.g. railway, highway, and management) will be important for determining population trend and focussing conservation efforts. The 1.2% mortality target is also used by Parks Canada and Alberta (Festa-Bianchet 2010), but depends on correct estimates of Banff's grizzly bear population, which is currently assumed to be 65 based on habitat-based population estimates (Boulanger et al. 2011). This estimate was the best available given data at hand, but had 95% CI's that ranged from 37 to 110 animals. However, the mortality target is likely appropriate because it represents roughly one adult female grizzly bear per year. The mortality target could be further improved with park-wide, habitat-based density estimates.

Considerations with regards to mortality:

- Parks Canada should continue to work with Canadian Pacific to implement off-track and on-track mitigations to reduce risk of grizzly bear mortality on the railway.
- With the twinning of the TransCanada Highway through Yoho National Park, we expect highway mortality will decrease but it will not disappear. The 93 North Icefields Parkway remains unfenced and may become a barrier as visitation increases. Sections of 93S Kootenay Parkway also remain unfenced. Fence-ends on the TransCanada Highway remain permeable to grizzly bears, particularly juveniles that can climb or cross texas gates. Experimental electrified texas gates proved effective over several years of pilot testing but lacked the durability needed to be put into common use.
- Alternate Travel Routes: Simply removing deadfall and clearing brush from wildlife trails may influence where bears travel and has potential to reduce: mortality risk along the railway, human-wildlife conflict in developed areas, and fragmentation effects associated with twinning and fencing of the TransCanada highway. Once the highway through Yoho is twinned, and based on results from our current "alternate travel routes" project, we should explore creating alternate travel routes for wildlife near the railway west of Lake Louise.

Summary

The combination of population density, occupancy, reproduction index, and human-caused mortality suggest the Banff, Kootenay, and Yoho population of grizzly bears is stable and that

management actions such as fencing the TransCanada Highway, installation of highway crossing structures, efforts to reduce mortality risk, seasonal travel restrictions and closures, fire management, and pro-active efforts to reduce food conditioning and human-wildlife conflict are helping to conserve grizzly bears. However, grizzly bears continue to face challenges on this busy landscape through displacement from high quality habitat and direct mortality. Juvenile, sub-adult, and adult survival rates from this study were similar to results from the Eastern Slopes Grizzly Bear Study from 1994 to 2002 (Garshelis et al. 2005). Continued conservation efforts to improve habitat quality and security combined with efforts to reduce human-bear conflicts and mortality are required to maintain a stable population of grizzly bears.

Acknowledgements/Partners

Anne Forshner and Jesse Whittington co-wrote this technical summary.

Many Resource Conservation staff collected and organised data including staff from Banff, Yoho and Kootenay National Parks in Human-Wildlife Conflict, Ecological Integrity Monitoring, Fire-Vegetation, Aquatics and the Equine program. Key collaborators included Mark Hebblewhite from the University of Montana, Richard Chandler from University of Georgia, and Mike Sawaya. HWC Specialist Steve Michel led the highly successful capture and collaring effort for all bears collared as part of the PC/CP Joint Grizzly Bear Research Project.

Contact

Anne Forshner, A/ Wildlife Ecologist for Species of Concern
Lake Louise, Yoho and Kootenay Field Unit
P: 403-431-1795
E: *anne.forshner@pc.gc.ca*

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: 404-763-8865
E: *jesse.whittington@pc.gc.ca*

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Grizzly Bear selection for Burned Habitats

Introduction



Figure 1. Image of GPS radio-collared grizzly bear occupying burned habitat. Photo: Laurens Put.

The North American distribution and population of grizzly bears (*Ursus arctos L.*) was significantly reduced in the late 1800's and early 1900's (Mattson and Merrill 2002). The current range of the species in Alberta constitutes most of the eastern edge of their continental distribution, so the conservation of these populations is essential to halting further range loss. In 2010, grizzly bears were listed as a threatened species in Alberta (ASRD 2010). Grizzly Bears (western population) are now federally recognized as "Special Concern" under the Canada Species at Risk Act. Even in protected areas, such as Banff National Park, populations are small and, at best stable (Sawaya et al. 2012; Whittington and Sawaya 2015, Whittington *et.al.* 2018). Animals in Banff have been protected for over a century, although grizzly bears in Banff still suffer from high rates of human-caused mortality (Benn and Herrero 2002; Nielsen et al. 2004) and low quality habitat (Gibeau 1998; Garshelis et al. 2005). Grizzly bears in Banff have apparent nutritional limitations (López-Alfaroa et al. 2015) resulting in, among other things, relatively small average litter sizes (1.8 cubs), long inter-birth intervals (4.4 years) and late age of first surviving litters (8.4 years). This has contributed to bears in Banff having one of the lowest reproductive rates of any studied grizzly bear population (Garshelis et al. 2005).

To promote a long-term positive or stable population trend, management and conservation can focus on minimizing mortality and/or increasing productivity of habitats. Primary factors affecting mortality and the location of mortality sinks for grizzly bears in Banff are known (Benn and Herrero 2002; Nielsen et al. 2004a) with management strategies continuing to be implemented to reduce mortality events (Bertch and Gibeau 2009). However, we know much less about what habitat factors are limiting local population abundance and which specific management actions can enhance or protect these habitats (Figure 1).

Primary grizzly bear habitat in the central Rocky Mountains has been described as areas composed of a mosaic of forest and open regions which are typically maintained by disturbance

agents such as fire or avalanche (Herrero 1972). Fire history studies suggest that wildfire was common in Banff prior to the twentieth century (White 1985), but since then, fire prevention and suppression has dramatically decreased the fire cycle from approximately 60-70 years in the montane ecoregion to over 280 years (Van Wagner et al. 2006). To increase wildfire frequency, Parks Canada commenced a prescribed fire program in 1983; reinstating fire as a primary ecological disturbance. Since then, our ability to safely and effectively apply prescribed fire has increased, and it is now considered a primary tool for enhancing grizzly bear habitat quality. However, to effectively enhance grizzly bear habitat with the use of prescribed fire, it is important to determine if grizzly bears use (select) burned patches and to evaluate the factors affecting which burns, or parts of burns, are most favored by bears.

Objectives

- Evaluate if grizzly bears selected burned habitats across a range of temporal and spatial scales.
- Test factors predicted to influence grizzly bear selection within burned patches.
- Develop prescriptive maps that predict where new prescribed fire would most effectively enhance grizzly bear habitat.
- Investigate if individual grizzly bears that selected burned habitats spent less time in human use areas where mortality risk is elevated.

Methods

Using GPS telemetry data collected from 14 female and 12 male grizzly bears between 2012 and 2015, we evaluated selection of burn patches using resource selection functions (RSF's; Manly et al. 2002) following a used/available design where grizzly bear "use" was compared to "available" locations bounded by spatial extents (Boyce 2006). We implemented a multi-scale approach to evaluate each of our specific objectives and to account for dependence of RSF results on spatial scale parameters (Boyce 2006; Ciarneillo et al. 2007). We developed seasonal RSF models at Johnson's (1980) third-order (within home range) and fourth-order (within patch) scales to account for spatial and temporal effects on selection variability (Boyce 2006).

At the third-order scale we examined if bears demonstrate selection for recent burns (1960-2012), old burns (1886 -1959) and human-use areas (roads, railways and town sites) during three different seasons: hypophagia (May 1 – June 14), pre-hyperphagia (June 15 – August 7) and hyperphagia (August 8 – October 31). For these analyses we used generalized linear mixed models (GLMM) where a random intercept accounted for unbalanced sampling of individual grizzly bears and autocorrelation (Gillies et al. 2006). To test if individual grizzly bears that select burned habitats showed reduced selection for human use locations, we investigated correlation between the percent of locations within burns and old burns to the percent of locations within

human use areas for each individual. We used Spearman rank correlation (r_s) with negative and significant values indicating that bears that select burns or old burns have a lower affinity for human use areas.

At the fourth-order scale, we modelled covariates that predict grizzly bear locations within burn patches during these same three seasons. We then extrapolated these models across the study area to produce prescriptive management maps that predict locations where prescribed fire would be most effective relative to generating productive grizzly bear habitat based on patterns of habitat selection to existing burns. We used a k-fold cross-validation to evaluate the predictive capability of each seasonal model (Boyce et al. 2002) by randomly withholding 20% (i.e., k=5) of grizzly bear location data and used this data partition to validate the model that was created with the remaining 80% of the 'training' data.

Results

1 Seasonal selection of burns, older burns and human-use habitats within home range (third-order scale)

HYPOHPAGIA - We recorded a total of 8,996 bear locations during the hypophagia season (May 1-June 14). Of these 1,055 (11.7%) occurred in recent burns, 782 (8.6%) occurred in old burns and 2,184 (24.3%) occurred within human use areas. At a population-level, bears positively selected for burn patches with an odds ratio (OR) of 2.39 (2.4 times more likely in burns than non-burns). Bears, as a population, also selected old burn habitats (OR 1.60) and heavily selected human-use areas (OR 9.66). Sub-adults had neutral selection for burns and old-burns, while adults and both sex classes demonstrated positive selection for all three habitats during the hypophagia. During the hypophagia season there was a negative and significant correlation between the percent selection of burns and human use areas indicating individuals who selected burns had lower affinity for human-use areas. However, there was also a positive, non-significant, correlation between old burns and human use areas.

EARLY HYPERPHAGIA - During the season of early hyperphagia (June 15th to Aug. 7th), we recorded 19,909 bear locations. Of these 2,297 (11.5%) occurred in burns, 998 (5.0%) were in old burns and 3,374 (16.9%) were in human use areas. In contrast to the hypophagia period, population-level selection for burned habitat increased slightly (OR: 2.46), whereas selection in both old burns (OR: 0.734) and human use areas (OR: 6.27) decreased. During this season, old burns were avoided. Evaluating age or sex-classes independently did not reveal any specific variation with both classes selecting for burns and human use areas and avoiding old burn habitats. There was a negative, non-significant, correlation between burn and human use percent selection during the early hyperphagia season. For this season, percent selection of old burn patches and human use areas continued to be positively correlated, however, they were not significant.

HYPERPHAGIA - During the season of hyperphagia (Aug. 8th to Oct. 31st) we recorded 24,770 bear locations with 4,636 (18.7%) in burns, 3,377 (13.7 %) in old burns and 1,408 (5.6%) in human use areas. At the population level, bears had a positive selection for all three habitats.

In comparison to previous seasons there was a notable increase in the selection of burns and old burns, while there was a reduction in selection of human use areas. At the population level, estimated odds ratios were 4.48 for burns, 2.43 for old burns and 1.98 for human use areas. The reduction of human use areas during hyperphagia was largely attributed to female bears avoiding these habitats. In contrast, an evaluation of differences among age-classes did not reveal any variation in selection from population-level results. During the hyperphagia season, the correlation between the percent of locations within burn patches and human use areas for each individual remained negative but non-significant. This measure for old burns and human use areas was negative during the hyperphagia season but also remained non-significant.

2 Seasonal within-patch selection of recent burns (fourth-order scale)

HYPOHPAGIA - The climate and terrain variables that best predicted the 1,005 grizzly bear locations that occurred within burn habitats during hypophagia included: mean annual precipitation (MAP), distance to water (dwater), end of frost free period (eFFP), slope, and elevation. During the season of hypophagia, grizzly bears selected steep sites at lower elevations that were further from water as compared to available burn habitat. Burn locations with lower annual precipitation and a late date of frost on-set also contributed to which burns, and where within the burns, bears selected. Model validation was good with a positive Spearman rank correlation (r_s = 0.925; SD = 0.026). Maps extrapolating this model provide predictions of priority sites for prescribed fire that should create or enhance grizzly bear habitat for the hypophagia period (Figure 2).

EARLY HYPERPHAGIA - During the season of early hyperphagia, the climate and terrain variables that best predicted the 2,297 grizzly bear locations occurring within burn patches included: mean annual precipitation (MAP), end of frost free period (eFFP), heat load index (HLI), distance to water (dwater), and slope. During this season grizzly bears selected burned areas in warmer and wetter sites with flatter terrain and further from water sources. Validation indicated this model fit well with a positive Spearman rank correlation (r_s = 0.919, SD= 0.028). Study area-wide maps extrapolated from this model indicated priority areas for creating or enhancing early hyperphagia grizzly bear habitat with prescribed fire (Figure 2).

HYPERPHAGIA - During the season of hyperphagia, the 4,636 grizzly bear locations that occurred within burns were best predicted by the terrain and climate variables elevation, slope, compound topographic index (CTI), climate moisture deficit (CMD), beginning of frost free period (bFFP), and mean coldest month temperature (MCMT). During this period, bears selected low angled and dry slopes at high elevations within burns in locations that were cold in the winter and where frost persisted late in the spring. Validation indicated this model had relatively good predictive capacity with a positive Spearman rank correlation (r_s = 0.867, SD =0.056). A study area-wide map extrapolated from this model indicates priority areas for creating or enhancing hyperphagia bear habitat with prescribed fire (Figure 2).

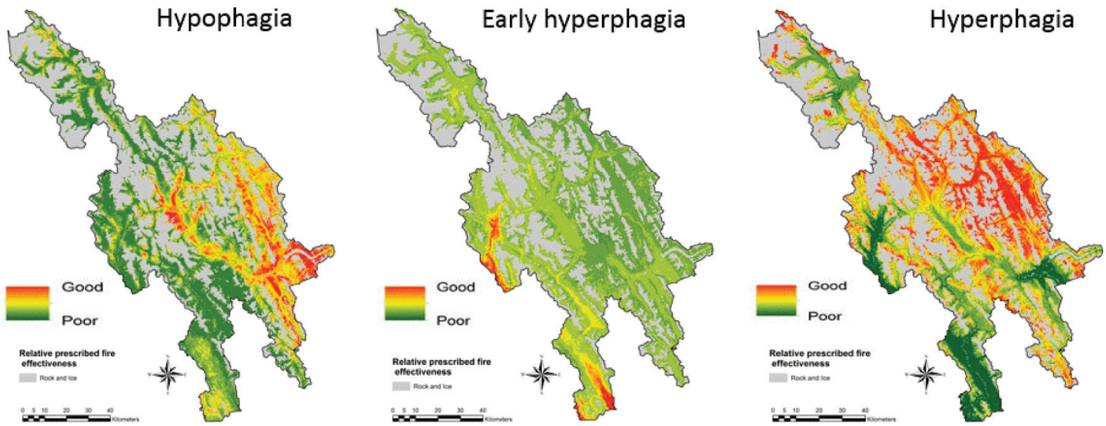


Figure 2. Maps extrapolated from grizzly bear selection models during hypophagia season (May 1st to June 14th), early hyperphagia (June 15th-August 7th) and hyperphagia (August 8th-October 31st) that illustrate the relative effectiveness of prescribed fire for generating *new* habitat that grizzly bears will select during these seasons.

Discussion

This study demonstrates that grizzly bears selected burned patches within home ranges during all active seasons, particularly during hyperphagia when they rapidly deposit fat in preparation for hibernation and successful pregnancy (McLellan 2011). During this time of year bears also selected for 55-110 year-old burns indicating the long-term value of burns as habitat for bears. Based on climate, terrain, and patterns of habitat selection of existing burns we developed models that predicted where prescribed fire and wildfire would increase grizzly bear habitat. This should assist fire managers in selecting locations where new prescribed fires will most effectively enhance habitat for bears. We do note that grizzly bears in this study also selected for human-use areas (highways, railways and townsites) where over 85% of the known mortality has occurred in the last 30 years (Benn and Herrero 2002; Berch and Gibeau 2009). This may have been influenced by the collaring protocols, which constrained capturing efforts to focus on bears whose home-ranges overlapped with the CPR right of way. Grizzly bears selection for these risky habitats notably decreased during the hyperphagia period when burns were selected most.

With the Banff grizzly bear population holding stable (Sawaya et al. 2012; Whittington and Sawaya 2015; Whittington et al. 2018) despite one of the slowest reproductive rates of any population studied (Garshelis et al. 2005), our study provides optimism that prescribed fire can help stimulate bottom-up habitat factors by enhancing and creating important habitat and at the same time, reduce top-down factors by drawing bears away from areas of high human use. Analytical methods that tie habitat selection to survival (Nielsen et al. 2011), reproduction (McLoughlin et al. 2007) and abundance (Boyce and McDonald 1999; Nielsen et al. 2010; Boyce et al. 2016) have grown considerably in recent years and have the potential to increase our understanding of how forest fires (natural and prescribed) affect bear populations. Additional research in Banff, Yoho and Kootenay National Parks on the demographics of grizzly bears

should examine the effect of fires on population growth. Given the substantial decrease of fire disturbance in these ecosystems over the last century (White 1985; Van Wagner et al. 2006), we encourage continued and increased use of prescribed fire in the Parks and additional evaluation of its importance to grizzly bears by measuring the foods produced, use by bears, and vital rates of bears before and after prescribed fire is applied.

Acknowledgements/Partners

Canadian Pacific Railway, University of Alberta, Parks Canada Wildlife Staff, Scott Nielsen, Jane Park, Kate Johnson, Leah Pengelly, Gavin Hurd, Brigitte Dreger. HWC Specialist, Steve Michel led the highly successful capture and collaring effort that provided grizzly bear location data for this project.

Contact

Charlie McLellan, A/ Fire Management Officer
Lake Louise, Yoho and Kootenay Field Unit
P: (250)-347-6174
E: *Charlie.McLellan@pc.gc.ca*

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Grizzly Bear Railway Mortality Mitigation: Electrified Mat, Fence Testing, and Off–Track Mitigations

Introduction

Train collisions are a key cause of mortality for grizzly bears in Banff and Yoho National Parks. Park management plans include commitments to reduce grizzly bear mortality from train strikes (Parks Canada 2010 a, b). Between 2010 and 2017, Parks Canada and Canadian Pacific collaborated on a joint research initiative for grizzly bears to: a) understand underlying causes that contribute to grizzly bear risk on the railway and b) identify and begin implementing solutions to reduce grizzly bear mortality on the railway.



Figure 1. Electrified mat and fence testing in Banff National Park.



Figure 2. Non-electrified fence testing in Banff National Park.

University of Alberta led several research projects including:

1. Methods for monitoring and estimating grain spillage and dietary contributions for bears (Gangadharan et al. 2017)
2. Use of railway by bears in relation to other linear features (Friesen 2016)
3. Vegetation enhancement, toxin exposure, and bear movement in relation to the railway (Pollock et al. 2017).
4. Sensory limitations and a train-based warning system (Backs et al. 2017)
5. Relationships between road mitigation and rail mortality (Gilhooly 2016)
6. Stable isotope analyses of hair samples from bears (Hopkins et al. 2014)
7. Analysis of contents of grizzly bear scats (Murray et al. 2017)
8. Conditioned taste aversion project (Lori Homstol et al. 2013)

Parks Canada led several research programs including:

1. GPS radio-collaring program and population trends (See Grizzly Bear Population Trends technical summary – SOPR 2018)
2. Fire as a means of habitat enhancement to deter bears from the railway (McLellan 2018 in progress)
3. Behavioural responses of bears to trains (Burley 2015)
4. Electrified mats and fencing to reduce wildlife access to railways (Forshner and Niddrie 2017)
5. Non-electrified fencing solutions to exclude wildlife (Rafla et al. 2017)
6. Factors affecting wildlife risk of railway mortality (in progress).

Independent contractors Pengelly and Hamer (2016) led a research project on enhancing bear travel routes to reduce bear use of rail beds.

Based on these research results:

1. Parks Canada committed to implementing off-track mitigations to reduce the risk of grizzly bear mortality on the railway. These mitigations include:
    a. Developing and improving wildlife travel routes adjacent to key areas that have a high risk for grizzly bear-train collisions;
    b. Ongoing use of prescribed fires and forest thinning to enhance grizzly bear habitat away from the railway.
2. Canadian Pacific committed to implementing on-track mitigations to reduce future risk of grizzly bear mortality on the railway. These mitigations include:
    a. A targeted, multi-year vegetation management program throughout Banff and Yoho National Parks that will decrease attractive vegetation and open escape paths in confined areas;
    b. A pilot exclusion fencing and electrified mat program around railroad greasers aimed at keeping bears away from this potential attractant.

Objectives

1. Summarize electrified mat and fence testing in Banff and Yoho National Parks
2. Summarize non-electrified fence testing project in Banff National Park
3. Summarize alternate travel route project – off-track mitigation
4. Summarize prescribed fire and thinning project – off-track mitigation

Methods

Electrified mat and fence testing

We used off-site trials to test whether electrified mats and fencing could exclude bears and other wildlife from high risk locations on the railway. We constructed two test sites in Banff and Yoho National Parks that were located away from the railway to ensure a safe and controlled setting (Figure 1). Sites consisted of a fenced exclosure, simulated railway tracks, an electrified mat that was on or off, and bait to attract carnivores into the test site. We tested electrified mats that were designed and installed by Lampman Wildlife Management Services. We used remote cameras and video cameras to record interactions of bears and other wildlife with the electrified mats and fencing.

Non-electrified fence testing

We used an off-site trial to test the effectiveness of a low maintenance, non-electrified fence modification to deter bears from climbing over barrier fences. The test site was located at Healy meadows where researchers evaluated the effectiveness of a modified fence design with an outward facing, 1 meter overhang at a 90° angle (Figure 2). We used remote cameras and video cameras to record interactions of bears and other wildlife with the non-electrified fence.

Off-track mitigation - Alternate travel routes

We used chainsaws, brushers and hand tools to create and enhance alternate travel routes in two high-risk areas of the railway – Morant's Curve and Five Mile Bridge (Figures 5, 6). We will use remote cameras to monitor effectiveness of the routes.

Off-track mitigation - Prescribed fire and thinning

We used a web-based GIS tool to assemble data and complete a scoping workshop. Specialists from Banff, Yoho and Kootenay National Parks used the GIS-based tool to identify where we could use prescribed fire and thinning in the next 10 years to restore grizzly bear habitat away from the railway in key locations.

Results

Electrified mat and fence testing

Between 2013 and 2015, electrified mats successfully deterred 85% of all crossing attempts of eight species and 34

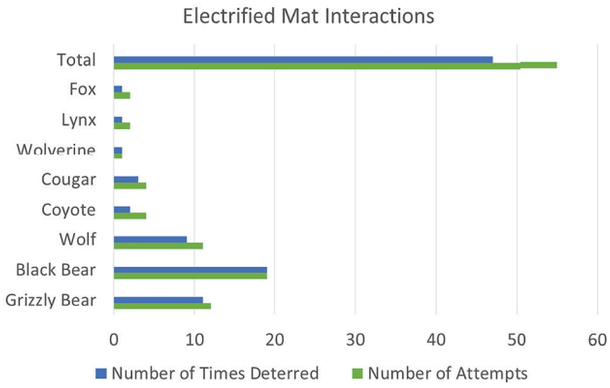


Figure 3. Comparison of total electrified mat crossing attempts and number successfully deterred

individuals into baited exclosures (55 attempts. Figure 3). Wildlife crossed the electrified mats into the exclosure eight times. Five of these crossings occurred when the electrified mat malfunctioned. One fox and two wolves crossed into the exclosure across the electrified mat when it was working. No grizzly bears or black bears crossed into the exclosure when the electrified mat was working.

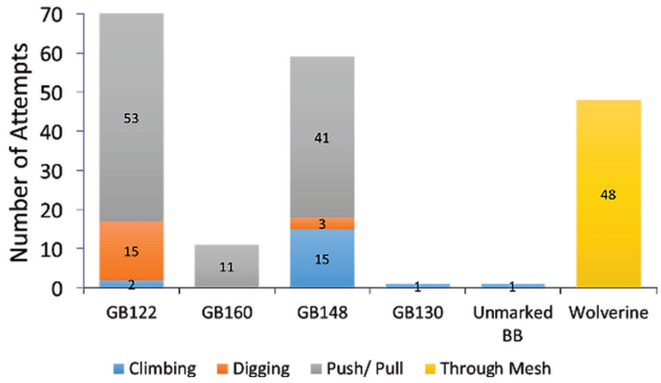


Figure 4. Number of attempts to access the baited exclosure by four grizzly bears, one black bear and a wolverine.

Non-electrified fence testing

Staff baited and monitored the non-electrified exclosure over 167 test days in 2014 and 2015. Five individual bears attempted to breach or interact with the fence 142 times (Figure 4). They attempted to gain access by digging, climbing or pushing/pulling on the fence wire or posts. Although no bears successfully climbed over the fence, two grizzly bears managed to break-in to the site by pushing and pulling on a weak point in the fence to create a large hole in the wire. A wolverine passed easily through the page wire near ground level 48 times.

Off-track mitigation - Alternate travel routes

In 2017, we enhanced 3 kilometers of new travel routes in the Morant's curve area near Lake Louise (Figure 3). In the winter of 2017/18 we enhanced 25 km of travel routes near Five mile bridge (Figure 6). The Five mile bridge routes were first cleared in 2015 by Pengelly and Hamer with funding from the joint research initiative (Pengelly and Hamer 2016). We have deployed remote cameras to monitor wildlife and human use of the enhanced travel routes.

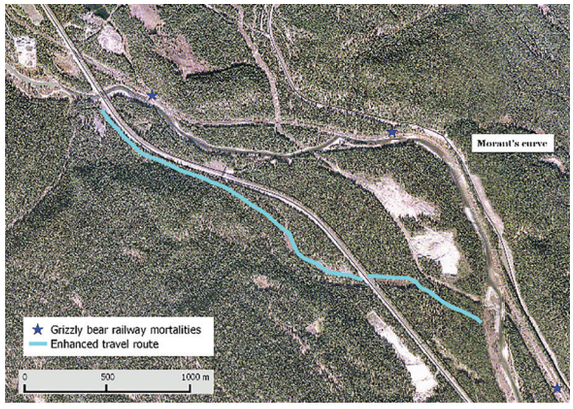


Figure 5. Alternate travel route near Morant's Curve – a high-risk area for grizzly bears.

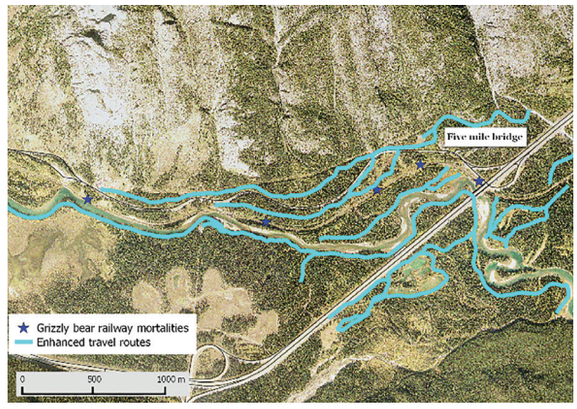


Figure 6. Alternate travel routes near Five-Mile Bridge – a high-risk area for grizzly bears.

Off-track mitigation - Prescribed fire and thinning

Based on grizzly bear movement routes, mortality locations, and landscape attributes, a number of areas were identified for restoring grizzly bear habitat away from the railway. Figure 5 shows an example of potential areas for burning or thinning around Lake Louise. A final report will be completed in winter 2018 to assist with planning and funding proposals (Forshner 2018, in progress).

Additionally, a large fuel modification project on the west slopes of Sulphur Mountain (just west of the Town of Banff) is planned for work to start in the winter of 2018/19. This will further enhance grizzly bear habitat in an area well away from the railway, but inclusive of the home range of bears occupying railway habitats.

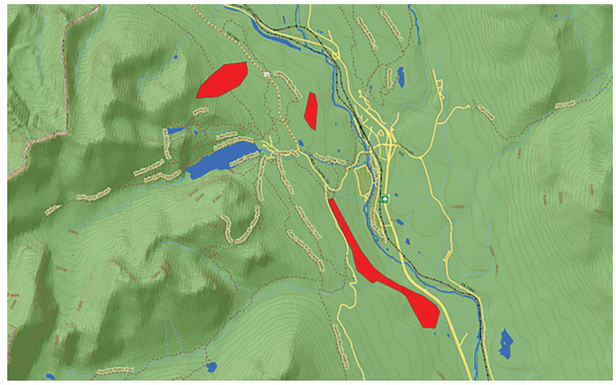


Figure 7. Proposed areas around the village of Lake Louise for restoring grizzly bear habitat through prescribed fire or thinning.

Discussion

Research

We found that the combination of electrified mats and fencing is a promising method for excluding bears and other wildlife from the railway in high risk areas (Forshner and Niddrie 2017). However, the mats and fencing remain experimental because they did not work well in the winter, and they are untested on ungulates. Parks Canada recently attempted to apply two of these mats in a much simpler, highway setting, in Banff Park and they failed completely (structurally and reliability) in a real-world setting (vehicle traffic, precipitation, and road salt); so much so, that it was not even possible to assess their effectiveness at deterring wildlife. As these designs remain experimental, it is not currently viable to use electrified mats and fencing to mitigate grizzly bear and wildlife mortality on the railway. So although Canadian Pacific committed to a pilot exclusion fencing and electrified mat program around railroad greasers aimed at keeping bears away from this potential attractant, this program has not been implemented yet, as it will require a new supplier/manufacturer, and design to be at all viable.

We also investigated the effectiveness of a low maintenance, non-electrified fence modification to deter bears from climbing fences. We found that the non-electrified overhang deterred bears from climbing a fence, and may be a viable upgrade to current fence designs (both current highway and future railway fencing), although more research and testing is warranted. Similar to the electrified mat and fence project, this modification remains experimental, and there are no plans to use fencing to mitigate wildlife mortality.

Mitigations

In 2017, we enhanced new and existing travel routes near two high-risk areas for grizzly bears, to try to decrease the probability of bears using the railway both as a transportation corridor and as a source of unnatural anthropogenic food (grain and legumes). This mitigation was implemented based on promising results from Pengelly and Hamer (2016). We will monitor these travel routes using remote cameras to determine the effectiveness of the project. Further, we will compare wildlife mortality data on the railway pre- and post-treatment to suggest whether these enhanced trails have assisted with decreasing wildlife mortality on the railway. Given small sample sizes and potentially slow changes to wildlife movement behaviour, it may take 5 to 10 years to detect a wildlife response. However, wildlife research demonstrates that wildlife and especially carnivores select low-human use trails as travel routes (Whittington et al. 2005, Hebblewhite and Merrill 2008), thus increasing wildlife use away from the railway should have a positive effect on wildlife populations.

For prescribed fire and thinning, we are preparing a report summarizing locations for future prescribed fire and thinning projects in key areas to restore grizzly bear habitat away from the railway. We will work with Fire / Vegetation specialists who have a number of other prescribed fires planned 2018–2026 with multiple objectives, some including grizzly bear habitat objectives.

We are optimistic these targeted science-based mitigations on and off the railway will help reduce the risk to grizzly bears along the railway in Banff and Yoho national parks. However, ongoing collaboration, communication and support by both Parks Canada and Canadian Pacific, will be required to reduce the risk of future grizzly bear-train collisions.

Recommendations

- Establish working group with Canadian Pacific to ensure we collaborate and communicate regarding:
- Ongoing operations related to cleaning up grain spills, removing carcasses, and using vacuum truck to remove spilled grain entirely.
- Progress made implementing mitigations.
- Monitor and report on effectiveness of alternate travel routes project. Implement in other high-risk areas adaptively.
- Create detailed implementation plans and environmental assessments for prescribed fire and thinning projects specific to restoring grizzly bear habitat away from the railway in key areas. This should include small-scale areas away from the railway that would benefit from mechanical thinning (e.g., areas with native fruiting understory).
- Further evaluate the combined effects of topography, grain, human use, railway vegetation, water, and habitat quality on mortality risk and the effectiveness of mitigations.
- Support Canadian Pacific should they decide to collaborate with the University of Alberta to install and further test warning systems for oncoming trains at high-risk locations. Preliminary results from this project were promising (Backs et al. 2017), but more field testing would be needed to assess the efficacy in a real-world application.

Acknowledgements/Partners

Prepared by Anne Forshner and Jesse Whittington. Many Resource Conservation staff assisted with these projects including staff from Banff, Yoho and Kootenay National Parks in Human-Wildlife Conflict, Fire-Vegetation, and Species of Concern programs. In particular, Dan Rafla, Tom Niddrie, Dave Garrow, Adam Sherriff and Anne Forshner played lead roles in these active management projects. HWC Specialist Steve Michel led the highly successful (some would say "unprecedented") capture and collaring effort for all collared bears monitored through this research. Funding was provided by the Joint Initiative for Grizzly Bear Conservation by Parks Canada and Canadian Pacific Railway.

Contact

Anne Forshner, A/ Wildlife Ecologist for Species of Concern
Lake Louise, Yoho and Kootenay Field Unit
P: 403-431-1795
E: *anne.forshner@pc.gc.ca*

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: 404-763-8865
E: *jesse.whittington@pc.gc.ca*

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Harlequin Duck Monitoring

Introduction

Harlequin ducks (*Histrionicus histrionicus*) are provincially classified as a species of *special concern* in Alberta, partially due to their sensitivity to in-stream disturbance. They have a life history strategy of wintering in coastal areas and breeding in mountain streams and rivers. Their sensitivity led Alberta to develop a provincial conservation management plan in 2010 (ASRD 2010).

We have been actively monitoring harlequin ducks in Banff National Park since 1995. At that time the section of the Bow River between Lake Louise and Castle Junction had one of the highest concentrations of ducks on breeding territory in North America. Monitoring was used to evaluate various mitigations implemented as part of the TransCanada Highway twinning projects; including modifications to the Moraine Creek bridge. The species has been well studied on the Bow River (Smith 2000) and Banff National Park has a specific monitoring program in place (Campbell 2005).

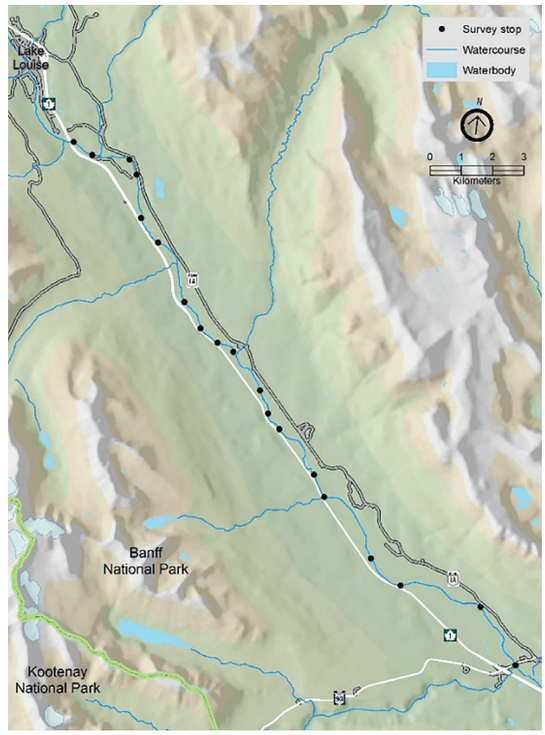


Figure 1. Harlequin duck survey stops along the Bow River from Lake Louise to Castle Junction in Banff National Park.

Objectives

- Monitor the spring population of Harlequin ducks on the Bow River.
- Examine the population productivity.
- Estimate population size.

Methods

We have conducted the Harlequin Duck Monitoring Program on the Bow River in Banff Park since 1995. The details of the harlequin duck monitoring methods are described in Smith (2000) and Campbell (2005). The program includes annual population indexing, annual brood count, and a population estimate conducted once every seven to ten years.

Indexing: We monitor ducks annually by conducting a roadside survey, modeled after Hunt and Ydenberg (2000) at 19 standardized locations from Castle Junction and Lake Louise between May 7 and June 14 (Figure 1). We strive to complete a minimum of seven surveys each year. During each survey, we record the number, gender and banded status of Harlequin ducks.

Productivity: We count ducklings annually, once during a roadside survey and—when possible—again during a boat survey. We do this late in the season when ducklings are aged as class 3 (feathered but flightless). This classification is important as it provides a realistic estimate of population productivity; the natural mortality rates of broods between hatch week and migration can be considerable.

Population Estimate: Every seven to ten years a population estimate is completed using banding and capture-mark-recapture method leading to the Lincoln Index, as described by Smith (200b).

Results

Indexing: In 2017, we conducted eight surveys from May 10 to May 29, resulting in 12 to 26 harlequin ducks observed per survey. For 2017, the roadside survey index value was 17 (± 5) ducks, down 64 % from 48 (± 7) in 1995. In the past decade (2007-2017) there was a mean of 19.7 ducks, down 36% from 36.4 ducks the previous decade (1995-2006, excluding the year 2000). Each point of the index data from 1995 to 2017 is based on a mean count derived from 6-11 surveys (Figure 2). When we fit a linear regression to these data there is a significant decline (r^2=0.77, -1.4/yr). In addition, peak duck observations are occurring earlier in the season; in 1995 they were observed June 12, while in 2017 they were observed May 17.

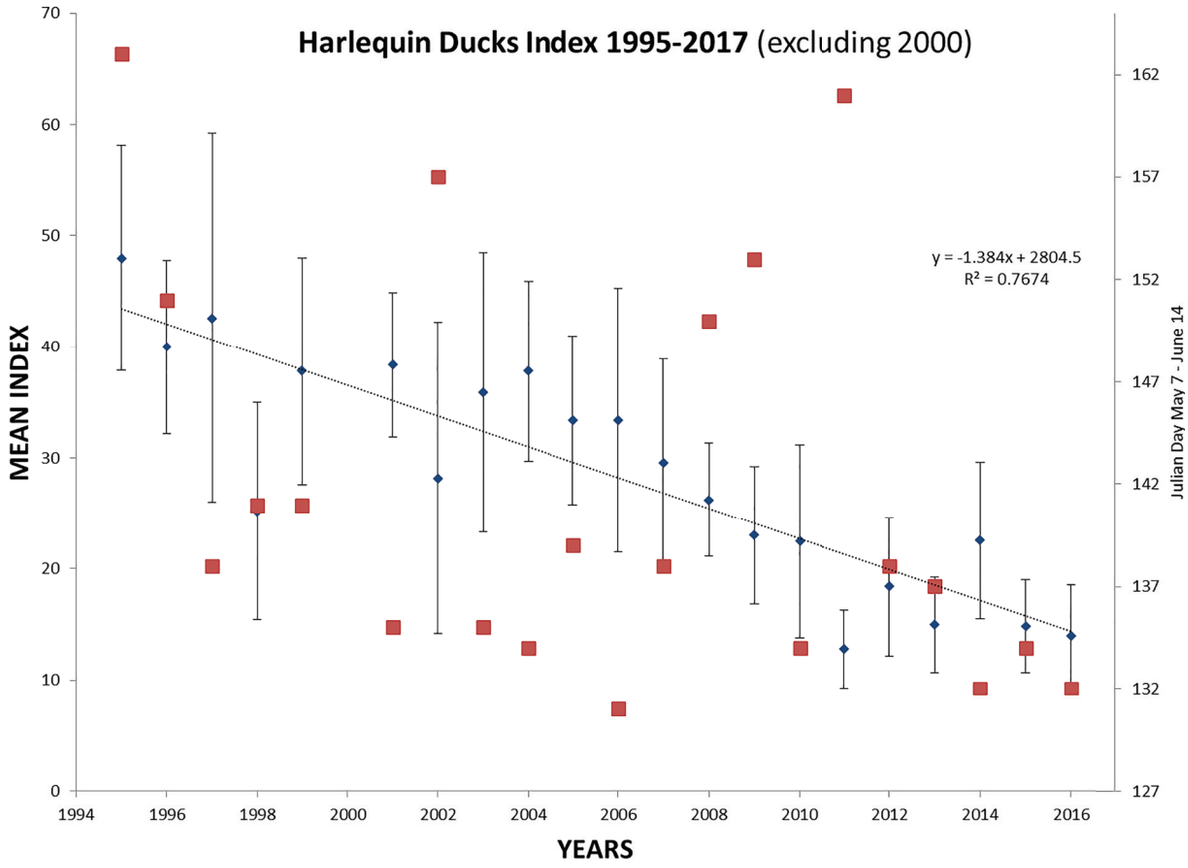


Figure 2. Harlequin duck roadside index 1995-2017 (excluding 2000). Error bars are standard deviations. Peak observation date are shown as red squares.

Productivity: From 2006 until 2017 Harlequin Ducks showed variable productivity on the Bow River (Table 1). A high degree of natural variability promotes difficulty in applying significance to trends. However, investigating the mean number of offspring produced over a female's lifespan (net reproductive rate [R_0]) provides insight into the longevity of the population. From 2006 – 2017 the R_0 ranged from 0.00 to 1.35 and averaged 0.23. This indicates that the Harlequin Duck population is not replacing itself and will decline.

Table 1. Success and productivity of female Harlequin Ducks on the Bow River in Banff National Park, 2006 – 2017.

Year	F_0	F with Broods	% F Successful	Ducklings	Ducklings/ Female	R_0
2006	26	1	3.85	3	0.12	0.36
2007	20	0	0	0	0	0.00
2008	16	0	0	0	0	0.00
2009	13	0	0	0	0	0.00
2010	17	0	0	0	0	0.00
2011	9	0	0	0	0	0.00
2012	15	0	0	0	0	0.00
2013	8	0	0	0	0	0.00
2014	14	1	7.14	6	0.43	1.35
2015	10	0	0	0	0	0.00
2016	7	0	0	0	0	0.00
2017	9	1	11.11	3	0.33	1.05
Overall Net Reproductive Rate						0.23

Population Estimate: We completed mark-recapture population estimates from 1995-2003, 2004, 2006, 2007, 2012 and 2017. With the revision of the monitoring protocol in 2003, data from prior to 2004 cannot be used for comparison. Population estimates from 1995, and between 2004 and 2017 are shown in Figure 3. The 2017 median population estimate is lower than the 2007 estimate but the 95% confidence intervals overlap. A paired t-test showed that there is no significant decrease in the last 10 years (2007 to 2017). However, there is a statistically significant decrease between 2017 population estimate and the 2004 and 2006 population estimates (Figure 3).

Table 2. Mark-recapture population estimates for 1995, 2004, 2006, 2007, 2012, and 2017.

Year	Pop Est.	n	Variance	S.D	S.E.	95% C.I.
1995	111	7	186	14	1.4	27
2004	83	8	111	10.5	1.2	20
2006	87	8	380	19.5	2.1	38
2007	45	6	230	15.2	2.3	29
2012	38	9	124	11.1	2.22	21
2017	28	8	42	6.5	1.2	12

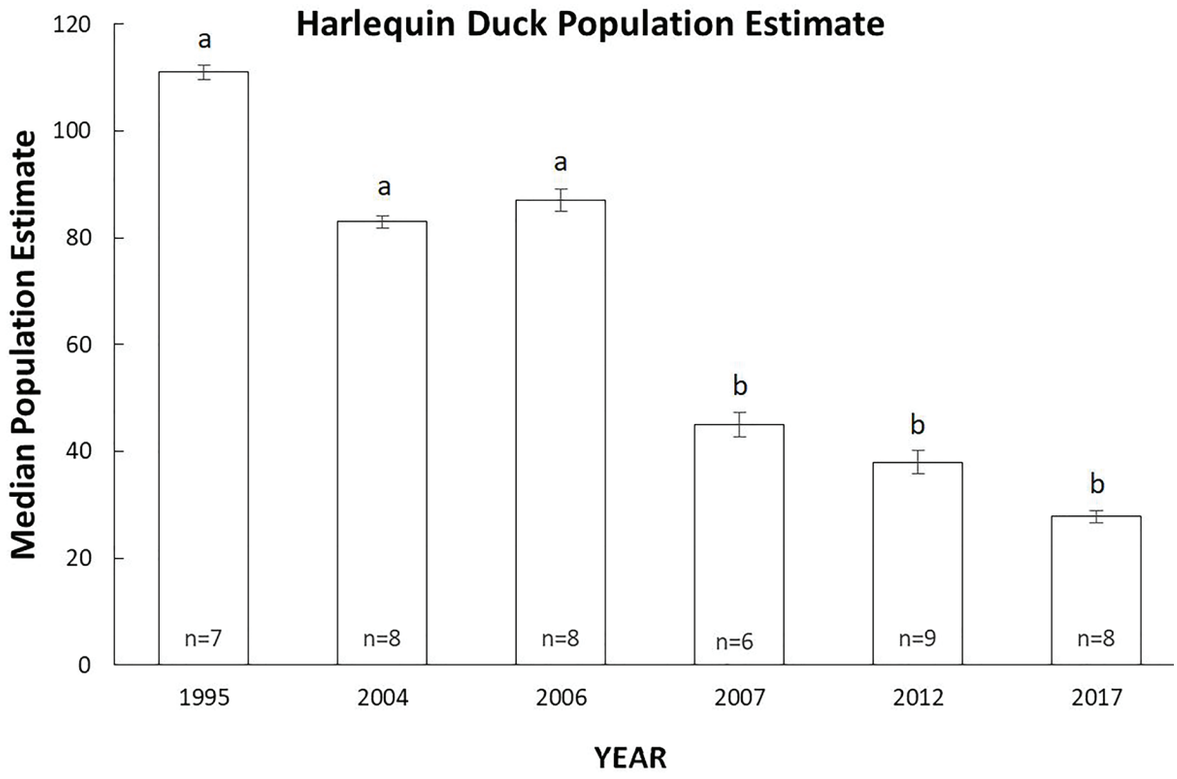


Figure 3. Harlequin duck population estimate. Values are medians ± standard error. Significant difference in median population estimates between years are denoted by different lowercase letters (a and **b**.

Discussion

Harlequin Duck monitoring indicates that the population returning to the Bow River in Banff National Park is in decline. This is evident from the consistent decrease in median population estimate from 1995 through 2017. While the median population estimate has decreased in each of the past three surveys (2007, 2012, 2017) these population estimates are not significantly different from one another. There is, however, a statistical difference between the population estimate surveys conducted in 2006 with each subsequent population estimate survey (2007, 2012, 2017).

During these observed declines in population estimate, Productivity Estimates have also declined. Net reproductive rates greater than 2.0 indicate that a population is successfully replacing itself with a surplus of young. Below a value of 2.0 and the population is no longer able to sustain and begins decline. From 1996 to 1999 the net reproductive rate (R_o) varied from 2.34 to 0.62 and averaged 1.33. This rate declined to an average of 0.23 with a range of 0.00 to 1.34 from 2006 to 2017. This trend is of concern. Exacerbating this change in net reproductive rate is the recognition that these values are an overestimate in terms of recruitment. This is due to additional mortality during fledging and before a female reaches breeding maturity.

Because they are a migratory species, declining abundance of Harlequin Ducks in Banff could be caused by impacts on wintering habitats along the west coast of British Columbia. However consistently poor recruitment in Banff suggests impacts on breeding ranges is likely occurring. Some authors speculated that declining harlequin ducks on breeding ranges is due to a decline in aquatic invertebrates as a result of historical stocking of previously fishless waterbodies (LeBourdais et al 2009). This theory makes sense, however fish stocking in Banff first occurred in the early 1900's, and has not occurred since 1988, so the timing is not consistent with the declines in harlequin ducks. Another theory is that when fish stocking occurred in high alpine lakes, harlequin ducks may have compensated by foraging on the mainstem Bow River, where nutrient levels would have been steadily rising from sewage plant inputs. In the late 1990's, wastewater treatment plants in both Lake Louise and Banff were upgraded to achieve much higher water quality standards, which likely resulted in less forage for fish and waterfowl, in the form of declining invertebrate abundance.

The effects of aquatic invertebrate declines can be seen in Christmas Bird Count data for the Bow River, where pre-2000 it was not uncommon for observers to record over 200 common goldeneye and various other waterfowl, but since about 2002, these have numbered closer to 20. If these theories are true, it is one more reason to continue with restoration efforts currently underway by Parks Canada to restore many lakes, historically stocked with non-native fish, to their original fishless state. By removing non-native fish, these alpine lake invertebrate communities can be restored to fill an important role in the rocky mountain food web.

Index and brood surveys will continue next year and we may obtain more information from external related research. For example, the Canadian Wildlife Service outfitted ducks with satellite transmission tags to examine migration and nesting patterns. This year's imagery showed that a small subset of these ducks migrated to Banff, Kootenay, Jasper, and Kananaskis with the majority going to the coastal mountains.



Figure 4. Banded male Harlequin Duck on the Bow River.

Acknowledgements/Partners

Cyndi Smith conducted her M.Sc. work on the Bow River harlequin duck population and led much of this work during her career with Parks Canada. She continues to support banding efforts and data analysis, even now she has retired. Her contribution has been invaluable and her commitment, expertise, and tenacity most appreciated.

Contact

Shelley Humphries, Aquatic Ecologist
Lake Louise, Yoho and Kootenay Field Unit
P: 250-347-6159
E: *shelley.humphries@pc.gc.ca*

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Helicopter Use in the East Slopes Region

Introduction

Within Banff National Park, helicopters are used by primarily by Resource Conservation (Aquatics, Fire and Vegetation, Wildlife, and Ecological Integrity Monitoring and Visitor Safety), and Asset Management (Trail Crew). Uses include both emergency and non-emergency operations. Helicopters are used for transport of personnel and equipment, search and rescue, avalanche control, prescribed fire operations, smoke patrols, wildfire operations and aerial surveys. Emergency helicopter use is defined as use necessary for wildfire operations, search and rescue and wildlife emergencies where public safety is at risk. All other operations are considered non-emergency.

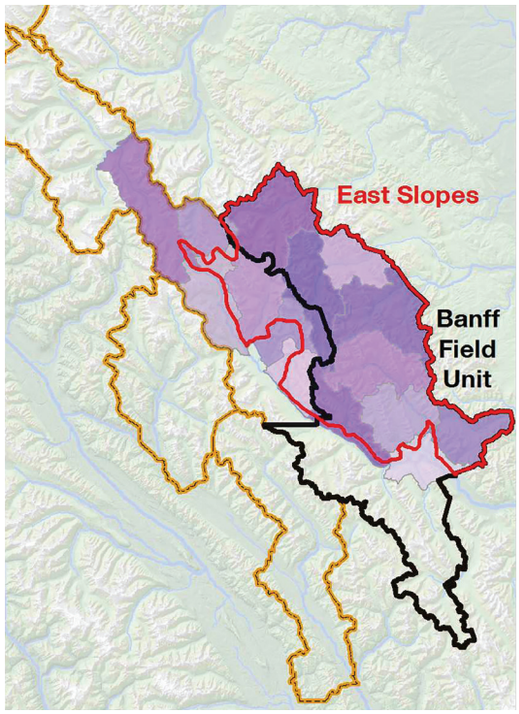


Figure 1 Map of zones used in the Helicopter Use analysis. Purple shading indicates LMU's contained within the East Slopes region, with the red line outlining the boundary of the East Slopes Region. The black line outlines the Banff Field Unit. Yellow lines indicate the boundaries of the Mountain National Parks.

There is specific direction in the 2010 Banff Park Management Plan related to use of helicopters within certain areas of the Park.

Specifically, the plan states:

- Work with helicopter companies to develop and implement flight corridors and best practices for overflights in order to minimize disturbance to wildlife and humans using wilderness valleys and passes (Section 5.2.1.7)
- Build on recent successes in reducing non-renewable fuel consumption and greenhouse gas emissions from national park operations by:
- In the East Slopes and North Saskatchewan areas, restricting Parks Canada helicopter use to that required for fire operations, search and rescue, and emergencies (Section 5.5.1.15)

These directives encourage reduction of helicopter use from an ecological standpoint (minimize disturbance to wildlife), a human-use standpoint (retain wilderness feel for backcountry visitors)

and to reduce non-renewable fuel consumption and emissions in Banff National Park. In terms of disturbance of wildlife from helicopter overflights, this has been investigated in several studies. Helicopter overflights have been shown to reduce foraging behaviour in goats (Côté et. al. 1996), reduce foraging intake in bighorn sheep (Stockwell et. al. 1991), and result in altered animal activity levels and vigilance both during and post-overflight in ibex (Brambilla and Brivio, 2018), mountain goats (Cadsand 2012) and moose (Støen 2010). Red-tailed hawks and bald eagles have changed home range size in response to helicopters (Andersen et. al. 1990). There is evidence that sensitive ungulates such as mountain goats do not habituate to helicopter traffic (Côté et. al. 2013). Some studies recommend minimum flight distances to avoid wildlife disruptions with ranges varying from 600 m for bald eagles (Grubb and Bowerman, 1997) to in excess of 2,000 m for sensitive species such as mountain goats (Côté 1996; Goldstein 2005; Côté 2013).

Monitoring of helicopter use zones, flight hours and trends in Banff National Park is important for meeting direction provided in the 2010 Banff Management Plan and for establishing future targets and protocols.

Objectives

The objective of this report is to provide a summary of helicopter use in Banff National Park, with specific focus on monitoring helicopter usage trends in the East Slopes Land Management Units. Specific monitoring objectives include:

- Monitor trends in non-emergency helicopter use within Banff National Park
- Document all flights that occur within the Eastern Slopes Land Management Units and identify trends in helicopter use in these zones.

The East Slopes Land Management Units (LMU) include Clearwater, Siffleur, Upper Bow, Pipestone, Upper Red Deer, Lower Red Deer, Panther, Skoki, Baker Creek, Cuthead, Sawback, Cascade, Banff Town and Minnewanka. For LMU's that have boundaries overlapping the TransCanada Highway, the East Slopes zone pertains to regions north of the highway and excluding the highway corridor (Figure 1.)

Methods

We compiled data from two different sources:

- We implemented a Banff Helicopter Flights Management database system in 2017, with each function having responsibility for entering helicopter use data.
- For flights prior to 2017, we gleaned data from individual flight tickets issued from contracted helicopter companies.

We allocated each flight as either 'emergency' or 'non-emergency', and indicated the LMU's that the flight time occurred in.

There were some limitations in data availability prior to 2014. Although flight hours were available from 2008 to the present, flight tickets did not record information on destinations or flight mission. As a result, we present data from 2014-2017 only. Additionally, flight tickets did not always contain information on flight time within each LMU on single flights. In these cases, we estimated the approximate flight time between LMU's. In cases where the flight pathway is not indicated, we allocated the flight time to the destination LMU.

The primary emergency helicopter use in Banff National Park is fire operations (Fire and Vegetation program), search and rescue and emergencies (Visitor Safety program). For data entry from flight tickets from these programs, we made a best attempt to ascertain whether flights were emergency or non-emergency, but this was not always possible due to limited information on the flight mission. In unknown cases, the flight hours were assigned to 'emergency' because this is the dominant helicopter use within these departments. As such, non-emergency flight time may be under-represented for those departments in this dataset. An additional challenge for flight time allocations occurs within Fire and Vegetation pertaining to the use of helicopter minimums for purposes other than Wildfire Operations. When contracted minimum flight hours are underutilized, other functions/departments often use these pre-paid hours for non-emergency activities in order to make the most efficient use of resources. In this analyses these uses were dominantly ascribed to Fire and Vegetation. Suggestions for improving this accounting are presented in the discussion section below.

The data presented herein is from the Banff Field Unit portion of Banff National Park. In some cases, the flight time in this analysis has occurred in the Lake Louise, Yoho and Kootenay Field Unit zones (e.g. Visitor Safety search and rescue from BFU staff). This is retained as being representative of flight time originating from the Banff Field Unit.

Results

We compiled helicopter flight hour data for the East Slopes region into emergency and non-emergency totals for the years 2014-2018, with annual and total sums (Table 1). Annual totals in non-emergency use ranged from a minimum of 100 hours in 2014 to a maximum of 174 hours in 2016. Usage varied considerably across functions with less than 5 hours of annual use in several departments (EI, Executive, Fire and Veg, Law Enforcement and Visitor Safety).

Table 1. Summary data of helicopter flight hours for the Eastern Slopes Region 2014-2018.

Non-emergency Flight Hours - East Slopes Only										
Year	Aquatics	Assets	EI	Executive	Fire and Veg	Law Enforcement	Visitor Safety	Wildlife-Bison	Wildlife-Other	Annual Total
2014	19	68.1	0	0	8.3	0.7	0.4	0	4	100.5
2015	43.3	79	0	2.5	0.3	1	2.8	18.9	23.3	171.1
2016	36.8	60.1	0	2.1	3	3.1	1.3	61.3	6.3	174
2017	12.6	33.3	1.2	1.7	3.8	2.6	3	84.8	18.7	161.7
Totals	111.7	240.5	1.2	6.3	15.4	7.4	7.5	165	52.3	607.3

Emergency Flight Hours - East Slopes Only										
Year	Aquatics	Assets	EI	Executive	Fire and Veg	Law Enforcement	Visitor Safety	Wildlife-Bison	Wildlife-Other	Annual Total
2014	0	0	0	0	86	0	23	0	0	109
2015	0	0	0	0	183.9	0	15.7	0	0	199.6
2016	0	0	0	0	20.5	0	72.7	0	0	93.2
2017	12.6	33.3	1.2	1.7	3.8	2.6	3	84.8	18.7	161.7
Totals	0	0	0	0	410.9	0	177.2	0	0	588.1

The highest non-emergency helicopter usage was by Assets, followed by the Bison Reintroduction Project and Aquatics (Figure 2). The 2013 June flood event resulted in substantial infrastructure damage to trails and bridges, which is evident in the trend in highest flight time usage by Assets in the following years as material and crews were mobilized to repair damage. The Bison Reintroduction Project had the highest use in 2017, the reintroduction year, with helicopter use expected to decline following their release from the fenced area. During the period of 2014-2017, Aquatics used helicopters to collect "pre-bison" aquatic data for the Bison Reintroduction project (so perhaps these should have been attributed to bison), paleo eDNA sampling for the West Slope Cutthroat Trout Recovery project, fish occupancy studies, whirling disease sampling, and the Upper Cascades Fisheries Restoration project. Helicopter support was necessary for water sampling protocols for timely delivery of water samples to the lab.

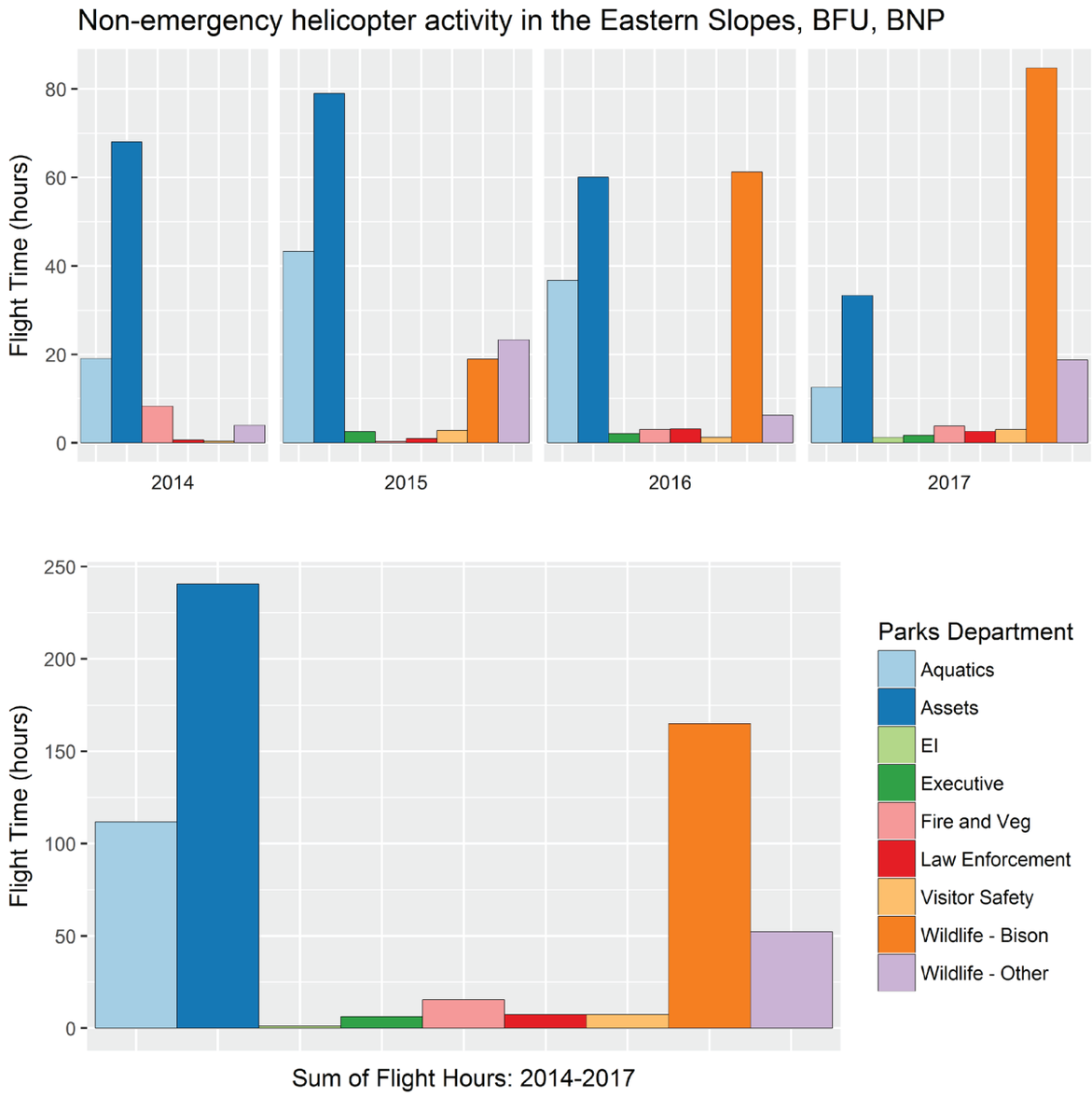


Figure 2. Helicopter flight time for the Eastern Slopes Region, Banff Field Unit by Department. Data shown is for non-emergency flights only (top: per year, bottom: 2014-2018 totals). For annual totals, missing departments indicates zero use for that year.

Discussion

This dataset provides useful insights into helicopter usage in the Eastern Slopes region of Banff National Park. Flight time accounting has improved with the implementation of the Banff Flights Management database, and additional procedural changes will further enhance data quality. Further attention to flight time accounting in individual LMU's, and division of flight time into non-emergency versus emergency use will also improve data quality.

This dataset presented primarily non-emergency helicopter usage summaries. It should be noted that some non-emergency flights are very non-discretionary – such as the Visitor Safety department servicing and maintaining remote avalanche control equipment. The installation or maintenance of remote avalanche control equipment is offset by a reduction of overall helicopter use by decreasing helicopter bombing for avalanche control. Similarly, helicopter usage by Assets often supports a decrease in usage by other functions, as flight time used to maintain and supply the Backcountry Patrol Cabins enables other functions to complete their work on foot and by horse. As such, some non-emergency helicopter use has the overall impact of reducing helicopter use across all departments.

Section 5.5.1.15 of the 2010 Banff Park Management Plan specifically directed reduction of helicopter usage in the Eastern Slopes Region for purposes of reducing National Park greenhouse gas emissions. Overall, helicopter use has been relatively steady in this zone, in part, due to the requirements of the Bison Reintroduction Project, which was also directed within the 2010 Banff Park Management Plan. When flight time from the Bison Reintroduction Project is excluded, there has been a decline during the years 2014-2017 in non-emergency flight time in the Eastern Slopes from a peak of 152 hours in 2015 to a minimum of 77 hours in 2017. However this peak early in the study period may have resulted primarily from 2013 flood remediation, so may not reflect declining use over time.

Section 5.2.1.7 of the 2010 Banff Park Management Plan directed the development of flight corridors to reduce disruption to wildlife and humans using wilderness valleys. At present, helicopter best practices have been developed for the Bison Reintroduction Project, highlighting specific areas to avoid during overflights, emphasizing travel over the middle of valleys and outlining minimum flight distances as 2000 feet above ground level. Expansion of these best practices to the entirety of Banff National Park could be considered, similar to the voluntary flight guidelines established by Jasper National Park (*https://www.pc.gc.ca/en/pn-np/ab/jasper/info/plan/survols-flight*, 2017).

Overall, the Banff Field Unit has successfully reduced non-emergency helicopter use during the years of 2014-2017 considered in these analyses. Opportunities to further reduce use on a per department basis should be considered, balancing helicopter usage with effectively completing program objectives.

Acknowledgements/Partners

Jane Park and Tao Gui developed the Banff Flights Management database. Rose Marino provided access to flight tickets from contracted helicopter companies. Resource Conservation summer students completed the data entry. Ali Buckingham and Natalie Cowell provided GIS support and Geoffrey Prophet provided data entry oversight and quality control. Quality control, analyses and writing was completed by Jaime Hood.

Contact

Derek Petersen, Monitoring Ecologist
Lake Louise, Yoho & Kootenay and Banff Field Units.
P: 250-347-6171
E: *derek.petersen@pc.gc.ca*

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Human-Caused Wildlife Mortality

Introduction

Many factors contribute to wildlife mortalities in Banff National Park. Some mortalities occur as part of natural ecological processes, while others are unnatural and often additive and can have detrimental effects on ecological integrity. Human-caused mortalities have historically and continue to have negative effects on the health of wildlife populations. Fortunately, human-caused mortalities can often by reduced by pro-active management actions. Monitoring human-caused wildlife mortalities is key to understanding an important stress to wildlife populations in Banff National Park and to monitor the effectiveness of management actions designed to reduce wildlife mortality (Figure 1).



Figure 1. A red fox that gained access to the TransCanada Highway by walking through the graduated fence mesh during winter was struck and killed by traffic.

Objectives

To monitor trends in human-caused wildlife mortality, and to identify and evaluate the effectiveness of management actions in reducing wildlife mortality.

Methods

We obtained records of human-caused wildlife mortalities from 1984 – 2017 from the Parks Canada mortality database. These records contain wildlife mortality and collision reports from

train operators on the Canadian Pacific Railway and from public and staff on the TransCanada Highway and other roads. Most mortalities are reported to Banff Emergency Dispatch. Each report is investigated by a Resource Management Officer. If a carcass is found, the report is classified as a "Mortality." If no carcass is found and the health status of the animal is unknown, the report is classified as a "Strike". Strikes could result in life threatening injuries, minor injuries, or the animal could be unscathed. "Destruction" is an additional class of human-caused mortality whereby an animal was euthanized because it was sick or mortally injured, or was destroyed for management purposes. All new mortality, strike and destruction data from 2017 was reviewed for location accuracy by cross-referencing the database notes of the incident.

Results

In 2017, at least 48 large mammals (coyote and larger) died from human causes including collisions with vehicles (23), trains (22), or were euthanized/destroyed (3) (Figure 2). There were 3 additional reports where a vehicle or train strike occurred with a large mammal, but the investigations found no wildlife remains, and mortality was not confirmed (Figure 3). Deer, elk and black bears had the highest number of mortalities, respectively.

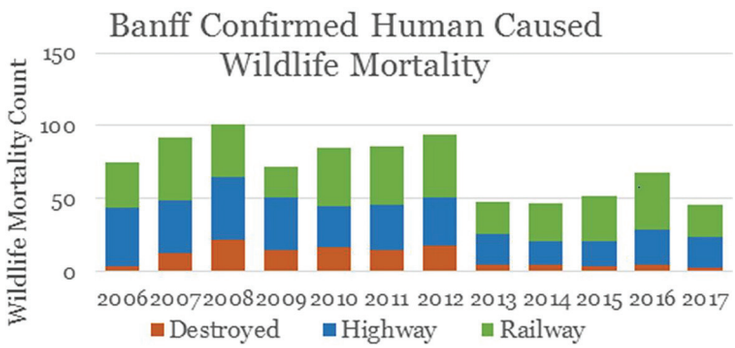


Figure 2. Confirmed annual human-caused wildlife mortality of large mammals in Banff National Park from 2006 to 2017.

Wildlife mortalities on the TransCanada Highway (TCH) were low in 2017 compared to the 1990's and were comparable to recent years. Carnivores, including wolves, black bears and coyotes comprise the majority of mortalities. Overall, yearly TCH mortality counts have decreased dramatically since the TCH fence installation begin in 1980 and the trend has continued (Fig. 4), despite increasing traffic volumes (Fig. 6).

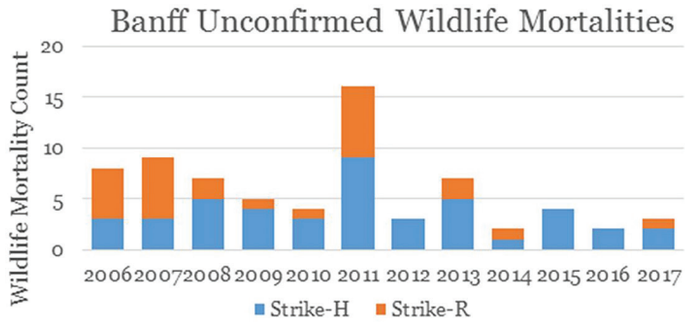


Figure 3. Annual strike data for collisions between wildlife and vehicles (Strike-H) and trains (Strike-R). These data reflect instances where there was evidence of a collision, but no carcass was found, so mortality was suspected but not confirmed.

In contrast, mortality risks on the railway has not been mitigated, other than through efforts to reduce grain spillage and address spill clean-up. As with pre-fence mitigation TCH data, current CPR mortalities comprise mostly of ungulates. During 2017, there were similar numbers of wildlife mortalities caused by trains compared to the previous years (Fig. 5); the reduction in overall elk numbers in the late 1990's and early 2000's is evident in these mortality data. Increased railway mortalities since 2010 could be influenced by changes in railway traffic, adjacent foods, and broader habitat quality.

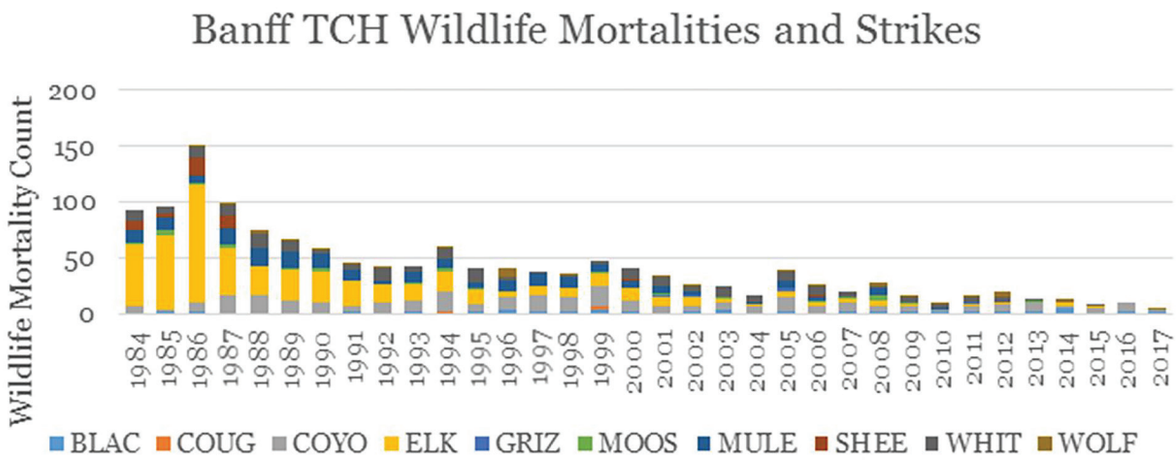


Figure 4. Combined strike and mortality data for wildlife on the TransCanada Highway. These data include mortality and strikes. BLAC = black bear, COUG = cougar, COYO = coyote, GRIZ = grizzly bear, MOOSE = moose, MULE = mule deer, SHEE = bighorn sheep, WHIT = white-tailed deer.

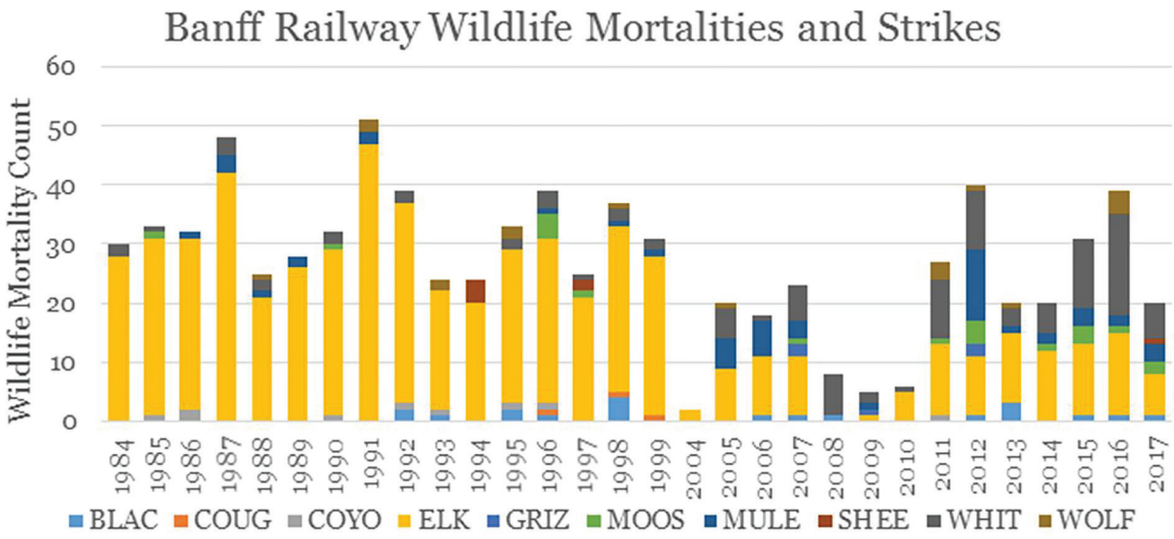


Figure 5. Combined annual strike and mortality data for wildlife on the railway. These data include mortality and strikes. Note – data is not available for 2000 – 2003.

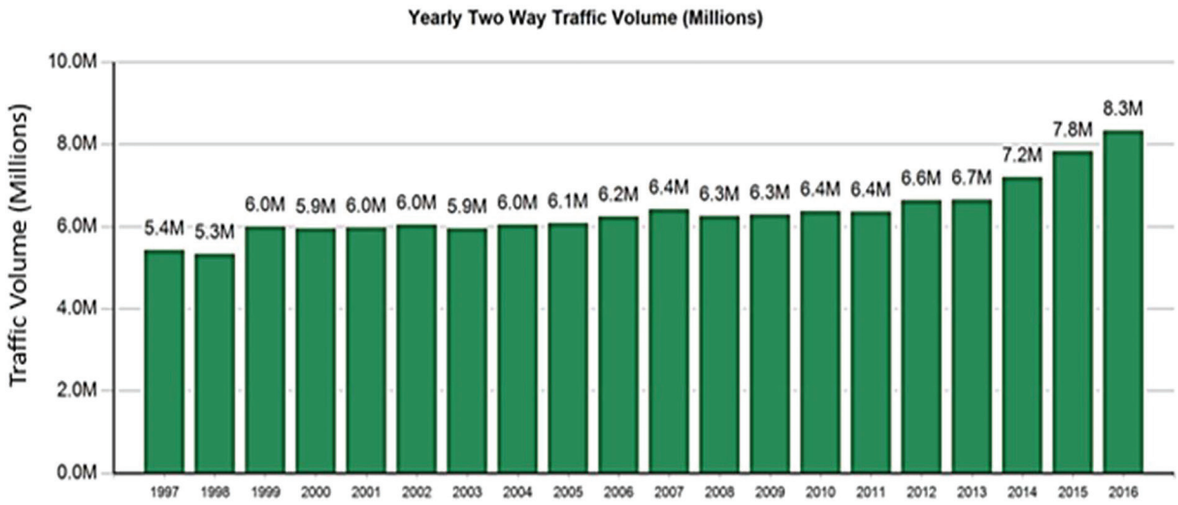


Figure 6. Yearly totals of motor vehicle traffic at the East Gate of Banff National Park

Discussion

The number of human-caused wildlife mortalities recorded in Banff was similar to recent years, and among the lowest since 2006 (Figure 2).

Mortality numbers throughout the park were likely influenced by changes in wildlife population abundance, variation in weather, and other unpredictable or uncontrollable factors, but highway and rail collisions were still main contributors to human-caused wildlife mortality. Human-caused wildlife mortality is an unnatural source of mortality that we can mitigate and

manage for. Highway-caused wildlife mortalities also present an often signficant risk to public safety.



Figure 7. a) The new TCH fence (top) complete with buried mesh apron and concrete gate bases (to prevent digging), spacing gradient from narrow at the bottom to larger at the top, and high tensile top wire to reduce impacts from falling trees. b Section of the TCH fence in disrepair (bottom).

Highway fencing in Banff National Park has reduced wildlife-vehicle collisions by more than 80% and, for elk and deer alone by more than 96%; representing one of the most important conservation actions for wildlife populations and a significant improvement to public safety. At present, wildlife mortalities still occur when wildlife find gaps in damaged portions of the fence (Fig. 7b) or some carnivores climb over the wood poles, dig under the mesh bottom and some of the smaller carnivores are able to walk through the fence mesh (Fig. 1). To reduce these types of fence breeches, the fence is being replaced and upgraded. To prevent wildlife such as wolves, coyotes and bears from digging under the fence, an apron is installed at the base of the fence and cement barriers are poured under gates (Fig. 7a). To prevent smaller mammals from walking through the fence, the installed mesh has a size gradient whereby the spacing narrows from top to bottom, making the bottom of the fence less permeable to small mammals. Additionally a high tensile top-wire now protects the mesh from falling trees. These upgrades aim to reduce wildlife breaching the bottom of the fence, a fairly common occurance which the earliest sections of fence were not built to address. An additional change being made is the allignment of the fence. The new fence is being built closer to the road to exclude habitat from the highway side of the fence. This will reduce attractiveness and the amount of cover widlife can utilze to hide if the fence is breeched, enabiling Resource Management Officers to more efficiently find the intruding wildlife and haze them to the “wild side” of the fence.

The TCH fence is an essential mitigation to improve safety for motorists and to reduce wildlife mortality. Prior to 1980, as many as 150 elk were killed each year on the TCH, almost 30% higher than the highest yearly total mortality of the past decade (2008 - combined all species and locations). Despite these successes, black bear can readily climb the fence and other wildlife including bears and wolves access the highway enclosure by crossing the texas gates. Recent experiments with “electro-mats” were initially promising, as the test structures performed well in repelling wildlife, but an in-situ pilot project on the TCH demonstrated the structures lacked the durability for a real-world application. We will continue to test new improvements and apply them through a process of adaptive management.

Athough the TCH fence has reduced human-caused wildlife mortality, both collisions with vehicles and trains are still a challenge for wildlife. Many unmitigated secondary roads run through wildlife corridors in Banff National Park, where no fencing separates the wildlife from the road. In these situations, it is crucial that motorists comply with speed limits, as increased speeds reduce the reaction time for both motorists and wildlife during a wildlife crossing. Parks Canada has recently increased signage and enforcement on these secondary roads to reduce incidents of speeding. Similarly, fencing along the railroad is challenging because no robust solution exists to prevent wildlife from entering at the fence ends (see Grizzly bear railway fence and electrified mat testing and off-track mitigations). However, wildlife use the railway for a number of reasons including easy travel combined with the food rewards from grain spills and adjacent vegetation. Enhancing historic wildlife travel routes through brushing and clearing, improving broader scale habitat quality, and reducing the attractiveness of the railway (i.e. reduce grain spills) could reduce wildlife use of the railway. As traffic continues to increase, mitigation efforts may need to be enhanced or expanded to reduce the human-caused wildlife mortality and the negative ecological conseques that result.

Mortality data provides useful information for planning, implementing, and evaluating mitigative actions aimed at maintainging ecological integrity. Parks Canada will continue to work closely with Canadian Pacific Railway and research organizations to reduce mortality risk along the railway, as it remains one of the most significant anthropogenic sources of wildlife mortality in the park. Continued efforts to reduce human-caused wildlife mortality overall will be important for conserving wildlife populations and natural ecological processes.

Acknowledgements/Partners

Prepared by Mike Grande, Emma Carroll, and Jon Stuart-Smith. Parks Canada staff from numerous functions including Resource Conservation, Visitor Experience, External Relations, Law Enforcement, and Highways worked to respond to and prevent wildlife mortalities.

Contact

Seth Cherry, Wildlife Ecologist
Lake Louise, Yoho and Kootenay Field Unit
P: (250) 347-6158
E: *seth.cherry@pc.gc.ca*

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403) 763-8865
E: *jesse.whittington@pc.gc.ca*

Hydro Power Mitigation Monitoring

Introduction

Within Banff National Park, 41.5 % of the Bow River watershed is regulated, obstructed or impounded (Schindler 2000).

The Spray River has been impounded since 1951 when Calgary Power Ltd. (now TransAlta) constructed the Spray Lakes power generation system. Stream flows from the upper Spray River watershed are diverted directly to Canmore, through the Spray Lakes Reservoir and canal system, resulting in reduced stream flows in the Bow River and the lower Spray River in Banff National Park compared to historic levels, with little seasonal variation in the latter.



Figure 1. Cascade River channel downstream of CP Rail 1904



Figure 2. Cascade River channel downstream of CP Rail 2017

The current Minnewanka Dam was constructed in 1941, forming the Lake Minnewanka reservoir and functionally retaining and diverting the Cascade River through the Two Jack Canal system to the TransAlta Cascade Hydro Power Plant at the TransCanada Highway just east of the town of Banff. Although previous smaller dams had already created a reservoir, the 1941 dam caused the largest change to lake levels (25 m rise) in addition to a winter drawdown whereby lake water levels are reduced seasonally. The dam reduced flows to the Cascade River (this impacted section is now referred to as Cascade Creek) by more than 99% (McCleary 1996) – see Figures 1 and 2. Cascade Creek now functions as the reservoirs' spillway for emergency flood situations, but only a small flow is maintained

by way of a riparian pipe through the dam (Godman 1999). These flows are a fraction of historic levels with little seasonal variation and flows are insufficient to even maintain water along the entire length of channel (Fig 2 – dewatered section).

The Banff National Park Management Plan (2010) identifies "Restoring the connectivity, function and natural biota of streams and lakes" as a key management priority for Parks Canada. TransAlta operates their hydropower infrastructure according to specific conditions established in their operating licenses designed to help mitigate the effects of hydropower production on the timing and magnitude of water flows and levels, and subsequent effects on aquatic resources in Banff National Park. In recent years, Trans Alta has been an active partner in supporting Parks Canada's restoration efforts on the Cascade Creek in Banff National Park.

Objectives

The objective in summarizing these monitoring data is to confirm that the specific conditions set out in TransAlta's licenses for storage and water power development on the Spray and Cascade Rivers, with respect to water flows and levels in Banff National Park, are being met:

- **Spray River:** TransAlta "will not by works outside the boundaries of Banff National Park reduce the flow of water in the Spray River at its junction with the Bow River in Banff National Park to an amount less than 5.66 m^3/s (200 f^3/s) during each of the months of June, July and August."
- **Lake Minnewanka reservoir:** "The maximum full supply level of Lake Minnewanka shall not exceed 1,475 m (4,840 elevation feet) above mean sea level (Geodetic datum) and no water shall be drawn from the lake below 1,465 m (4,805 elevation feet) above Geodetic datum except under emergency conditions and with the written authority of the Minister. In such circumstances the absolute minimum draw-down level shall be 1,463 m (4,801 elevation feet) above Geodetic datum."
- **Cascade Creek**: TransAlta "shall arrange for a flow of water to be released from storage into the Cascade River channel to meet the needs of all interests at all times as determined by the Minister, and which, for the period April 1st to September 30th of each year, shall be a minimum continuous flow sufficient to meet Park needs as decided by the Minister."

Methods

The Water Survey of Canada, in partnership with the provinces, territories and other agencies, operates over 2,800 active hydrometric gauges across the country. Historical and near real-time data from historic and current hydrometric gauges is made publicly available by the Water Survey of Canada. We use water level and discharge data from the following active hydrometric

stations to monitor for potential ecological impacts by tracking TransAlta's compliance with their license operating conditions:

- Station 05BC001: Spray River at Banff (1910 to 2016)
- Station 05BD003: Lake Minnewanka near Banff (1916 to 2016)

Results

Spray River: Table 1 and Figure 3 demonstrate that minimum discharge requirements set out for the months of June, July and August in TransAlta's operating license have seldom been met from 2006 to 2016, particularly during July and August.

Table 1. Spray River Daily Discharge at Banff (Water Survey Canada) Relative to Required Minimum Flow for June, July and August (5.66 m^3/s)

Month	Minimum Flow Requirement (5.66 m3/s) Met for Period?										
	2006	2007	2008	2009	2010	2011*	2012	2013	2014	2015	2016
June	X	√	√	X	X	√	X	X	√	X	X
July	X	X	X	X	X	√	X	X	X	X	X
August	X	X	X	X	X	√	X	X	X	X	X

* In 2011, an emergency shut-down of a turbine at the Canyon Dam hydro-electric plant made it necessary to release the excess build-up of water in the Spray Reservoir, through the Spray River and Goat Creek, in Banff National Park, from June through September.

√ = Yes, minimum flow requirements met for entire month

X = No, minimum flow requirements not met for part or all of the month

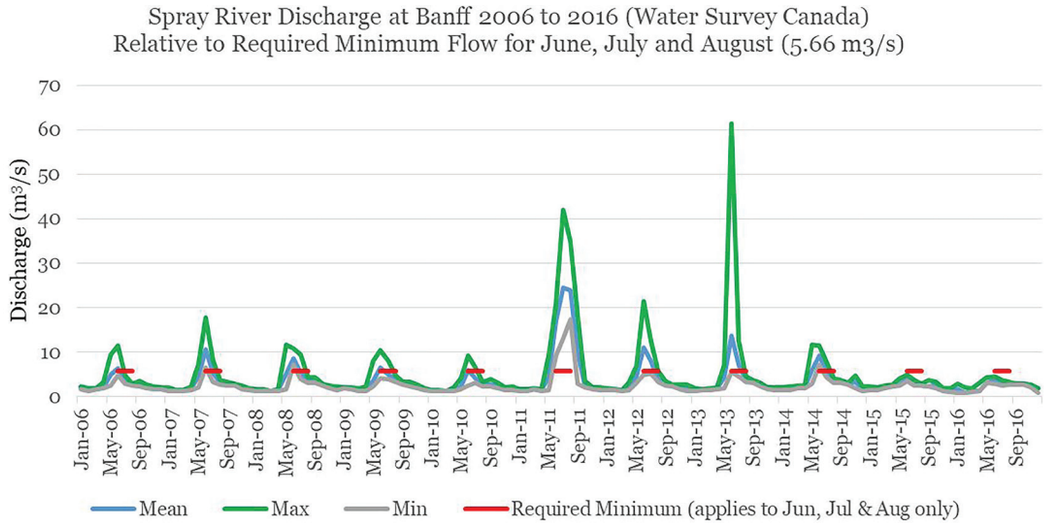


Figure 3. Spray River Daily Discharge at Banff (Water Survey Canada) Relative to Required Minimum Flow for June, July and August (5.66 m^3/s). Anytime the grey line falls below the red line (bar), minimum flow requirements identified in the license have not been met.

Lake Minnewanka reservoir: Figure 4 demonstrates that Trans Alta has successfully operated the Lake Minnewanka reservoir within the minimum and maximum lake levels prescribed in their Storage and Water Power Development License for the years 2006 to 2016.

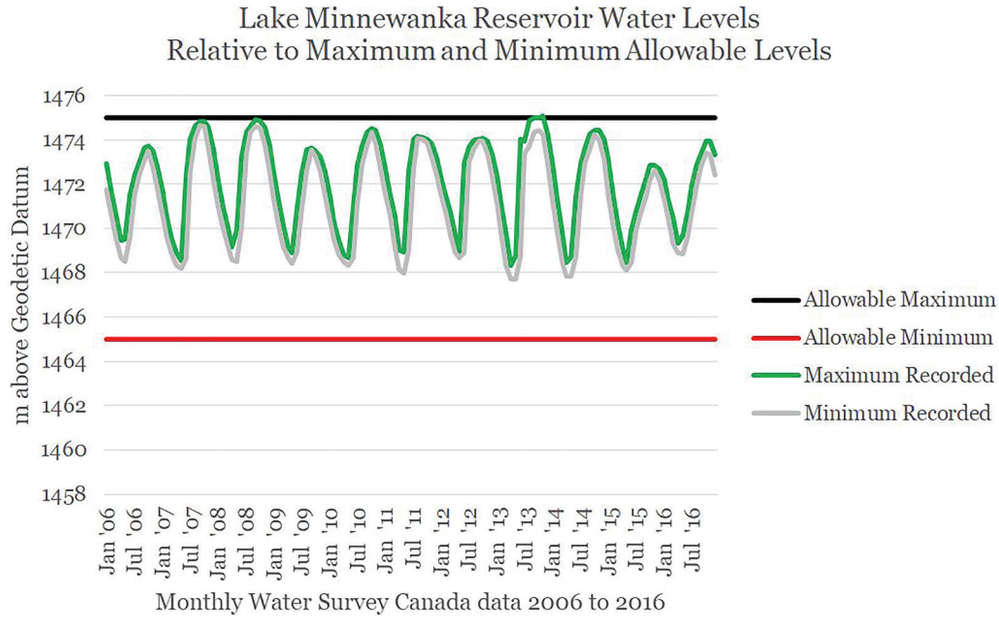


Figure 4. Lake Minnewanka water levels relative to maximum and minimum allowable levels. Between 2006 and 2016, approximately 3 m of water depth, in excess of the allowable minimum water level, has been maintained in the Minnewanka reservoir at all times.

Cascade Creek: Figure 5 illustrates the considerable changes to flows in Cascade Creek as a result of construction of the Minnewanka Dam and Two Jack diversionary canal.

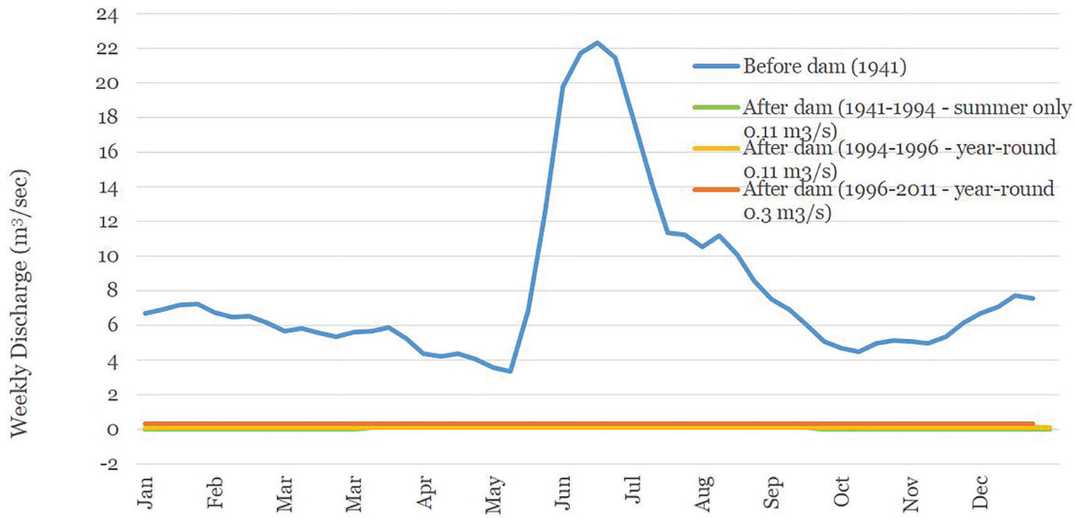


Figure 5. Cascade River – Annual Hydrograph. Discharge into the Cascade River, below the Minnewanka Dam is a mere fraction of the historical (1941) flows and lacks any seasonal variation that might emulate natural stream flow patterns.

The significantly reduced flows in Cascade Creek have been insufficient to support a healthy aquatic ecosystem (Dames and Moore 1992; McCleary 1996; Golder Associates 1996; Godman 1999), including the following changes to floodplain characteristics below the Minnewanka Dam (Figure 6; McCleary 1996):

- Reduced length of active channel (not enough flow to connect with the Bow River);
- Reduced floodplain area;
- Reduced channel area; and
- Reduced riparian zone.

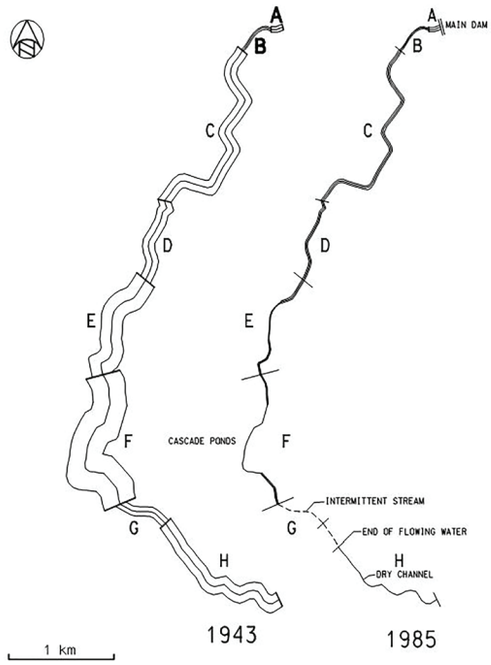


Figure 6. Changes in Cascade River floodplain following water diversion (From McCleary 1996).

Discussion

1 Spray River

Low stream flows have reduced and homogenized available fish habitat in the Spray River (Eaton 2004). In addition, the low number of pools, lack

of deep pools and lack of in-stream cover, limit habitat suitability for native fish species such as bull trout and westslope cutthroat trout (Eaton 2004).

TransAlta has not maintained the required minimum flows in the Spray River for the months of June, July and August between 2006 and 2016, (even during the 2013 flood) with the exception of 2011 when an emergency shut-down of a turbine at the Canyon Dam hydro-electric plant near Canmore forced excessive flows to be diverted through Banff National Park via both the Spray River and Goat Creek. Reduced flows in this system may have resulted because discharge targets were previously being met by diverting flows down Goat Creek (rather than the Spray River) which resulting in excessive discharge and erosion. A key challenge is that the Spray River riparian valve, located at the Canyon Dam on the Spray Reservoir in Alberta, is remote and labour intensive to operate.

Parks Canada will work with TransAlta and the province of Alberta to identify measures to reduce the impacts of hydro development on the aquatic resources of the Spray River, starting with TransAlta meeting the minimum summer flow requirements established in their operating license Memorandum of Agreement. We will also review potential effects of low winter flows in the Spray River.

2 Lake Minnewanka reservoir

TransAlta has operated within the maximum and minimum lake elevations, as per their license requirements for the Lake Minnewanka hydro development, from 2006 to 2016. This is a commendable accomplishment given the potential variations that must be anticipated and accommodated within and between years. Parks Canada will continue to monitor TransAlta's compliance with their licensed minimum and maximum allowable reservoir levels.

In addition to flows from the Cascade watershed, the Lake Minnewanka reservoir is supplied by TransAlta's diversion license from the Ghost River. The Ghost Diversion was built in the 1940s during the same period as the Lake Minnewanka Reservoir and Cascade Hydro Power Plant. The intent of the Diversion was to direct additional water into Lake Minnewanka to increase production at the Cascade Plant. The Diversion is located in Alberta's Ghost Waiparous Region, just outside the Banff National Park boundary. The June 2013 flood rendered the Ghost Diversion inoperable and it has yet to be re-built. Given the hydraulic considerations for the Lake Minnewanka reservoir and Cascade Creek, Parks Canada will continue to engage in the Alberta and DFO regulatory review of TransAlta's proposed Ghost Diversion re-build.

The Ghost drainage has since tested positive for Whirling Disease, which has not been documented in the upper Cascade River and Lake Minnewanka reservoir of Banff National Park, so resuming water diversion from the Ghost into Lake Minnewanka reservoir may have direct negative impacts on critical habitat for westslope cutthroat trout which occurs, in several lakes and streams in the upper Cascade River watershed.

3 Cascade Creek Restoration



Figure 7 One of seven fish habitat enhancement sites (V-weirs and excavated pools with boulders and large woody debris) constructed by TransAlta on the lower Cascade River (2012) that was later destroyed by the 2013 flood.

Parks Canada's mandate requires the restoration of a healthy aquatic ecosystem in Cascade Creek (i.e. one that is capable of supporting native fish species by providing appropriate year-round habitat and achieving connectivity between these habitats). With the cooperation and support of Fisheries and Oceans Canada, Canadian Pacific Railway, and TransAlta; Parks Canada is undertaking a major project to restore both habitat and native species composition in Cascade Creek below the Minnewanka dam. Key components of this work include removing non-native brook trout that were historically introduced by Parks Canada, and reclaiming sections of stream impacted by the surface mining of gravels by Parks Canada (Cascade Ponds and Cascade Pits) for road construction and maintenance. This also includes working with TransAlta to increase the volume and variability of riparian flows and developing a downscaled stream channel that maximizes aquatic ecosystem benefits while minimizing the need for additional stream flow.

4 Habitat Structures – The Cascade Tailrace

The Lower Cascade River channel, downstream of the confluence of Cascade Creek and the Cascade Hydro Power Plant tailrace, has been subject to several "stop flow" events during the lifetime of the plant due to overhauls of the two power generating units. These "stop flow" events have occurred under Fisheries and Oceans Canada Authorizations and each required that TransAlta undertake compensation works to offset negative impacts to fish and fish habitat. Compensation measures included construction of deep pools and fish habitat features made of large woody debris in the Lower Cascade River in order to provide holding habitat for fish during low flows. Unfortunately, these constructed habitat features were destroyed in the 2013 flood. Parks Canada is working with TransAlta and Fisheries and Oceans Canada, to determine appropriate replacement habitat features and is now focused on creating pool habitats that are adjacent to the main trail race flow so they may be more resilient to high flow levels.

5 Fish Screens – The Two Jack Canal and power plant intakes

The Cascade Power Plant receives water from the Lake Minnewanka reservoir via Two Jack Lake and the Two Jack canal. Water flows from the south end of the canal, down two buried penstocks, into the Power Plant and out the tailrace towards the Bow River. (TransAlta buried these penstocks and added a wildlife crossing structure to the canal in the late 1990's to support improved wildlife movements in the Cascade/Fairholme wildlife corridor). However there are currently no fish screens at the intake of the penstock, nor on the outflow of the Power Plant. As a result, fish periodically enter these sites, from upstream and downstream, and are killed (masticated) by the turbines. Following repeated incidents, several years ago, TransAlta conducted some test netting to try to determine how most fish were entering the Power Plant (from above or below) and conducted an initial investigation to assess mitigation options; including bubble curtains, electrical deterrents, and velocity barriers. This deficiency in the design of the power plant has not yet been successfully mitigated.

Acknowledgements/Partners

Fisheries and Ocean Canada has supported our monitoring and restoration of these systems by providing input, expertise and permitting. CP Rail has facilitated construction access to sites near their railway and upgraded railway culverts on this reach. TransAlta has been an engaged and supportive corporate partner throughout these many challenging projects and continues to work to ensure the safe and responsible operation of hydro facilities in Banff National Park.

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: 403-762-1418
E: *mark.taylor@pc.gc.ca*

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Lake Trout Population Estimate for Lake Minnewanka Reservoir

Introduction

Lake trout (*Salvelinus namaycush*) are native to waters in Banff National Park, including Lake Minnewanka reservoir. They are slow growing, late to mature and have low reproductive rates, which make them susceptible to overexploitation from angling. The Lake Minnewanka reservoir is the only waterbody in Banff National Park where commercial operators are permitted to guide anglers; thus greatly increasing angling success rates.

In 1991, in an effort to limit over-exploitation, Parks Canada implemented fishing regulation changes which reduced the possession limit from ten to two fish per angler per day.



Figure 1. SPIN sampling on Lake Minnewanka in August 2017.

In 2005, a Lake Minnewanka Fisheries Assessment Planning Workshop was held at Barrier Lake, Alberta. Participants included: Parks Canada, Alberta Environment, academics, fishing guides and numerous other stakeholders. The goal of the workshop was to discuss possible techniques for quantifying lake trout population information from Lake Minnewanka reservoir. An intensive monitoring program was proposed, and a key component of this program included test-netting.

Summer Profundal Index Netting (SPIN) is a rapid assessment method, specifically designed to estimate lake trout populations. Developed by the Government of Ontario, the method is well established, and easily adaptable to suit lakes of various size and depths. Parks Canada began implementing SPIN sampling on Lake Minnewanka reservoir in 2008 to assess the lake trout population (Figure 1).

Objectives

1 Estimate the biomass density of harvestable size (>300mm) lake trout in Lake Minnewanka reservoir.

Methods

SPIN sampling on Lake Minnewanka reservoir occurs over an eight year cycle. Three consecutive years of netting are followed by 5 consecutive years of no netting. Netting occurs over a five day period in August when surface water temperatures are at their peak.

We categorized Lake Minnewanka reservoir into seven depth strata spanning the full depth of the reservoir (0-101 m), and an area-weighted sampling approach was used to guide the SPIN sampling methodology. We further divided the reservoir into four equal sectors containing a total of 57 sites. Depth strata that comprise a larger proportion of the reservoir contain more sample sites.

Monofilament gillnets were 64m long x 1.8m tall with eight mesh panels ranging from 2.25" to 5". These were set along the bottom of the reservoir at each site for two hours.

We harvest all lake trout caught in the gillnets and record the fork-length, weight, sex, maturity and stomach contents; these data may be used to evaluate the population's biological integrity and to monitor long term changes.

We calculate a selectivity adjusted Catch-per-Unit-Effort (CUE) to adjust for the differences in gear vulnerability between various sizes of lake trout. We then use CUE to calculate lake trout biomass density.

Results

- Lake trout CUE has declined significantly from 3.01 in 2008 to 2.17 in 2017.
- Mean harvestable lake trout fork length has declined significantly from 478mm in 2008 to 430 mm in 2017.
- Lake trout biomass density has declined significantly from 13.6kg/ha in 2008 to 6.7 kg/ha in 2017. (Figure 2).

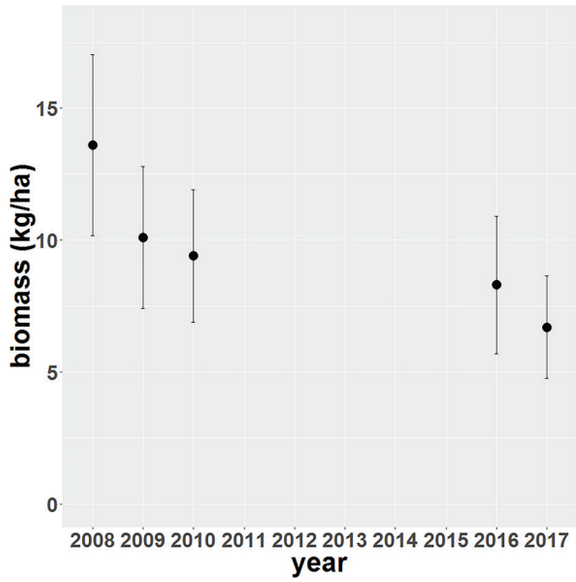


Figure 2. Decreasing trend in Lake Minnewanka lake trout biomass density (kg/ha).

Discussion

A possible reason for declining trends in lake trout size and number could be an artifact of the liberal fishing regulations prior to 1991. Unfortunately, fisheries data from Lake Minnewanka reservoir does not occur until 1984. Before 1991, the bag limit was ten lake trout per day, and this was when Lake Minnewanka reservoir experienced its maximum angling pressure. During the mid-1980's, the estimated annual angler effort was 50,369 hours. From 1991 to 2004 the estimated annual angler effort declined to 20,383 hours (Pacas and Hunt 2004). Although we

have reduced possession limits and the recreational angling pressure has declined over the past 25 years, the lake trout population may be experiencing lag effects of over-exploitation.

Another contributing factor may be the increase in guided anglers on Lake Minnewanka. From 1995 to 2000, the effort of guided anglers increased by 71% and the efficiency at which they were able to catch fish was more than double that of a recreational angler (0.59 fish/hour vs. 0.22 fish/hour, respectively) (Pacas and Hunt 2004). This efficiency and overall increase of guided anglers since the early 1990's may be overriding the intended consequences of the reduction in bag limits set in 1991.

Another possible impact may be the effects of catch and release fishing, especially if survival of released lake trout is poor. We consider the potential impacts of deep water fishing through the use of weighted down-rigger systems that are commonly used by the guides, especially later in the summer when lake trout move to deeper waters in search of cooler temperatures.

There are two potential mechanisms for increased mortality related to rapid surfacing from depth: barotrauma (damage to the swim bladder) and thermal stress. A sealed balloon brought up from a depth of 30m (100ft) will increase roughly 3 times in volume due to the decrease in pressure at the surface. Despite being pulled up from depths of up to 100 m, (≈ 300 ft) lake trout have a physostomous swim bladder that enables them to maintain neutral buoyancy throughout the water column.

While this reduces the likelihood of barotrauma related injuries, changes in water temperature from below the thermocline to the surface may result in increased catch and release mortality. Recently, Sitar et al. (2017) found that post-release mortality rates of lake trout at surface temperatures of 10°C or greater were 1.5 to 2.5 times higher than at times when surface temperatures were lower than 10°C. Furthermore, when surface temperatures exceeded 16°C, released lake trout exhibited mortality rates between 43% and 78%. As Lake Minnewanka reservoir has mid-summer temperatures at or exceeding 16°C (J. Murphy Pers. Comm., Rawson 1939), it is possible that a majority of fish released during the summer months may succumb to post-release mortality. Coupled with increased guiding success, this may have contributed to the overall lake trout decline in Lake Minnewanka reservoir, in spite of reduced possession limits. Further research is needed to quantify what affect post-release mortality has on the lake trout populations in Lake Minnewanka reservoir.

In 2004, Parks Canada biologists recommended changing the lake trout fishing regulations on Lake Minnewanka reservoir. Pacas and Hunt (2004) identified that lake trout harvest in 2000 was 2.4 times higher than sustainable levels (Healy 1978). They provided a number of recommendations to prevent further degradation of the fishery including: reducing the lake trout bag limit to one, reducing the total number of anglers permitted to fish on Lake Minnewanka reservoir, and/or adopt a catch and release only policy. However, due to insufficient information, managers were unable to justify changing the angling regulations at that time (Dormer and Paul 2005). Biologists were tasked with applying a more rigorous protocol to assess lake trout populations, and identified SPIN sampling as that methodology.

From 2008 - 2017, we collected five years of lake trout population data from Lake Minnewanka reservoir using the SPIN sampling method. An obvious downward trend in lake trout CUE, length, and biomass density has emerged; producing irrefutable information that the fishery is in decline. Based on these recent findings a restrictive change to the lake trout angling regulations is urgently needed to protect this native species and ensure future angling opportunities at Lake Minnewanka reservoir. Further, given the potential impacts of catch and release fishing when surface waters exceed 10°C, regulatory changes must address both allowable harvest and the impacts of catch and release mortality rates.

Amending the National Park Fishing Regulations is a very cumbersome process therefore we anticipate that a Restricted Activity Order, and/or changes to stipulations for licensed guides (updated annually) will be the only mechanisms available to make timely adjustments needed to protect lake trout in the Lake Minnewanka reservoir. We recommend these changes be implemented no later than the Banff National Park Management Plan renewal, scheduled for implementation in 2020.

We will conduct SPIN sampling again in 2018 to complete the most recent sampling cycle. During a new SPIN netting cycle in 2024-2026, we can evaluate the effectiveness of any regulation changes made in response to this most recent sampling cycle.

Acknowledgements/Partners

Steve Sandstrom-Ontario Ministry of Natural Resources and Forestry

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: 403-762-1418
E: *mark.taylor@pc.gc.ca*

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Non-Native Vegetation Monitoring and Management

Introduction

Non-native vegetation (ie. Invasive Alien Plants) is globally recognized as a serious threat to native ecological communities and bio-diversity. According to the International Union for the Conservation of Nature (IUCN), invasive species are the second most significant cause of global extinction following habitat loss (ICUN 2011). The Convention for Biological Diversity and associated Strategic Plan for Biodiversity 2011-2020 specifically address invasive species, envisioning a world where: "Invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment"(UNEP 2011).



Figure 1. Spotted knapweed (Centaurea maculosa) a priority 1 non-native vegetation species in the Banff Field Unit

Invasive plants reduce biodiversity and compromise ecosystem function by out-competing native species, altering nutrient cycling, destabilizing soils and causing erosion, among other impacts (Pimentel et al. 2005). Climate change may have synergistic effects on non-native vegetation, altering species distributions and local resilience to invasion (Zavalet and Royval 2002). Within the "Consolidated Guidelines for Ecological Integrity Monitoring in Canada's National Parks" (2011), non-native vegetation are identified as a stressor of alpine and forest ecosystems.

While most infestations in Banff National Park are associated with obvious anthropogenic disturbances, numerous vectors also exist with the ability to transport non-native vegetation within the field units, including (but not limited to) vehicles, trains, wind, water, recreationalists, horses, pets, wildlife, and maintenance and construction machinery. The potential ability of non-native vegetation to move across the landscape and invade native, undisturbed habitats is

an ongoing management concern. Active management (control) is used to contain (infestation not increasing in size/density), reduce (infestation decreasing in size/density), and eradicate (infestation is eliminated) non-native vegetation infestations. Banff National Park is broken into two distinct field units (Banff Field Unit and Lake Louise, Yoho, and Kootenay Field Unit) which operate similar but separate non-native vegetation programs.

Furthermore, monitoring the condition of this stressor (Alpine and Forest Ecosystems) will help Park Managers understand the state of non-native vegetation in the Parks and whether prevention, containment and control measures are being effective on a landscape scale over time (Parks Canada 2010, Parks Canada 2015).

Objectives

Non-native vegetation Prevention

1. Educate public and staff about non-native vegetation to reduce spread through human vectors, and improve skills for identification and reporting.
2. Ensure construction projects follow detailed best management practices to reduce the chance of non-native vegetation seed transmission.
3. Restore newly disturbed sites using early successional native species.

Non-native vegetation Monitoring

1. Complete Invasive Alien Plant Condition Class Monitoring for Alpine and Forested Ecosystems and report through the Information Center on Ecosystems.
2. Implement management effectiveness monitoring on project sites to determine effectiveness of treatments.
3. Conduct surveys in sensitive areas with high susceptibility to non-native vegetation invasions and complete official trail network bi-annually.

Non-native vegetation Control

1. Prioritize infestation control based on level of "invasiveness" of the species and the sensitivity of the environment they are found (priority ranking and ecological management zone classification).
2. Implement the most effective and efficient means of non-native vegetation control (mechanical, biological, chemical and cultural methods).
3. Conduct infestation mapping during control efforts to accurately track areas of infestation.
4. Use spray contractors on larger infestation sites in Integrated Control Zones

Methods

Prevention

Focus has been placed on ensuring projects occurring in the field unit include non-native vegetation mitigations (transmission prevention and/or pre/post disturbance control). Soil movement within the field units and soil import have also been addressed through a more rigorous screening process which employs chemical, nutrient and weed seed analyses. Best management practices have also been developed to prevent the transmission and establishment of invasive species as well as ensuring re-vegetation of disturbed sites.

We regularly involve the public through various volunteer opportunities (weed pulling) throughout the growing season and provide staff with a variety of non-native vegetation species identification tools so they can report non-native vegetation outbreaks. Additional programs to engage public and staff will continue to be explored.



Figure 2. Ecological Management Zones of Banff National Park

Monitoring

The first set of data for formal Condition Monitoring of the Alpine and Forest Ecosystems was completed in 2016-2017. This long term monitoring will occur every 5 years and is reported as an ecological integrity Condition Measure elsewhere in this document. These forest plots will be visited again in 2021 and the Alpine in 2022.

In Banff Field Unit, we implemented Management Effectiveness Monitoring protocols at Moose Meadows prescribed burn (focal species: Canada thistle), Stoney Warden cabin (focal species: buttercup), Windy Cabin (focal species: Yellow Toadflax) and at the Castle Warden Cabin site (Restoration: %vegetation cover and dominant species). As all control actions are recorded in a geo spatial database; monitoring of infestation size and density can be accomplished on a site-by-site or broader (drainage, road, filed unit etc.) resolution.

In the Lake Louise, Yoho and Kootenay Field Unit, a broader scale Management Effectiveness Monitoring protocol is completed and reported on separately.

In Banff Field Unit, we conduct trail surveys on half the field unit annually; alternating North and South of the Trans-Canada Highway. We visited certain active and historic grazing areas in 2017 and will continue to monitor these during future trail surveys to ensure non-native vegetation are absent.

Control

Banff National Park uses an integrated approach to non-native vegetation control to ensure efforts are efficient and effective. Currently cultural (re-vegetation), mechanical (cutting and pulling), and chemical (herbicide) control are being employed, however we are evaluating the potential use of biological control (use of a natural predator).

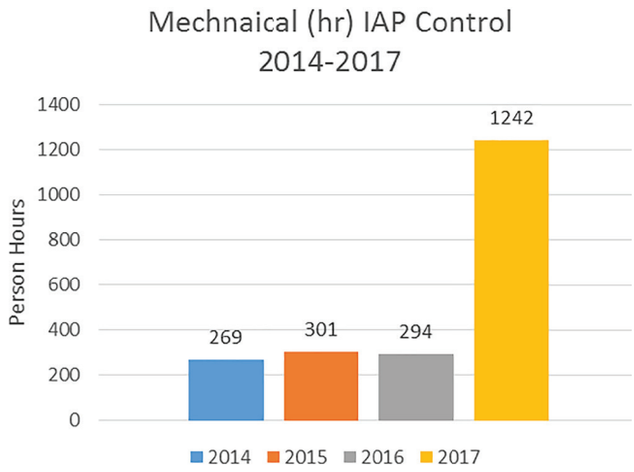


Figure 3. Mechanical (person hours) control efforts over the last 4 years in Banff National Park.

Generally in Banff Field Unit infestations are prioritized based on their level of invasiveness (Priority) from priority 1 (very invasive) to priority 3 (ubiquitous and/or less invasive) as well as the sensitivity of the local environment they are found.

The Lake Louise, Yoho, and Kootenay Field Unit uses a similar prioritization but group's species into 5 categories. Early detection and rapid response species occurrences are the highest priorities in any zone, followed by category 1 as very high, category 2 as high, category 3 as moderate and category 4 as low (Parks Canada, 2017). Early detection rapid response is critical for controlling new infestations before they become widespread and surpass manageable levels.

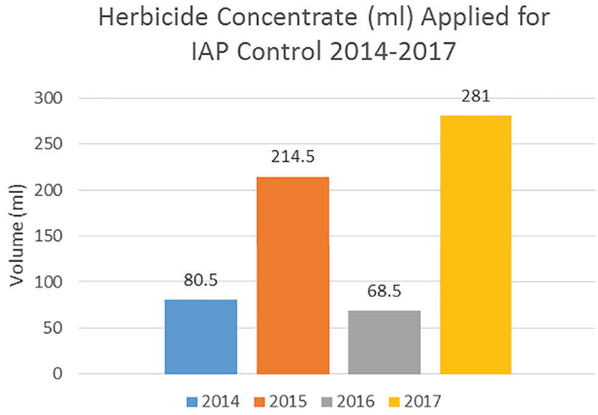


Figure 4. Chemical (volume of concentrated herbicide) control efforts over the last 4 year in Banff National Park.

The field units are broken into three Ecological Management Zones (see figure 2). Generally, the Ecological Preservation Zone (backcountry) is the most remote and sensitive (no trails), the Enhanced Control Zone (midcountry) includes trails and backcountry facilities and the Integrated Control Zone (frontcountry) includes front-country high-use areas (highways, roads, town sites, day-use areas, etc.). Infestations found in the midcountry zone are more of a priority than the frontcountry zone because they are a greater threat to ecological integrity, however all high priority species are controlled. Control methods are chosen based on focal specie(s), phenology and sensitivity of the local environment. We use a control guide based on the Alberta Invasive Species Council fact sheets to ensure consistent (and current) control actions are employed. We record details of each control action (mechanical, chemical, etc.) in geospatial databases for later analysis and progress tracking. This is accomplished in the field using hand-held devices that accurately mark non-native vegetation extent as well as pre-determined site specific details.

A variety of spray contracts have been employed by the Banff National Park in the last 10 years. Typically they address sections of the TransCanada Highway right-of-way to allow internal resources to be deployed to more sensitive areas. The TransCanada Highway is also mowed regularly by Highway Engineering Services for aesthetics and sightlines but also helps mechanical control non-native vegetation found in this right-of-way.

Results

Monitoring

Ecological Condition Monitoring for non-native vegetation that is representative of overall forest and alpine ecosystems are reported separately as Condition Measures.

Control

Data collection during active management of non-native vegetation has been improved in recent years however, the types of data previously collected do not allow us to trend the majority of parameters. In 2017, Banff Field Unit databases were converted to a single spatial database that allows better tracking, monitoring and will help guide management decisions. In 2015 a similar exercise was completed in Lake Louise, Yoho, and Kootenay Field Unit.

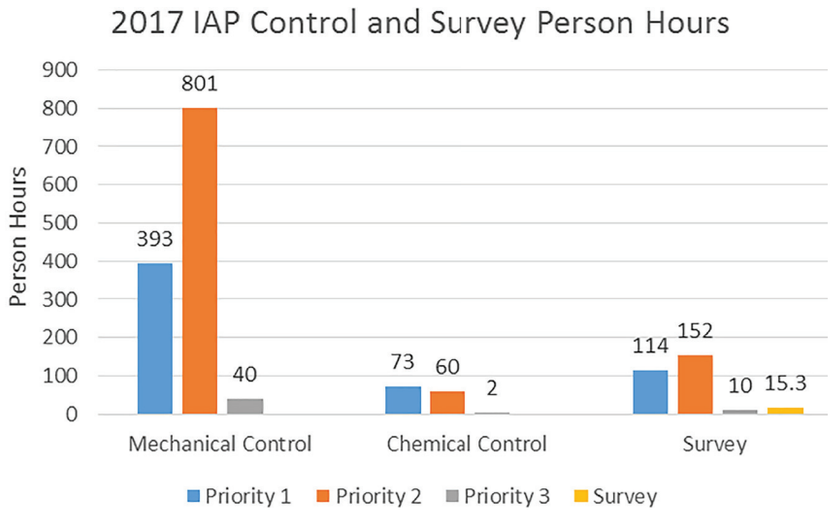


Figure 5. Non-native vegetation control and survey person hours by control method and non-native vegetation priority

Figures 3 and 4 show the historic known data for mechanical and chemical control efforts (non-native vegetation control was occurring in Banff National Park prior to 2014).

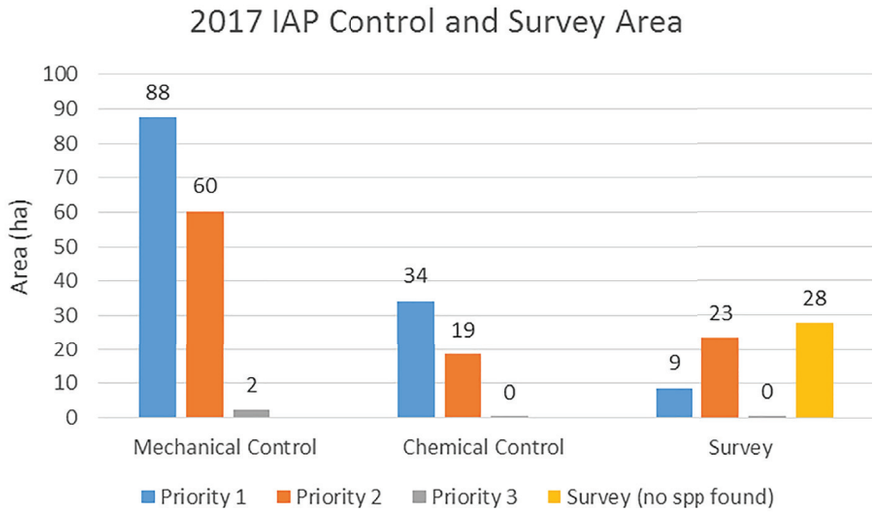


Figure 6. Non-native vegetation control and survey area (ha) by control method and non-native vegetation priority

In 2017 a total of 1,660 person hours were recorded for non-native vegetation management in Banff National Park (mechanical control, chemical control and surveying: Figure 5). Overall, the most control time was spent on priority 2 species; however more area of priority 1 species was controlled in 2017 (Figure 6). Time spent is not a meaningful measure, as it is the amount of work achieved and the effectiveness of that work that matters, so we will be working to improve our reporting measures.

Note that infested areas are controlled multiple times per year therefore the control areas reported here are not the area of infestation.

Discussion

Non-native vegetation continues to be a significant threat to native biodiversity in Banff National Park. Increased effort and effectiveness of active management methods are required to ensure the current infestations are contained, reduced or eradicated.

Improved data collection processes began in 2015 with the development of spatial databases and field data collection devices for Banff National Park. We now quantify non-native vegetation extent as polygons in the database; which allows for better resolution when determining the effectiveness of control actions to inform future management actions as the dataset grows.

In the Banff Field Unit (2017), on average, we controlled priority 1 species 1.37 times, priority 2 species 1.03 times, and priority 3 species once. In 2018 we will amend existing guiding documents to allow for better application of zoning and prioritization with the goal of more effective control strategies. As depicted in figures 3 and 4, 2017 had a distinct increase in control efforts due to the increased number of resources dedicated to control and increase tracking of control activities. The amount of non-native vegetation control we can complete is directly correlated to the resources dedicated to the program (e.g. summer staff). Over time, the resources allocated to the program has increased dramatically but continues to fluctuate due to project-based funding. Stable funding to maintain recent resourcing levels would help achieve program goals through better proactive planning. Specific control objectives need to be established in order to be able to accurately gauge the success of each field season.

Banff National Park is intersected by a variety of linear disturbances (rail, roads and utilities), human-use areas (towns, commercial operations) and trail networks which all pose a large risk for vector transmission of non-native vegetation into more sensitive areas. Vector transmission is occurring in the field unit as non-native vegetation of various priorities are noted in front and backcountry locations. There is an opportunity to reduce this vector transmission by putting more effective and consistent control methods to use in the Integrated Control Zone, especially along linear disturbances. In these areas chemical control is more efficient and effective than mechanical control.

Mechanical control will continue to be used in sensitive environments as it is the best strategy for low impact control. It should be noted mechanical control is time-intensive and requires multiple passes of a site to ensure effective control has been completed. We will continue to use new research and technology to control non-native vegetation in the most appropriate, efficient and effective ways possible.

Key Issues and Opportunities

1 Non-native vegetation in the Ecological Protection Zone/Enhanced Control Zone

   a Ensuring consistent non-native vegetation control and surveying in these zones is much more difficult as they are typically foot-access only. Due to the time required for access and the relatively short growing season it is challenging to visit these sites multiples times in a season.

   b We recommend that program resources (described below) are allocated consistently to mitigate further infestation growth and establishment in the backcountry zone and midcountry zone.

   c We also recommend that all historic grazing areas and camps are surveyed to ensure non-native vegetation is not establishing.

2 Non-native vegetation in Integrated Control Zone (linear disturbances, town sites, day-use areas)

   a The frontcountry zone continues to need the majority of program resources and is currently in FAIR condition, no trend is available at this time because there is only one year of data. Vector transmission is occurring from this zone into more sensitive zones (based on non-native vegetation found throughout the front and back country).

   b We recommend that consistent biannual herbicide application is completed on the Trans-Canada highway and other highly infested areas within the frontcountry zone (ditches, pits, parking lots, etc.).

   c Risk associated with herbicide use in these areas is lower as they are ecologically less sensitive (and disturbed) and are not used by humans or (typically) wildlife. Using herbicides that have short residual times (as those that are currently used in Banff National Park) and using buffers around all riparian areas will further mitigate the risk.

   d Roadside parking is a significant potential vector for the distribution of non-native vegetation. Recent efforts to prevent or reduce spill-over (offroad) parking at day use areas, for reasons of safety, to reduce wildlife impacts, and for human-use management, will also benefit efforts to reduce non-native vegetation and reduce the need for herbicide application.

3 Non-native vegetation on leaseholds

   a There are a variety of leaseholds on Parks Canada jurisdiction that are operated by private companies. We recommend that the status of non-native vegetation be assessed and recorded as part of annual leasehold inspections, so we can monitor for changes and provide useful advice to leaseholders.

4 Partnering with neighbouring land managers

   a Currently Banff National Park is a member of the Calgary & Area Governmental Weed Committee (CAGWC) however exchange of information between neighbouring jurisdictions (Town of Banff, Canmore, Alberta and British Columbia) should be increased to ensure sharing of best practices and cooperative approaches.

5 Assessing biological control options

   a Yellow toadflax (*Linaria vulgaris)* is a widely distributed perennial non-native vegetation in Banff National Park and has not responded well to historic and current control methods (mechanical). It has been found in all three ecological management zones. This species is distributed in many areas where herbicide application is not recommended, since the herbicides that have been found to be effective generally have long residual times in soil and water.

   b We recommend that biological control agents be assessed for use in Banff National Park as a pilot project. While there is inherent risk with this approach, through rigorous Environmental Assessment and input from subject matter experts, biological control could be employed to control this focal species.

   c Biological control in the form of non-native weevils (insects) that prey on the focal plant species, has been successfully used across Western Canada, including releases in Waterton Lakes National Park, Kootenay National Park and Glacier National Park.

Contact

Brian Yakiwchuk, Resource Management Officer
Banff Field Unit
P: (403) 762-1495
E: *brian.yakiwchuk@pc.gc.ca*

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Site Reclamation – Banff National Park

Introduction

Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (Parks Canada, 2008). In a similar, but smaller context, reclamation (in the scope of this document) refers to the process of assisting in the recovery of disturbed sites that have been degraded damaged or destroyed. In reclamation is it not necessary to restore entire ecosystems (e.g. trophic interactions) but components of those ecosystems (e.g. soil that supports vegetation). In Banff National Park site reclamation typically refers to smaller scale project sites that are in close proximity to human-use areas whereas we use the term "restoration" in reference to larger scale with the goal of ecological restoration. This report focuses on reclamation efforts in Banff National Park.



Figure 1. Reclamation crew willow staking at the 40 Mile Landfill reclamation site.

Disturbed sites (areas with vegetation removal and/or soil disturbance) can be created by humans or by natural phenomena. Fire, floods and rockslides are examples of natural disturbances that are an integral part of functioning ecosystems. Humans also create disturbed sites by building infrastructure, modifying vegetation and using natural areas.

Disturbed sites are particularly susceptible to non-native vegetation establishment as well as wind and water erosion. This is due to bare soil being exposed; which is not a common state in nature. Weed seeds can travel far distances in the air or be transported on animals, people or equipment and easily establish on bare soils. Generally, invasive plants germinate and establish themselves more easily on disturbed sites than their native counterparts, as they are more adapted to this survival strategy. Once infestations are well established it can take decades, if not centuries, for native species to out-compete invasive vegetation. However, invasive vegetation will generally continue to spread in density and extent. The most effective way to mitigate the effects of non-native vegetation is to prevent their establishment by proactively managing anthropogenic disturbances. Non-native vegetation control efforts are reported separately for Banff National Park.

Disturbed sites are also very susceptible to soil loss through wind and water erosion. Soils depths in Banff National Park vary, but with generally thin top soil layers (A horizon) small losses of soil often cause significant impacts to the abiotic characteristics of functioning ecosystems. Soil conservation is an extremely high priority to prevent losses and to exercise sound environmental practices.

The goal of disturbed site reclamation is to restore native vegetation cover, which in turn increases ecological integrity and biodiversity. In addition to ecological benefits of site reclamation, native vegetation also contributes to the overall aesthetics of a disturbed site.

Natural disturbances do not require reclamation except in very specific cases where they occur near anthropomorphic areas; which are likely to become vectors for non-native vegetation transmission or require additional work to avoid impacting human development (for example, re-vegetating a section of stream bank, post-flood, to stabilize soils near a bridge abutment). In 2013 a large flood impacted a lot of infrastructure in Banff National Park resulting in ongoing efforts to reclaim many areas where both emergency work and post-flood reconstruction left unmitigated disturbed areas.

In Banff National Park there is a long history of human use and some of these changes have left a legacy of disturbed sites including contaminated sites (historic garbage dumps or spilled/leaked hydrocarbons) and abandoned infrastructure (dams, gravel pits, fragmented roads, and trails); even the remains of historic communities and coal mining activity (e.g. Bankhead and Anthracite). More recently, some key changes to human use have restored ecosystem function such as the Cascade Wildlife Corridor (removal of horse corrals, buffalo paddock and Cadet Camp in the late 1990's). Along with numerous other disturbed sites, most of these areas have recovered naturally over the years. Some sites require additional reclamation effort to ensure they are on a trajectory to become fully functioning components of the Banff National Park ecosystems (see Cascade Creek Restoration – impacted by gravel and coal extraction, introduced species, and water diversion).

In recent years Banff National Park has benefited from the Federal Investment of Infrastructure (FII) funding which resulted in the development of a more standardized approach to reclamation. It is important to note that the majority of projects exist in disturbed areas in which reclamation is required. Many projects cause site disturbance when upgrading aspects of roads, day-use-areas (DUA), buildings and bridges. While these are generally small disturbed areas they require reclamation actions to ensure that native vegetation establishes and they do not become invaded by non-native vegetation.

In the "Consolidated Guidelines for EI Monitoring in Canada's National Parks" (Parks Canada, 2011), non-native vegetation is identified as a stressor of alpine and forest ecosystems. Quality of reclamation directly influences non-native vegetation in the park and therefore reclamation is designed to mitigate the effects of non-native vegetation in the alpine and forest ecosystems. Reclamation aligns with direction from the Banff National Park Management Plan (Parks Canada, 2010) that indicates that disturbed areas are restored to functioning ecosystems and that environmental impacts of development activities are minimized. Furthermore, the Park

Management Plan explicitly indicates that native plant communities are to be managed to become more resilient to invasive and non-native species and that management actions should prevent further introduction of alien species (non-native vegetation).

Objectives

1 Reclaim historic and newly created disturbed sites in Banff National Park.
   - **a** Identify sites where restoration goals can be attained.

2 Ensure mitigations are in place for new site disturbing projects to:
   - **a** Prevent soil erosion
   - **b** Prevent the establishment and spread of non-native vegetation
   - **c** Establish native vegetation and suitable habitat.

3 Develop standards for reclamation and restoration for Banff National Park.

Methods

We review each project separately during the environmental assessment process to ensure site-specific goals are achieved. We provide a "reclamation prescription" to project managers to communicate reclamation goals, objectives and site-specific requirements. We incorporate these prescriptions into the environmental assessment, ensuring they include the following considerations:

1 Background
   - **a** Project goals/methods
   - **b** Historic use of site
   - **c** Current non-native vegetation issues

2 Timing
   - **a** Site disturbance
   - **b** Planting/Seeding windows



Figure 2. Willow stakes showing first year growth at Castle Warden Station reclamation site on the Bow Valley Parkway, Banff National Park.

3 Abiotic Considerations
   a Landform changes
   b Soil (texture, pH, nutriments, etc.)
   c Site hydrology

4 Biotic Considerations
   a Special vegetation (Rare, SARA, Species of Special Concern)
   b Vegetation Removal (methods)
   c non-native vegetation Assessment/Control
   d Re-Vegetation
      - Species selection
      - Specific planting/seeding methods

5 Monitoring
   a General site monitoring as well as plant germination/mortality/vegetative cover.

6 Project Delivery/Methods
   a Equipment cleaning
   b A variety of best management practices and guiding documents

There is a large degree of variation in project size so reclamation prescriptions are tailored to ensure they are appropriate for the project. Generally when projects involve demolition and removal of infrastructure there are more detailed reclamation prescriptions with the goal of restoring habitat.

Reclamation activities are delivered through a variety of mechanisms. Internal resources often complete a project assessment, non-native vegetation assessment and control, smaller scale seeding and planting (willow staking, translocation etc.), soil amendments as well as installation of erosion matting. On larger projects, these activities as well as others, require contractor involvement.

Results

Reclamation in Banff National Park is ongoing and results are difficult to quantify. However, in 2016 additional resources were allocated to provide input and guidance to reclamation in Banff National Park. While reclamation has occurred in the park for decades; information has not yet been consolidated to a single database. In 2016, we created a database to store reclamation requests, prescriptions and monitoring outcomes. Figure 3 depicts a rough breakdown of current

status of the projects housed in that database. These numbers do not represent all projects in Banff National Park; only those in which detailed reclamation plans are required as of late 2016.

In 2016, we developed interim Reclamation Best Management Practices (BMP) (currently under review) and are applying these to many projects. Activity specific process BMPs were also developed for seed ordering and soil movement (under review) within the field unit.

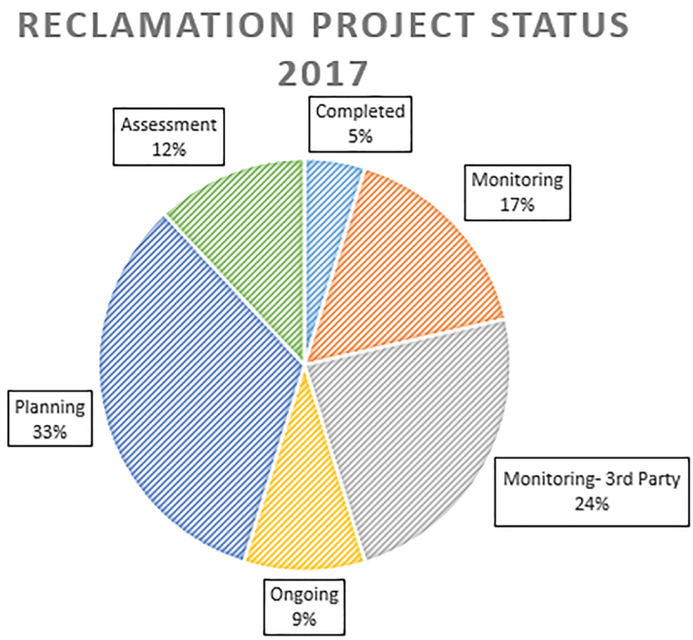


Figure 3. Break down of reclamation project status in the Banff Field unit (Total of 32 projects).

Discussion

Reclamation has been ongoing in Banff National Park for many years in various forms. New efforts are being made ensure reclamation is consistently completed to a high standard. We have developed Best Management Practices and additional support products to improve consistency and efficiency. However, effort is required to ensure all disturbed sites are on satisfactory reclamation trajectories.

Key Issues and Opportunities

1 Reclamation Standards for Projects

   a Currently there are few methods being used to gauge reclamation project success as it is difficult to assess during the relatively short project timelines (1-2 years). It may take a several years to asses and determine if additional reclamation actions are required.

b We recommend that clear and comprehensive reclamation standards be developed for use in early project planning and contracting. These standards could be consistently added to project specification documentation to ensure reclamation is on an appropriate trajectory.

c These standards should include how sites will be monitored to ensure projects account for additional reclamation activities post-construction.

2 Historic Reclamation Assessment

a Reclamation has occurred for many years in Banff National Park. Many reclamation activities have been documented but have not been stored in a centralized database. This makes it difficult for project managers to assess the effectiveness of completed (pre-2010) reclamation activities.

b We recommend that subject matter experts identify sites within the field unit to represent historic reclamation practices and compile/review related documents to understand the effectiveness of these actions for future use in the Park.

c This information could be used to increase the overall success of reclamation projects.

Contact

Brian Yakiwchuk, Resource Management Officer
Banff Field Unit
P: (403) 762-1495
E: *brian.yakiwchuk@pc.gc.ca*

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Buffaloberry Productivity Monitoring Project

Introduction

Canada buffaloberry (*Shepherdia canadensis*) is an important food resource for grizzly bears throughout the Rocky Mountains and affects both health (body mass and growth) and population demographics. Annual variation in the timing, distribution and abundance of berry production affects bear behaviour and movements. Monitoring berry production as a gauge of food availability, helps park managers better understand grizzly bear habitat-use, and predict the probability of human-bear interactions as a result of varying berry abundance year-to-year (Figure 1). This knowledge allows us to implement pro-active human use strategies to reduce risk for bears and park users.



Figure 1. Buffaloberry productivity monitoring in the field.

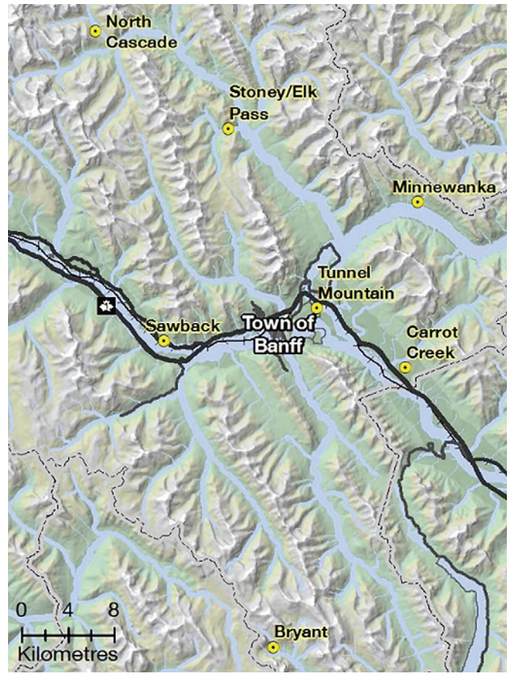


Figure 2. Buffaloberry monitoring plots within the Banff Field Unit.

Objectives

To monitor inter-annual productivity of buffaloberry in core grizzly bear habitat across the Banff Field Unit.

Methods

We monitored seven characteristically distinctive buffaloberry plots (thinned areas, prescribed burns, different elevation bands) across the Banff Field Unit (Figure 2). Within each plot, we sampled ten fruit-producing buffaloberry plants during biannual site visits. On each of these plants researchers counted the number of berries on two tagged stems (~10 mm diameter). At each plot we collected and weighted a sample of 50 ripe berries to obtain an

estimate of average biomass. From this same sample we acquired a measure of sugar content (°Bx) using a brix refractometer (Figure 3). We also documented any incidence of natural mortality or presence of infection on the fruit or leaves – anything affecting forage quality for bears.

We used bootstrapping techniques to estimate the stem-count population averages for each plot during each season (2014-2017). Through an analysis of variance we used the four-year average for the entire Field Unit as a baseline measure from which to establish whether a particular berry season was *good* or *poor* – a characterization that will become more refined as monitoring continues. We also calculated corresponding averages for brix and biomass.



Figure 3. Brix refractometer.

Results

At the Field Unit-scale, the first four years of monitoring have shown significant inter-annual variability in berry production ($F = 71.05$, $p < 0.001$) (Figure 4). The ANOVA results show that 2017 was a normal year in regard to productivity and so was 2014. However, 2015 was significantly less productive (by 31.4%) and 2016 was significantly more productive (by 22%).

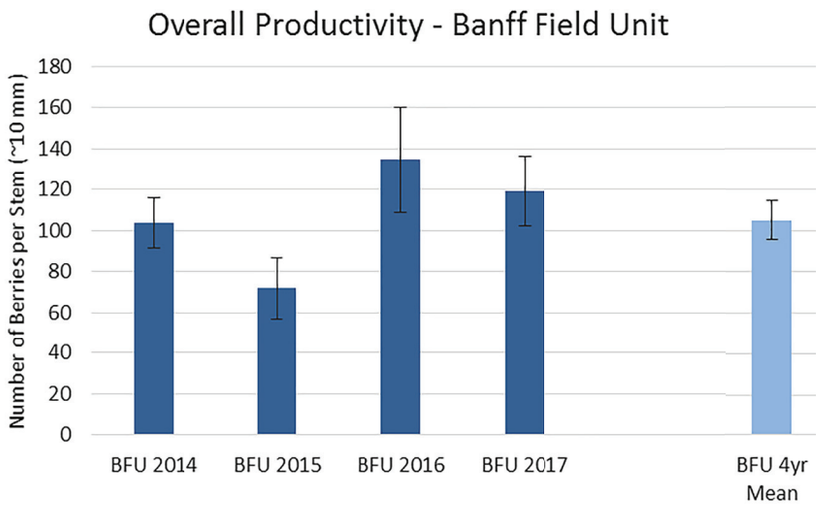


Figure 4. Comparison of the mean number of berries (per stem) within the Banff Field Unit (all plots combined, 2014-2017). The four year average (right) is considered the baseline, or 'normal', productivity within the Field Unit. Confidence intervals established at 95% significance.

There was much more inter-annual variability at the plot-scale (Figure 5). These irregularities were likely a result of differing meteorological conditions affecting both the present and preceding growing seasons when the berry buds were first established (Krebs *et al.*, 2009). Anomalous weather events can also impact productivity, for example the failed crop at Carrot Creek in 2015

may have been caused by a localized frost event that damaged flowers during bloom. There appeared to be no long term trends in productivity, but there were distinct overall differences between plots year-to-year in general (Figure 6).

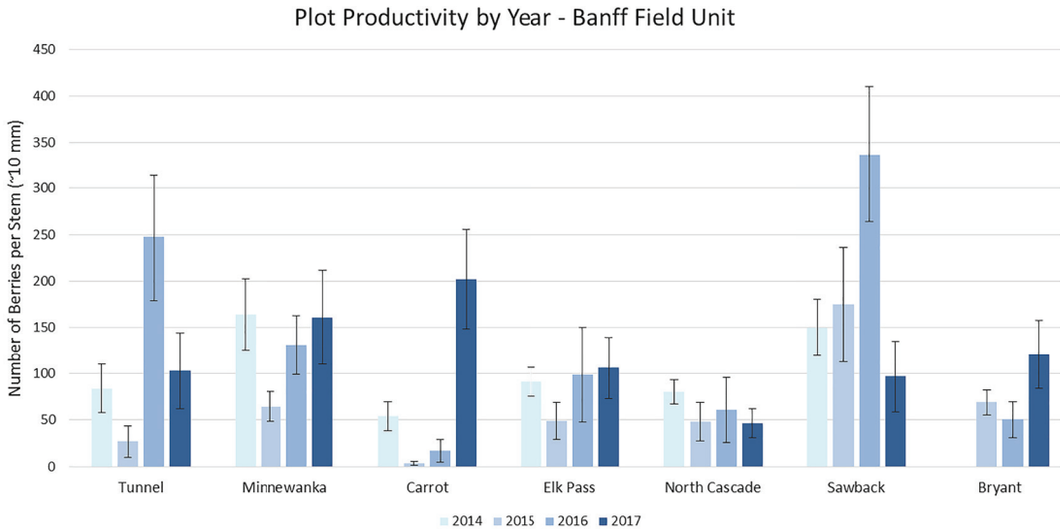


Figure 5. Comparison of the mean number of berries (per stem) within each monitoring plot (2014-2017). Monitoring at the Bryant plot began in 2015.

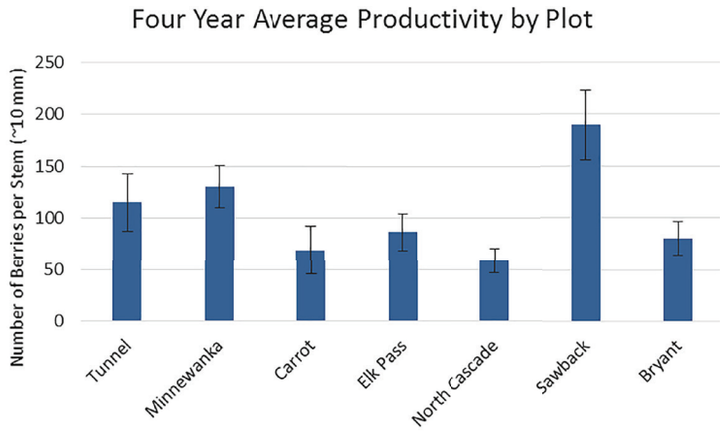


Figure 6. Four year average showing overall plot productivity.

On average, the Sawback and Minnewanka plots were significantly more productive than the Field Unit average, while other plots were significantly less productive. The exception being the Tunnel Mountain plot which could be considered *typical* productivity, consequently making it an ideal plot for more intensive monitoring. Berry counts were the primary measure of productivity, however berry size and sugar content also factor in assessing forage quality. 2017 was the first year of this project to obtain complete brix (% sugar) measurements at each plot (Figure 7).

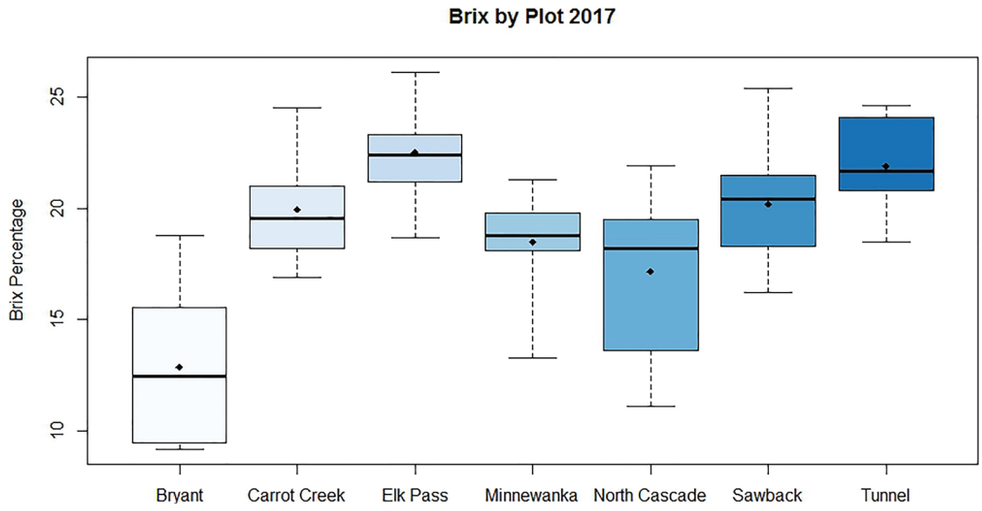


Figure 7. Berry sugar content (%) at each plot for 2017 (box colour is arbitrary).

Overall, brix ranged between 10% and 25% with less than 10% mean variation between plots, and 5% variation year-to-year. We found that sugar and weight were highly correlated (2017: R^2 = 0.85), which could help reduce field effort in the future by perhaps measuring only one of these variables (2017 mean biomass: 0.18 g/berry). It should be noted that brix values were sensitive to the time of season. Bryant for example was a high-elevation plot that was slow to ripen and had lower sugar content as a result. Efforts were made to visit plots at relative 'peak ripeness' for brix measurements to avoid biasing the results. Similarly, berry counts should occur before peak ripeness to avoid loss to dispersal which would underestimate productivity.

Buffaloberry monitoring in the LLYK Field Unit started in 2016 and a first look suggests more than twice as much productivity in 2016 than 2017. For the two-year average (2016-17), the stem count was 231 berries while Banff averaged only 127 over the same period – a difference of 45% (Figure 8). It will interesting to see if this high productivity trend in LLYK persists as monitoring continues.

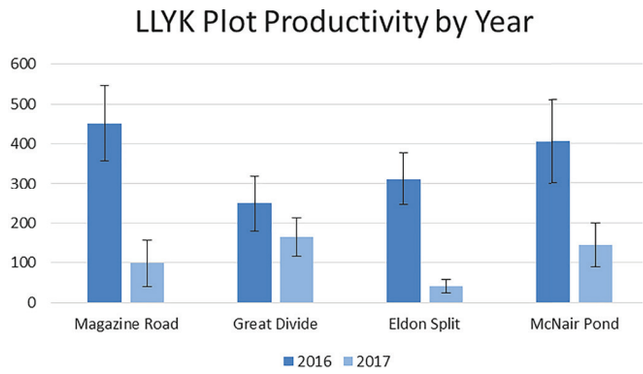


Figure 8. Comparison of the mean number of berries (per stem) within each LLYK monitoring plot (2016-2017) (CI 95% sig).

Discussion

After only four years of monitoring, it is evident that buffaloberry productivity is variable in both space and time. This implies that forage quality for grizzly bears is also considerably dynamic across the Field Unit and year-to-year. The principle objective of this monitoring project is to determine how this variability affects human-wildlife conflict in the Park. Does an abundant berry crop in the Bow Valley result in a higher probability of human-bear conflict? Or is it a failed crop that results in more conflict? Can we predict what will happen next season? It is questions like these that we can now begin to explore as the project moves into its fifth season. The summer of 2017 was record-setting in regard to high temperatures and low precipitation, as a result the berry crop of 2018 may be dramatically impacted – and so might the bears that depend on it.

Moving forward, the ability to predict next year's berry crop would support efforts to proactively mitigate the risk of human-bear conflict. This type of predictive modeling will require more detailed characterization of the field plots including fine-scale measurement of meteorological variables. We are working to equip the plots with simple in-situ precipitation and temperature loggers for the 2018 season. Considering that the goal is to predict inter-annual crop variability, the unit of analysis is a 'year', therefore it is essential to begin acquiring these environmental covariates as soon as possible.

Comparatively, this project is still in the primary stages of development, with ongoing protocol refinement and a relatively short time-series available for trend monitoring. Field and analytic protocol refinement in upcoming years will enable accurate standardization and interpretation of inter-annual berry counts. Data summarized in these results are not yet standardized to account for change in plant growth over time.

Acknowledgements

Prepared by David Laskin. Thanks to the BFU Resource Conservation staff who have been tirelessly counting berries every summer.

Contact

Jesse Whittington, Wildlife Ecologist
Banff Field Unit
P: (403)-763-8865
E: *jesse.whittington@pc.gc.ca*

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Storm Water Quality Monitoring in the Bow River

Introduction

Riverine systems may be adversely affected by human activity from both point sources (such as a Wastewater Treatment Plant outflow) and nonpoint sources. Nonpoint sources describes pollution resulting from many diffuse sources. Nonpoint sources of pollution generally come from land runoff, precipitation, atmospheric deposition, drainage, and seepage. Tracing this kind of pollution back to a single source is difficult (Sleavin et al. 2000).

Numerous studies demonstrate a direct relationship between the amount of impervious surface within a watershed and pollution of its surface waters (Sleavin et al. 2000). Impervious surfaces can be loosely defined as any surface through which water cannot penetrate. Impervious surfaces are designed and constructed to collect precipitation and convey it out of the watershed via storm water. Since storm water generated from these impervious surfaces often does not receive any treatment before entering a watercourse, one might expect downstream impacts to water quality. Runoff from roads may contain fuel, oil, grease, brake fluid, antifreeze and corrosive products. Gases, aerosols and soot may appear from vehicle emissions (Göbel et al. 2007).



Figure 1. Storm water outflows in the Town of Banff where untreated flows contribute to nonpoint source impacts to the Bow River in Banff National Park.

While Parks Canada can sample for culprit contaminants directly by collecting water samples, the results would represent only a snapshot in time. Instead, scientists use biological communities (e.g., benthic algae and macroinvertebrates) to monitor the condition of surface waters (i.e. biomonitoring; Reynoldson et al. 1997) because biological communities are representative of conditions over the long term. Monitoring programs based on riverine water chemistry and biomonitoring have been ongoing in Banff National Park since 1998 to determine the management effectiveness of the Banff and Lake Louise Wastwater Treatement Plants and are presented elsewhere in this document.

Parks Canada started a monitoring program in 2015 using a Reference Condition Approach. The sampling methodology followed the Canadian Aquatic Biomonitoring Network (CABIN) protocol to assess the impacts of nonpoint sources of pollution on local water quality. Biological assessments using the Reference Condition Approach evaluate water quality by comparing the biological community at a test site to a collection of reference sites. When the structure of the Benthic Macro Invertebrate community at the test sites falls outside of the range of natural variation at the suite of reference sites it is deemed to be divergent (e.g., outside of reference condition).

Here we report on the initial two years of biomonitoring data (2015 and 2016) that followed a gradient from upstream to a point 8 km downstream of the Town of Banff.

Objectives

Monitoring Question

Is the water quality in the Bow River impacted in vicinity of the Town of Banff?

Thresholds

CABIN Reference Condition Approach

Thresholds are based whether the sites are found to be within reference condition. The sites are classified as either poor (highly divergent), fair (divergent) and good (within reference).

Methods

The biomonitoring program monitored 8 locations in the vicinity of the Town of Banff:

- **Site 1** – located 10.6 km upstream of the Town.
- **Site 2** – located immediately adjacent to the Town.
- **Site 3** – located 2.5 km downstream of the Town.
- **Site 4** – located 5.9 km downstream of the Town.
- **Site 5** – located 6.9 km downstream of the Town.
- **Site 6** – located 10 km downstream of the Town.
- **Site 7** – located 11.3 km downstream of the Town.
- **Site 8** – located 15.6 km downstream of the Town.

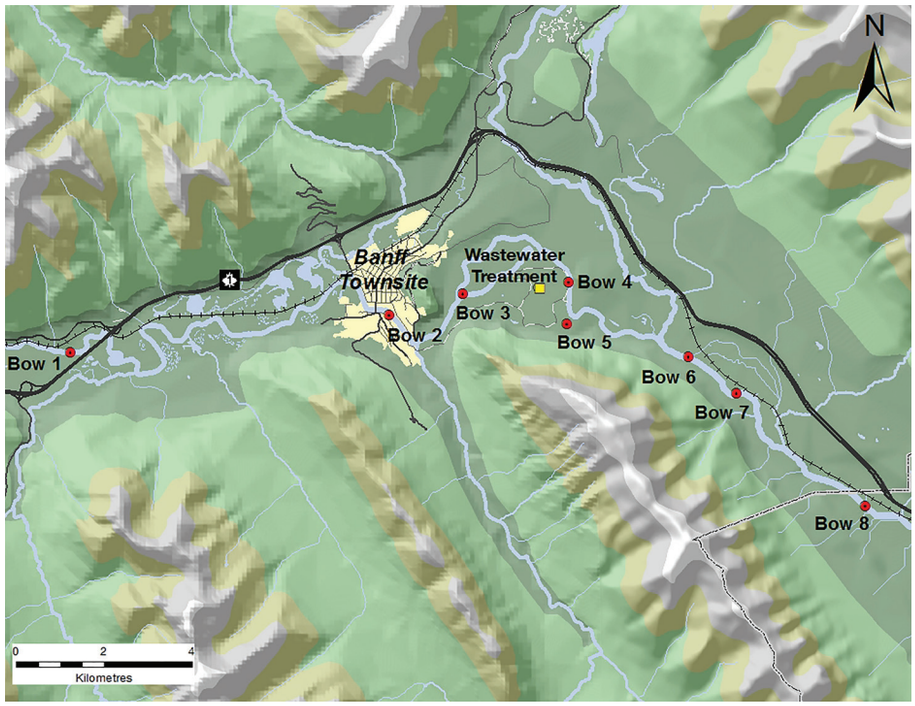


Figure 2. A map of the Town of Banff and the 8 sampling sites. Note the WWTP outflow is at Bow 4.

We used a Reference Condition Approach following the CABIN biomonitoring protocol. Detailed CABIN field methods are available on the Environment Canada website: *http://publications.gc.ca/site/eng/422979/publication.html*.

We present these results in a table for each site. Using the same data, we calculated individual metrics which had previously been shown to discriminate between sites contaminated and not contaminated with waste water (Bowman 2014). These metrics were plotted according to their longitudinal position on the Bow River in order to determine their response to the presence of the town site or any other landscape features of interest. Since Site 1 was well upstream of the town site infrastructure, it represented the reference condition.

Results

Table 1 shows individual Reference Condition Approach site classifications in 2015 and 2016. A number of sites were "divergent" or "highly divergent". The six most upstream sites (sites 1 – 6), were "highly divergent" in one of the two given years. The two most downstream sites (sites 7 and 8) were either "divergent" or "within reference". This suggest that a number of different sources of pollution may be entering the Bow River. No regular pattern of divergence is seen longitudinally.

Although site classifications are determined based on the entire invertebrate community, we also calculated values for individual metrics to provide more insight into potential patterns of

impairment. Figure 3 demonstrates how chemical and biological metrics follow a longitudinal pattern along the Bow River relative to human use nodes such as the Banff town site and waste water treatment plant (WWTP). Site 1 is the most upstream site and therefore is not influenced by runoff from the town site. As a result, chironomid and algae abundance is low while mayfly abundance is relatively high. At the next most downstream site (Site 2), the Bow River is adjacent to the town and chironomid and algae abundance increase, and mayflies decrease sharply. Recovery of these values are seen downstream of the town site as the Spray River joins the Bow River upstream of the WWTP. Chironomids and algae decrease until they spike again downstream of the WWTP. Sites 7 and 8 are the farthest away from impervious surfaces and the metric values at these sites suggest the river is more similar to upstream of the town site.

Table 1. Status summary of eight sites monitored in 2014-2016 using the Mountain National Park reference model.

Year	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
2015	Divergent	Highly Divergent	Highly Divergent	Within Reference	Highly Divergent	Highly Divergent	Within Reference	Divergent
2016	Highly Divergent	Highly Divergent	Within Reference	Highly Divergent	Highly Divergent	Highly Divergent	Divergent	Within Reference

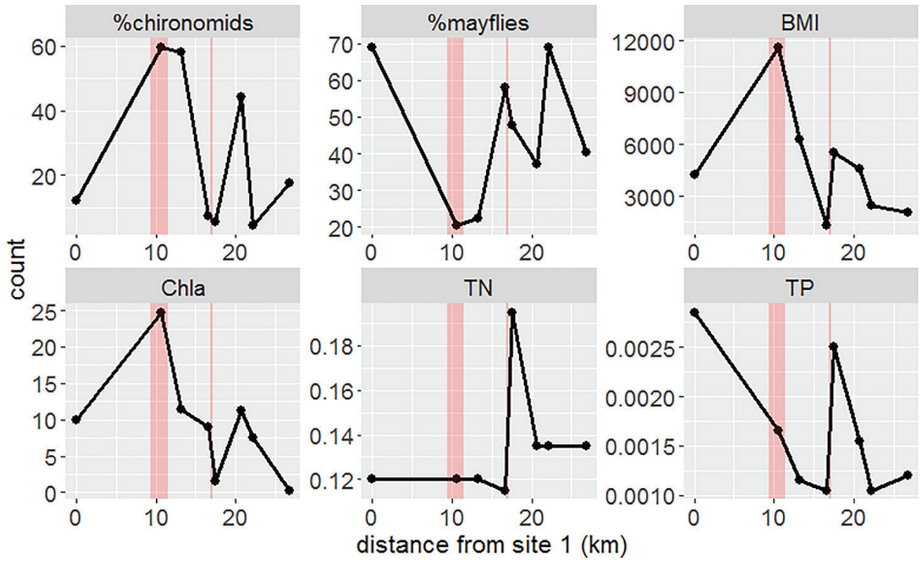


Figure 3. Individual metric values for biomonitoring sites on Bow River. Black points represent sites 1-8 plotted as linear distance (km) from site 1. Red band on the left represents the linear distance occupied by the town of Banff. The red line on the right represents the WWTP. See Figure 2 for site locations. *Chironomids (invertebrates indicative of low oxygen/muddy substrates), mayflies (invertebrates indicative of high oxygen, rocky substrates), BMI = Benthic Macro-invertebrates (invert diversity measure), Chla = Chlorophyll-a (measure of plant or algal growth which increases in response to nutrient impacts), TN = Total Nitrogen (increases from nutrient inputs), TP = Total Phosphorus (increases from nutrient inputs).*

Discussion

Using the Reference Condition Approach we quantified the longitudinal gradient of community change from the upstream Site 1 to the eastern park gate (Site 8). Many sites were highly divergent. Sites downstream of the town site were no more likely to be within reference than sites downstream of the WWTP. Detailed monitoring up- and downstream of the WWTP was ongoing since 1998 (See WWTP Monitoring SOPR). These results suggest an even greater level of impairment is associated with the town site, relative to the WWTP. Sites closest to the eastern boundary (Canmore) were more likely to be in reference.

Looking at individual metrics calculated from the same data that informs the Reference Condition Approach, we revealed longitudinal patterns in the distribution of BMI communities, algae and nutrients that are associated with the town site and the WWTP. Pollution-tolerant chironomids and algae increased sharply adjacent to the town site. As chironomid and algae abundance decreased downstream of the Spray River, mayflies became relatively more abundant - indicating a return to more pristine waters.

The Banff town site has 10 storm outfalls that convey surface run-off from impervious surfaces such as roads and parking lots. The exact cause for water quality impacts to the Bow River in the vicinity of the town site is not known without targeted studies. However, pollution from impervious surfaces is a mechanism that is well understood (e.g. see Göbel et al. 2007). For example, dry and wet deposition forms a residue on the land surface and washes into waterways as a concentrated injection of pollutants with precipitation (Göbel et al. 2007). Storm water runoff can contain inorganic pollution like trace metals, but also organic pollutants such as particles from the combustion of fossil fuels, drip losses from vehicles and tire wear. Even roof surfaces can be a source of trace metals as products of corrosion.

Ongoing discussion with the Town of Banff will help determine the needs for more focused studies and perhaps planning for improved storm water management. Potential mitigations include new infrastructure such as storm-ceptors which help prevent heavy (sediment and metals) and light (hydrocarbon) components of storm water from entering the watershed; or engineered wetlands which use natural ecosystem components such as ponding and vegetation to capture similar contaminants. Parks Canada will work with the Town of Banff to ensure the storm water system meets the Government of Alberta's Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems.

Acknowledgements/Partners

This monitoring program is not possible without the strong partnership with Environment and Climate Change Canada, in particular, Stephanie Strachan, Environmental Monitoring Scientist for Pacific, Athabasca Arctic Watershed. Garry Scrimgeour was instrumental in design and coordination of the 2007 and 2008 field campaign across seven mountain parks to complete the reference collection and subsequent predictive model development. Ghost Consulting completed

the Mountain Park Model. Michelle Bowman conducted the water quality monitoring of the WWTP until 2013.

Analysis: Renee Lazor and Fonya Irvine.

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
P: 403-762-1418
E: *mark.taylor@pc.gc.ca*

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Sunshine Meadows Summer Use

Introduction

Roughly 33 years ago, in the summer of 1984, Sunshine Village (SSV) began offering access to Sunshine Meadows with their gondola and chairlift operations, following extensive review and permitting by Parks Canada. This made the meadows one of the most accessible alpine locations in Banff National Park, resulting in higher levels of summer use both in and outside the leasehold. Banff conducted summer-use monitoring as there was concern that the human use would adversely impact the fragile alpine ecosystem. However after 1991, Sunshine Village stopped operating the gondola/chairlift; but continued to offer restricted bus access to Sunshine Village each summer. Parks Canada stopped monitoring also.

In 2016, 25 years later, Sunshine Village resumed summer gondola and chairlift operations 4 days each week (Fri – Mon) and long weekends from July 1st to Sept. 5th. In 2017, Sunshine Village added hotel operations to the summer offer at Sunshine Village, as permitted in the original 1984 agreement.

Unlike other gondola operations in Banff National Park, where use at the upper terminal is either formally (Lake Louise and Norquay) or operationally (Sulphur Mountain) constrained to a small area, gondola access at Sunshine Village provides a "fast-pass" to adjacent Zone II Wilderness areas of Banff National Park. Zone II wilderness is characterized by:

> *"...rudimentary services and facilities ... remoteness and solitude ... and activities that do not conflict with maintaining the wilderness itself; ... where motorized access and circulation will not be permitted..."* (Parks Canada, 1994).

Because of the sensitivity of the Sunshine Meadows landscape and the potential spill-over effects of gondola-facilitated access to Zone II Wilderness areas, the revival of summer gondola use at Sunshine Village in 2016 necessitated resumption of Parks Canada's focussed Sunshine Monitoring Program.

Objectives

1. Understand the levels and patterns of human activity in the Sunshine Village leasehold as well as areas surrounding the leasehold—from Citadel Pass to Healy Pass, including areas in Mount Assiniboine Provincial Park - the Sunshine Monitoring Program (SMP) area.
2. Document the current condition of the environment and species that inhabit the area.

3 Use the information gathered from 1) and 2) to highlight management issues and inform future management decisions.

Methods

We monitored human-use, trail conditions, invasive and rare vegetation occurrences and key wildlife species in 2016 & 2017. We monitored human-use using remote cameras, trail counters, two road counters and ticket sales information provided by Sunshine Village. We examined numbers of visitors and vehicles using the road, bus, gondola and trails to further assess direction of travel, diurnal patterns of use, and use of adjacent areas originating from Sunshine Village. Starting Aug. 8th 2016, Parks Canada implemented a Restricted Activity Order (RAO) to prevent off-trail use during the summer season with a goal of preventing further vegetation trampling and unofficial trail development and to reduce wildlife disturbance. A key concern was trying to maintain or improve grizzly bear habitat security values, as required in the Park Management Plan, while permitting increasing levels of use within the Sunshine/Egypt Land Management Unit (Parks Canada 2010). This trail restriction was lifted once bus operations ended in 2016 (October 12th). Parks Canada will implement this restriction, preventing all off-trail use, annually (between June 1 to October 16th), whenever summer use is occurring at Sunshine Village.

In the fall of 2016 and 2017, we evaluated the condition of trails by using B.C. Parks' Backcountry Recreation Impact Monitoring (BRIM) Protocol, where we conducted site, segment and repeat photography surveys. The protocol scores the condition of each trail segment by combining the severity of trail widening/braiding, deepening, rooting, and mucking and then defines the impacts as *none (good trail condition), slight (fair trail condition), moderate (moderate trail condition), or severe (poor trail condition)*. We also recorded trail widths along trail segments, to document any changes over time.

We investigated vegetation conditions by adapting the Invasive Alien Plant Condition Class Monitoring protocol (IAP-CCM; McLellan 2015) for a suite of control or non-impacted (n = 16), random (n = 16) and impacted (n = 38) sites. This allowed us to measure the condition of invasive alien plants (IAP) and bare soil/trampling trailside. We also conducted walking surveys to identify invasive species occurring beyond fixed sites. We completed a preliminary rare plant survey along select official and unofficial trails in the area to highlight areas of concern. We monitored wildlife using remote cameras, surveys, observations and conducted desktop analysis of datasets (observations, occurrences, mortalities, VHF/GPS collars). We conducted surveys of bird and bat presence following Avian Species Relative Abundance (Banff National Park [BNP] 2017) and North American Bat (NABAT) protocols (USDA 2015), respectively. We examined wildlife of concern, corridors, displacement, diurnal activity and human-wildlife conflicts. We updated the grizzly bear habitat security model from the 2010 Park Management Plan using monthly human-use data and observations in the field. We also investigated potential changes to this model based on implementation of the Restricted Activity Order.

Results

Human-use

Visitation and Access

In each of 2016 and 2017, there were more than 30,000 visitors who took the gondola, bus, hiked, biked or took a guided tour up to Sunshine Village during the operational season (Table 1). This increased 57% and 62%[1], respectively, from the peak visitation level documented between the years 2000 and 2015; which was 21,784 in 2015 (Hirose 2016). The increase was also significantly higher than the general park visitation trends (+7% and +9%) for the same two year period[2]. Total visitation was fairly constant between 2016 (31,199) and 2017 (31,356) for the peak activity period (30 June to 24 September). However, due to fire closures and smoky conditions in 2017, the days available for visitation in 2016 (87 days) was notably higher than for 2017 (75 days), and for a further seven of these operating days in 2017 hiking trails were closed which means the total visitation was further constrained to a 68 day operating period. When considering only comparable periods between both years, visitation increased by 28% from 2016 to 2017. Also, the average daily visitation in 2017 was higher than 2016 for the peak activity period (418 *vs* 359) (or 443 vs 328 if the seven day period of trail closure was excluded from both years. Sunshine Village operated their hotel in the summer of 2017.

Table 1. Summary of visitation stats for the Sunshine Monitoring Program (SMP) Area during Sunshine Village operational dates. Data includes visitors accessing the area by gondola, bus (including hotel) and service road (hikers/bikers/runners).

Year	Dates SSV Operational	Visitation in SMP Area[1]	Days of Operation	Daily Average Visitation (peak dates)	Peak Number of Visitors[3]
2016	June 15 - October 3	33,761	111	359	1,127
2017	June 30 - September 24	31,356	75[2]	418	908

[1] Totals are for Sunshine Village operational dates only.

[2] Operational opening/closing dates included a total of 87 days, however fire closures reduced this to 75.

[3] 1 August 2016 (August long weekend: Monday) and 29 July 2017 (August long weekend: Saturday).

Visitors to the Sunshine Meadows can access the area through Sunshine Village by one of three modes: gondola/chairlift, bus or hiking/biking the service road – the latter is free of charge. The gondola operates 4 days each week (Friday to Monday) and the bus on weekdays, though in 2016 White Mountain Adventures ran buses to the village every day of the week, and SSV only operated the gondola Friday-Sunday and holiday Mondays. In both 2016 and 2017 the majority of visitors accessed Sunshine Village by gondola. Visitors and staff alike use the service road to access SSV. There were 16,713 vehicle events on the Sunshine Service Road during the 2017 visitor operating period (or 21,950 for the period of the RAO [June 2 to 16 October]). Traffic activity peaked at 17:00 but was documented at all hours of the day and night.

Trail Usage

In 2016 trail use in the SMP area was highest on the trails within the Sunshine Meadows, and in particular, on the trails leading from the top of Standish Chairlift down into Mount Assiniboine Provincial Park (MAPP) and looping back to SSV (Figure 1).

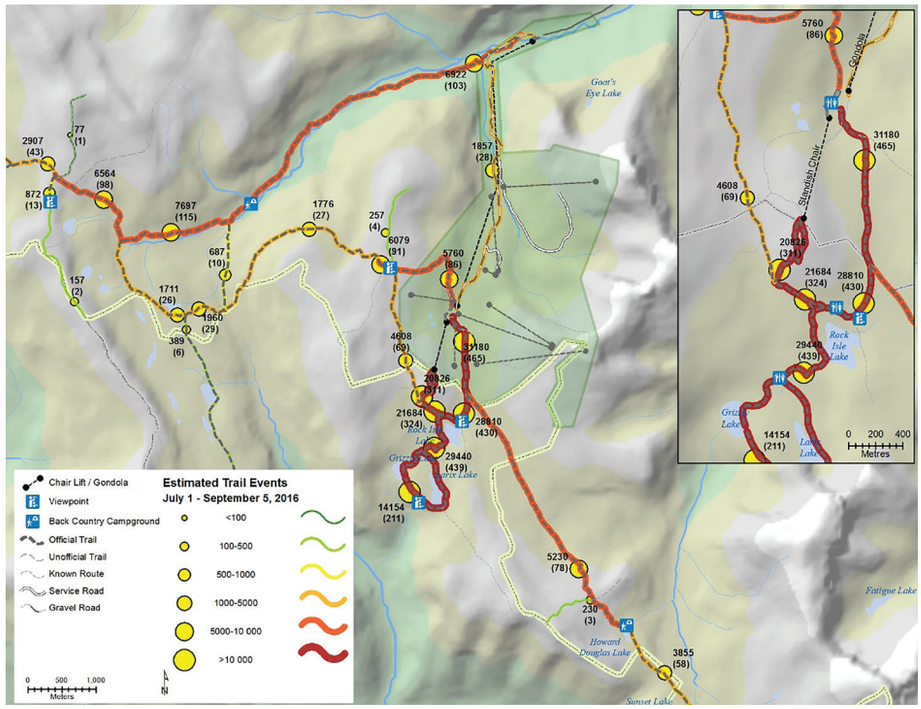


Figure 1. Total and daily average events (in parentheses) on each trail segment from July 1 - September 5, 2016 (dates gondola operating)

We are currently analysing trail data for 2017, thus it is unavailable for this report. However we can compare similar data for human-use on trails in the SMP area occurring in 2012 and 2016. Within the leasehold, most use on the two main trails from Sunshine Village occurred between 8:00 A.M. to 6:00 P.M (2016). The two trails leading to areas beyond the Sunshine Meadows (Citadel Pass and Simpson Pass trails) both experienced increases in usage in 2016 during the period the gondola was operating (45% and 30%, respectively), though these increases were similar to those observed for four other locations around Banff National Park. When considering direction of travel however, Citadel Pass had a marked increase (91%) in visitors travelling away from SSV when comparing 2012 & 2016, whereas there was no change in travel direction proportion for the increased usage on Simpson Pass trail.

Restricted Activity Order (RAO)/Illegal Activities

With the RAO in place, all human-use on unofficial trails is considered non-compliant within the SMP area. Events of non-compliance on unofficial trails increased in 2017 (356), however

levels of non-compliance were similar between 2016 and 2017 when correcting for the late implementation of the RAO in 2016. We recorded < 2% difference between years when comparing data from Aug 11 to Oct 3; while under the RAO. All five of the known unofficial trails had non-compliant human activity in both years, however the Monarch Ramparts Viewpoint Trail was added to the RAO in 2017 and accounted for 75% of the recorded non-compliance. Off-trail use was also observed in the areas surrounding the official trails. Day users were more likely to go off-trail than backcountry users throughout the SMP area. Additional compliance issues included biking on trails where biking is not permitted (especially in the late fall) and visitors with dogs off-leash.

Trail conditions

Over the entire SMP area, trail conditions range from fair (61%), moderate (33%) to poor (6%) and the status of many categories, particularly trail width, are at risk of increasing due to human activity. Most trails maintained by Sunshine Village (8 segments) are in fair condition, except for the Rock Isle-Grizzly Connector, which was in moderate condition due to high levels of two way traffic - causing widening and deepening of the trail. The most common problems along the remainder of the Sunshine Village-maintained trails are: trampling of vegetation, trail widening from two-way traffic and gravel spillage. Of the trails maintained by Parks Canada (9 segments) three are fair, five moderate and one is in poor condition. There is rooting and mucking on Healy Pass Trail (fair to moderate), widening, braiding and deepening on Simpson Pass East (moderate) and major braiding, deepening and mucking on Citadel Pass South (poor) (Figure 2). Healy Pass Trail conditions are influenced by human activity and its wet nature. Simpson Pass East Trail conditions are influenced by human activity and water erosion. Citadel Pass South has a small section over a wetland next to Howard Douglas Lake as well as trail braids from past horse activity, which are perpetuated by hikers and water erosion. The Eohippus Trail (BC Parks) is in fair condition. Average trail widths did not change from 2016 to 2017, providing a good baseline for future monitoring.



Figure 2. Example of trail braiding due to intensive use in a wet alpine habitat. Citadel area near Sunshine Village in Banff National Park, 2016.

Vegetation conditions

Rare plants

The most significant component of Sunshine Meadows is its unique vegetation. Vegetation of concern are the Whitebark pine (*Pinus albicaulis*), which is federally-listed as Endangered (Government of Canada

2017), as well as the 69 known rare plants documented in this area (Hirose 2016). We discovered five species of note through a 2017 rare plant survey: alpine dandelion (*Taraxacum scopulorum,* S1), sandwort (*Arenaria longipedunculata,* S2), dwarf grape fern (*Botrychium simplex,* S2), pink false dandelion (*Agoseris lackschewitzii,* S3), and Lemmon's rockcress (*Boechera lemmonii,* S3) (Tannas 2017). All five species are classified as sufficiently rare within Alberta to be of conservation concern and are therefore tracked by the Alberta Natural Heritage Information Centre. The S rank (S1, S2, etc.) listed for each species above denotes the level of rarity within Alberta. *Taraxacum scopulorum* is of particular note, as this is the first record of this species in the area and the species has the highest level of ranking for rare plants in Alberta (S1).

Invasive Alien Plants (IAP)

We assessed the prevalence of IAP along roads and trails within the Sunshine leasehold and surrounding trails, as increased use and facilitated public access through gondolas and chairlifts may increase the spread of IAPs in sensitive alpine habitats. The majority of the 13 IAP species found (11) were located around Sunshine Village and at lower elevations along Healy Pass and Meadow Park Trails (Table 2). Six of these IAP species are considered high priority and will need to undergo management control.

Table 2. Invasive alien plants identified in the Sunshine area. Species listed in bold are considered high priority for control.

Invasive alien plants	Species name	Location	Control
Orange Hawkeed	Hieracium aurantiacum	Healy Pass West	Priority 1
Annual/Perennial Sow Thistle	Sonchus aspera or arvensis	Sunshine Village	Priority 2
Canada Thistle	Circium arvense	Sunshine Village, Area 15	Priority 2
Tall Buttercup	Ranunculus acris	Meadow Park, Sunshine Village	Priority 2
White Cockle	Silene latifolia	Citadel South	Priority 2
Oxeye Daisy	Leucanthemum vulgare	Sunshine Village, Area 15	Priority 3
Common Dandelion	Taraxacum officinale	Healy Pass East, Mid Healy Pass, Healy Pass West, Mid Simpson Pass, Simpson Pass East, Meadow Park, Twin Cairns, Sunshine Village, Area 15	Priority 3
Field Pennycress	Thalspi arvense	Sunshine Village	Priority 3
Pineapple Weed	Matricaria discoidea	Sunshine Village	Priority 3
Plantain	Plantago major	Sunshine Village	Priority 3
Tansy Mustard	Descruainia pinnata	Sunshine Village	Priority 3
White clover	Trifolium repens	Healy Pass East, Meadow Park, Sunshine Village	Priority 3
Dock	Rumex spp	Sunshine Village	Priority 3

Orange hawkweed (*Hieracium aurantiacum*, priority 1), was found near Healy Pass and white cockle (*Silene latifolia*, priority 2), was found on Quartz Hill along the Citadel Pass Trail. Within the Sunshine leasehold three priority 2 species were identified (sow thistle, Canada thistle, tall buttercup) as well as oxeye daisy, which is priority 3 but is of increased concern within alpine environments.

To complement IAP surveys and monitor potential avenues of IAP propagation, we assessed the extent of trampled vegetation and bare soil within trailside IAP transects. Of all the trailside sites surveyed (38), an average of 75% have trampled vegetation and 28% have bare soil, whereas control sites away from trails have no trampling and only 2% bare soil.

Wildlife conditions

Wildlife Species-At-Risk (SAR) documented in the SMP area include the *Threatened* Westslope cutthroat trout, found at Healy Lake-2, and the *Endangered* Little Brown Myotis, in the vicinity of Sunshine Village (Table 3). Bull trout (COSEWIC - recommended as *Threatened*) have also been documented in Healy Creek downstream of the Sunshine parking lot. Other mammals of concern documented in the SMP area include grizzly bear, wolverine and American badger (all COSEWIC-listed), and the lynx (listed in Alberta as *Sensitive*). Other sensitive mammals inhabiting the area include mountain goat and bighorn sheep. Birds of concern that have been observed in the SMP area include the Clark's Nutcracker and the Golden Eagle, both of which are listed as sensitive species in Alberta. SARA-listed Olive-sided flycatcher (*Threatened*) have been observed at Whistling Pass, within the Sunshine/Egypt Landscape Management Unit (LMU), and it remains possible this species is present within the SMP area, due to the presence of similar habitat.

Table 3. Species of concern in the SMP area.

Species	Listing	Most recent observation
Little brown myotis	SARA; *Endangered*	2017
Westslope cutthroat trout	SARA; *Threatened*	2006
Bull trout	COSEWIC; *Threatened*	2006
Grizzly bear	COSEWIC; *Special Concern*	2017
Wolverine	COSEWIC; *Special Concern*	2014
American badger	COSEWIC; *Special Concern*	mid-1980's
Lynx	Alberta; *Sensitive*	1997
Clark's nutcracker	Alberta; *Sensitive*	2017
Golden Eagle	Alberta; *Sensitive*	2017

It is well understood that Healy Creek is an important wildlife movement corridor that connects the Bow and Vermillion Valleys (Heuer, 1998). The drainage is a moderate route with high quality habitat that allows a wide variety of species to move through the area, but is extremely restricted in the area adjacent to the parking lot and base of operations. Species known to use the corridor include grizzly bear, black bear, cougar, wolf, coyote, elk, bighorn sheep, moose, deer, as well as the occasional mountain goat, lynx, and wolverine.

Conflict between humans and wildlife are also a concern in the area, as increased human activity could result in more encounters with wildlife. Since 2005 there have been 49 human-wildlife occurrences between June and September on the Sunshine Road/parking lot and in the SMP study area. During this timeframe there was an average of four occurrences per year, with four and six incidents in 2016 and 2017, respectively. Occurrence 'type' has included observations, presence in human-use zones, wildlife attractants, injury, mortality and aggressive incidents. July has the highest number of human/wildlife conflict occurrences, accounting for 43% of all occurrences. Seventy-one (71%) percent of occurrences were grizzly-related (35), including 6 aggressive incidents since 2005.

Grizzly bear habitat security

The Grizzly Bear Habitat Security Model (GBHSM), implemented through the 2010 Management Plan, estimated a security value of 50.7% for the Sunshine/Egypt Landscape Management Unit (LMU) (Figure 2A). As the model incorporates levels of human use as one of its evaluation criteria it is important to continue to review and revise the human use information resulting from ongoing monitoring. Assessing the most current human use data against the GBHSM threshold of 100 events/month, we found that *Healy Pass Ridge* and *Eohippus Lake Trail* changed from unsecure to secure, while the *Wawa Ridge*, *Monarch Ramparts* and *Quartz West* unofficial trails changed from secure to unsecure, thereby adjusting the overall GBHSM value for the Sunshine/Egypt LMU to 51.7% (Figure 2B).

With the implementation of the Restricted Activity Order in August of 2016, human-use levels on these unofficial trails are expected to decrease to fewer than 100 events/month. If this expected change occurs, the percent of secure habitat for grizzly bears within the Sunshine/Egypt LMU would further increase to 52.5% (+1.8% from 2010) (Figure 2C). However, it should be noted that further monitoring needs to be performed to validate the assumptions of the GBHSM values for activity during the RAO. In particular, the Goat's Eye Road (Sunshine Leasehold) and the Monarch Ramparts unofficial trail have a level of uncertainty that require monitoring of human use levels to confirm their current status as 'secure'.

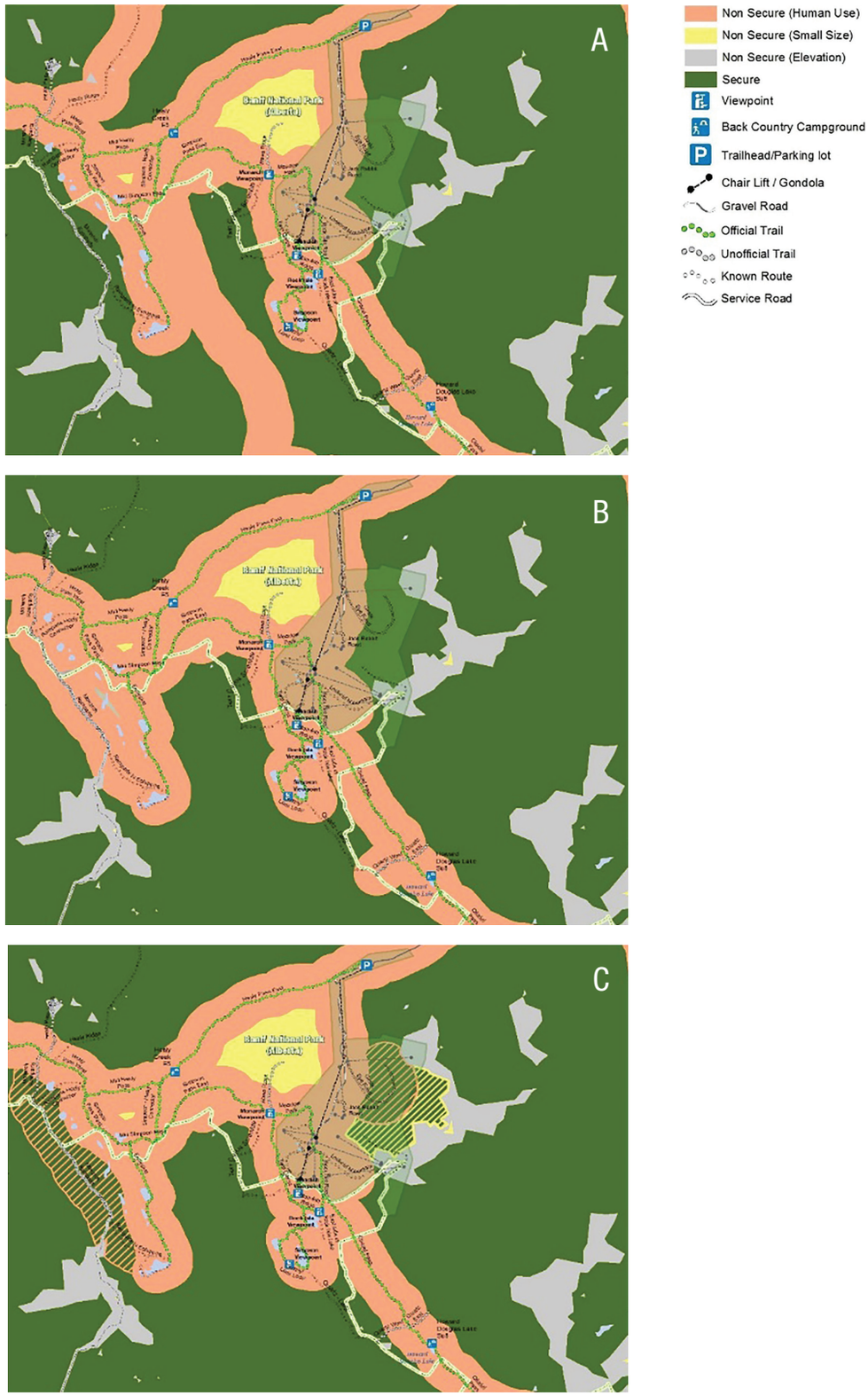


Figure 3. Grizzly Habitat Security in the SMP area reported in the 2010 Banff National Park Management Plan A, updated security B, and security with RAO in place and if Goat's Eye Service Road was considered non-secure (cross-hatching; C.

Discussion

Human-Use

Visitation and Access

Visitation at Sunshine Meadows has increased substantially during each of the past two years, since SSV resumed operation of the gondola and chairlift. Average daily visitation has also increased from 2016 to 2017, including on the days that only the gondola was operating. Furthermore, hotel operations at Sunshine Village began in the summer of 2017. Peak use on the service road to SSV was at 17:00, but there was traffic at all hours of the evening and night, as the service road is also used by staff residing in the village and was also used to transport guests arriving late. The increased visitation and evening operations at SSV (hotel/service road use) has the potential to both disturb wildlife during sensitive crepuscular and night periods, including Little Brown Myotis, and cause impacts to vegetation and trails over time. Temporal restrictions to reduce or constrain nocturnal use of the access road would reduce potential disturbance for wildlife.

Trail usage

Within the SMP area, trail usage is highest within the Sunshine Meadows, and more specifically, from the top of the Standish chairlift down onto Standish, Rock-Isle and Grizzly connector trails as well as on the Grizzly-Larix Loop and Rock Isle Road Trail, suggesting the chairlift improves access to these higher elevation trails. Although current trail use is diurnal, hotel operations have the potential to expand the period of human activity by increasing activities during evening and early morning periods. We expect that trails in the vicinity of the Sunshine Meadows, but outside of the leasehold, will also experience increases in usage, due to improved access to the area, by both day hikers and backpackers. Citadel Pass is of particular interest as some backpackers use this trail to access the popular backcountry area of Mount Assiniboine Provincial Park and would normally have to hike up the service road to reach the trailhead. It is possible that the gondola operations will improve access to this popular backcountry area. Similarly, Healy Pass is a popular day hike within Banff National Park, and gondola access to the Simpson Pass trail is expected to facilitate access to the Healy Pass and Egypt Lake area, given reduced elevation gain when accessing via Sunshine Village. Continued monitoring will help us understand if future trail restrictions are needed to constrain the effects of motorized access (gondola) within the leasehold (Zone III Natural Environment) in an effort to maintain the wilderness character Zone II Wilderness areas adjacent to the leasehold.

RAO Compliance

New to the RAO in 2017 was the exclusion of the Monarch Ramparts viewpoint from the official Trail offer. This segment runs just 350m from Healy Pass along a well-defined trail on the Monarch Ramparts cliff band to a viewpoint. It was thought that the inclusion of this short trail

segment within the official trail network in 2016 resulted in visitors continuing to hike along the Monarch Ramparts ridge and onto the unofficial trail, so the 2017 RAO was amended to improve compliance. In 2017 human use on this section of trail accounted for 75% of non-compliance of the RAO, though there was decreased activity overall. This also amounted to a reduction in the numbers of visitors further along the ridge. It is anticipated that compliance will improve in future years due to signage improvements, and efforts to reclaim vegetation in this area, however additional enforcement presence may also be required. Three of the unofficial trails within the SMP area also require restoration work to obscure their presence.

Trail conditions

None of the trails surveyed received a condition score of *good*, all received a score of *fair*, or worse. Overall, Sunshine-maintained trails scored better than Parks Canada-maintained trails. Sunshine Village is actively maintaining trails within the leasehold: in 2017 Sunshine staff were putting down new gravel, managing gravel spills off trails onto vegetation, replacing decaying wooden retaining logs and erecting rope barriers at common off-trail use areas to prevent trail widening and erosion. Parks Canada-maintained trails received moderate to poor scores largely due to effects of past horse use and generally wet conditions. Re-routing of the Citadel Pass Trail (*poor*) to avoid wet meadows[1] and slopes near Howard Douglas campground would stop additional damage to vegetation and soils in the area. For the trails surveyed in 2017 (*12 of 18*), average trail widths did not change from that observed in 2016. As trail conditions are not expected to undergo major changes from year to year, but over a period of several years, this result is not surprising. We will continue monitoring to ensure trail conditions are not deteriorating, with increased human-use in the SMP area, over time.

Vegetation

Rare plants

The identification of rare plants trailside in the SMP area (Simpson Pass Trail) provides support to maintain the off-trail travel restriction (RAO) in the SMP area. Additional rare plant surveys could identify additional species, vegetation communities and locations of concern. Whitebark Pine, a species at risk, are being managed through the Banff National Park Multi-Species Action Plan (Parks Canada Agency, 2017).

Invasive Alien Plants

The identification of six priority invasive alien plant species highlights the importance of control work in the Sunshine Village Leasehold and surrounding areas to eliminate current occurrences

1 Developing new connector trails to concentrate hiking away from wet meadows is a key action for the Main Ranges Area (Parks Canada Agency 2010).

and prevent their spread to nearby alpine locations. Continued monitoring of trailside IAP sites will be crucial in identifying the appearance and spread of IAP to trampled/bare soil sections of the Sunshine Meadows trails over time.

Wildlife

Species at risk are being managed through the Banff National Park Multi-Species Action Plan (Parks Canada Agency, 2017). Due to the identification of Little Brown Myotis (SAR, *Endangered*) in the SMP area in 2017, additional surveys will be required to assess population status and local habitat requirements, particularly the potential presence of hibernacula and/or maternity roosts. This information will be key for maintaining distribution and protecting habitat for this species (Parks Canada Agency 2017; see also "Little Brown Myotis/Northern Myotis"). Continued monitoring of bird species' presence will be key in identifying presence or absence of olive-sided flycatcher within the SMP area as well as additional birds of concern previously observed, particularly around Sunshine Village operations. Local populations of Westslope cutthroat trout are also expected to be protected under the RAO. Activity on the roads and the trails increase the risks of wildlife disturbance, human-wildlife conflicts and wildlife vehicle collisions. Of particular concern is the use of the Sunshine Service Road during all hours of the day and night, which may cause conflict during the crepuscular periods of the day when wildlife activity is known to be greater. Additionally, with hotel operations having started in the summer of 2017, visitors and staff now have greater ease of access to the area outside of gondola operating hours (08:00 to 18:00). Continued monitoring of wildlife occurrences will be key to understanding impacts to wildlife due to increased human use in the area and monitoring of wildlife trails will help to fill knowledge gaps on off-trail wildlife activity.

Grizzly bear habitat security

Compliance with the RAO was an issue on Monarch Ramparts in 2017, and this is expected to improve in 2018 with improved/permanent signage and remediation of unofficial trails. Continued monitoring will confirm the effectiveness of the RAO in decreasing the amount of human-use on unofficial trails such as the Monarch Ramparts, and will also confirm the human activity level in the Goat's Eye area within the Sunshine Leasehold. Upon completion of future human activity monitoring we will be able to properly reassess the status of grizzly bear habitat security in the Sunshine/Egypt LMU. We will need to complete further monitoring to confirm improvement to habitat security along this ridge.

Given that "motorized access and circulation" is not permitted in Zone II Wilderness, a key concern is the potential for use of Zone III areas within SSV leasehold to have a spill-over impact into Zone II wilderness areas nearby. Now that hikers can use the gondola to quickly and effortlessly access the alpine at SSV (elev. 2,200m), we anticipate increased overnight use in areas like Egypt Lake, through connector trails such as Simpson Pass Trail, which provides access to Healy Pass (elev. 2,330 m) and Egypt Lake with minimal elevation gain compared to

starting at the parking lot trail head (elev. 1,400m). Accessing Egypt Lake backcountry campsite by way of SSV, reduces the elevation gain for overnight hikers by 800m (>2,600ft); which is significant when carrying a large pack. Parks Canada will continue to monitor use in these adjacent areas, to determine if operations permitted on the SSV leasehold are impacting grizzly bear habitat security, water quality, or other factors, within the leasehold and/or in adjacent Zone II Wilderness areas.

Conversely, if human use patterns were to shift so that most hikers began accessing Healy Pass & Egypt Lake area via Sunshine Meadows (gondola assisted), such that the levels of use on the Healy Pass Trail dropped below 100 users per month, this could result in a significant benefit for grizzly bear habitat security, as that trail segment, and the yellow zone south of it (Figure 3) would all become "secure" habitat for grizzly bears. An alternate way to achieve similar results would be to eliminate the Simpson Pass connector trail, so that the only way to access Healy Pass is the northern route from the Sunshine base parking lot.

Finally, additional enforcement effort is needed to eliminate unlawful use of mountain bikes in this area. Monitoring revealed a pulse of unlawful biking immediately following the end of the operating season each fall.

Acknowledgements/Partners

Sunshine Ski Village, British Columbia Parks, Tannas Conservation Services Ltd, Tierra Environmental Consulting.

Volunteers: Alison Andrews, Anne Landry, Hugh Johnson, Jodi Conuel, Ken Hill, Lynn Brown, Mitch Brown, Nancy Ulrich.

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
P: (250) 347-6171
E: *derek.petersen@canada.ca*

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Traffic Levels on the Bow Valley Parkway, Golf Course Road and Norquay Road

Introduction

Human use activities have the potential to disturb wildlife (Knight, 1995; Cole & Landres, 1996; Duke et al. 2002; Hebblewhite et al. 2005). In particular roads can have a negative impact on large animals specifically where species show avoidance of traffic disturbance or where vehicle/wildlife collisions can occur. This avoidance behaviour may result in direct wildlife injury/mortality or a reduction in the animal's access to high quality habitat (Rogala et al. 2011, Lesmerises et al. 2013, Mace et al. 1996, Gibeau et al. 2002, Chruszcz et al. 2003, Waller and Servheen 2005, Northrup et al. 2012). Furthermore large carnivores such as bears and wolves have been shown to change their diurnal movement patterns by travelling near roads at night, thereby reducing their probability of encountering people (Percy 2003, Theuerkauf et al. 2003, Hebblewhite and Merrill 2008, Northrup et al. 2012, Ordiz et al. 2014). The impact of these avoidance patterns has a greater effect where roads are located within sensitive wildlife corridors or important habitat areas (i.e. montane ecosystem).

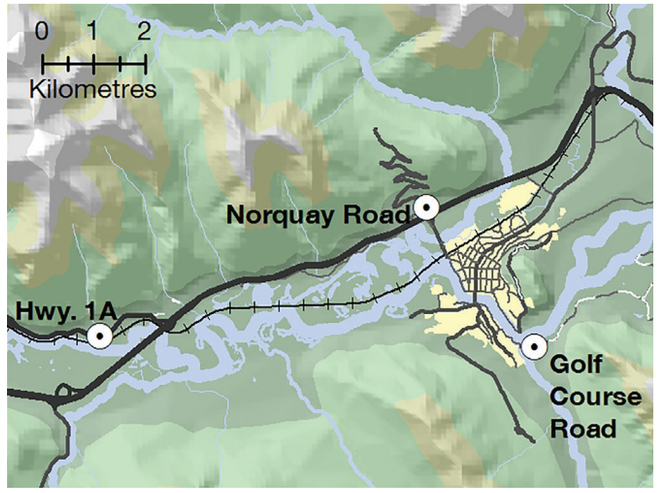


Figure 1. Location of Traffic Road counters around the Town of Banff including Bow Valley Parkway (Hwy 1A), Norquay Road and Golf Course Road.

Management actions, including modifying human use patterns, can have a positive impact on wildlife populations (Hebblewhite et al. 2005; Duke et al. 2002). Seasonal travel restrictions can be used as a management tool to reduce the impact of human activity, particularly during important crepuscular and evening periods. Currently two seasonal travel restrictions exist within Banff National Park: Bow Valley Parkway (BVP) and Golf Course Road. The latter only restricts vehicles, whereas the Bow Valley Parkway travel restriction applies to vehicles, bikes and foot traffic. A third traffic management effort is in place on the Mt. Norquay road, where the ski area operator is attempting not to exceed traffic volume thresholds, by offering public transit, as a requirement of the environmental assessment for approval of summer use at this ski hill.

Monitoring changes in vehicle activity is the key measure used to infer changes in habitat security for wary wildlife. Changes in vehicle traffic volumes may be attributed to changes in park attendance, response to localised development or visitor opportunities. Monitoring these activities is important to understand the relationship between vehicle traffic and the maintenance of ecological integrity.

Objectives

Measure vehicle activity to:

1. Assess the effectiveness of the Bow Valley Parkway seasonal travel restrictions,
2. Assess the effectiveness of the Golf Course Road vehicle travel restriction and
3. To monitor traffic volumes to determine if the Norquay Road remains below the threshold agreed upon in the Mt. Norquay Ski Area Site Guidelines for Development and Use (Parks Canada, 2011).

Seasonal Road Restrictions

1 Bow Valley Parkway seasonal travel restriction

Initially a voluntary spring travel restriction was implemented from 1998 to 2013 along a 17 km section of the Bow Valley Parkway from the east entrance to the west end of the Hillsdale split. Restriction times were specified from March 1st to June 25th daily from 6 pm to 9 am. The purpose was to reduce wildlife disturbance in this ecologically important area during the spring when most wildlife species den, calve, and have young to feed and higher elevation habitat is snow covered. After 15 years, Parks Canada concluded that a voluntary restriction was not effective. In 2014, following extensive evaluation and consultation Parks Canada implemented a mandatory travel restriction preventing any use of this portion of the roadway between 8 pm to 8 am from March 1st to June 25th. This restriction occurs annually and incorporates automated gates and signage as well as active compliance and enforcement. The mandatory travel restriction does not prevent access to Johnston Canyon or any overnight accommodations; which are all accessible via Castle Junction. We use vehicle traffic patterns to assess the effectiveness of voluntary and mandatory restrictions from 2010 to 2017. For further information on wildlife response to the mandatory restriction period see the State of Park Report (SoPR) “Bow Valley Parkway Travel Restriction”.

2 Golf Course Road seasonal vehicle travel restriction

The Banff town site is surrounded by four key wildlife corridors that support major wildlife movement through the Bow Valley. The Golf Course Road loops though one of these important wildlife corridors. Since 1997, Parks Canada has restricted vehicle traffic from November 1 to May 1 to improve habitat security. During the vehicle travel restriction, foot and bike traffic is permitted to access ice climbing routes further east, and vehicle access is allowed for employees of the Fairmont

Banff Springs, the Town of Banff, and Parks Canada for operational purposes. In 2016, in response to poor compliance in keeping the gate locked, Parks Canada installed an automated gate with an electronic swipe card system to ensure the gate remained closed and to record the time, date and organisation accessing the area. We use traffic road counters and gate logs to assess vehicle use before and after the introduction of the drop-down gate; and to monitor use during crepuscular times of the day through the winter period (Nov- March 4 pm-9 am; April 8 pm-8 am).

3 Mt Norquay Summer Operations

In accordance with the expansion of summer operations at Mt Norquay ski hill, threshold vehicle limits were established to reduce the frequency and number of disturbances through the Cascade wildlife corridor. As specified in the Mt Norquay Site guidelines (Parks Canada, 2011) and Mt Norquay's Long Range Plan (LRP) (Mount Norquay, 2013) the goal is to limit "nighttime" traffic events to less than 25 events per hour from 6 pm to 9 am during the period June 1st to August 31st. From September 1st to October 31st the critical time period changes to 5 pm to 9 am. We examine traffic data to determine if the Norquay Road remains below the thresholds established in the Site Guidelines, LRP and associated environmental assessments.

Methods

We used in-road magnetic road counters (Gold River) managed by DataWest and Cornerstone Solutions Inc. to collect and process traffic counts along the Bow Valley Parkway, the Norquay Road and the Golf Course Road. Traffic counters calculate vehicle usage for either total or inbound/outbound volumes on an hourly, monthly or seasonal basis.

The Bow Valley Parkway counter is located 0.6 km along the Bow Valley Parkway west of the intersection with the TransCanada Highway (approximately 10 km north of the Town of Banff).

The Norquay counter is located along the Norquay road 0.3 km north of the intersection of the Norquay Road with the Trans Canada Hwy. This counter is located down-hill from the "green spot" viewpoint and will also include visitors accessing this site. Due to problems with the counter installation this counter did not record data in 2011 or 2012.

Golf Course Road vehicle activity was documented using the key card entries that show user and user group details. User groups include Parks Canada, the Town of Banff and the Fairmont Banff Springs whose golf course caretaker resides within the restricted area. A road counter, installed in 2015 is located approximately 0.3 km along the road past the gate. We are not able to determine the extent of travel along the Golf Course Road past the counter, however the operational activities within this area include the Town of Banff sewage plant, and summer use of the Fairmont golf course and club house.

Annual visitor usage within the Mountain Parks is calculated arithmetically based on traffic counter data volumes, six gate counters (located throughout the mountain national parks) and in accordance with results outlined in the Mountain Parks Visitor Survey report (Parks Canada, 2003).

Results

1 Bow Valley Parkway

There was a notable decrease in total traffic activity along the Bow Valley Parkway from 8 pm to 8 am following the introduction of the mandatory travel restriction in 2014 (Figure 2). The average vehicle activity declined from ~37 (voluntary) to ~8 (mandatory) vehicles per day during the hours of the restriction when it became mandatory.

Traffic volumes were highest in 2012 with 4,293 vehicles recorded during the restricted time period (8 pm – 8 am). Traffic volume was lowest in 2014 with 637 vehicle recorded during the restricted period. In all years monthly traffic volumes were highest in June.

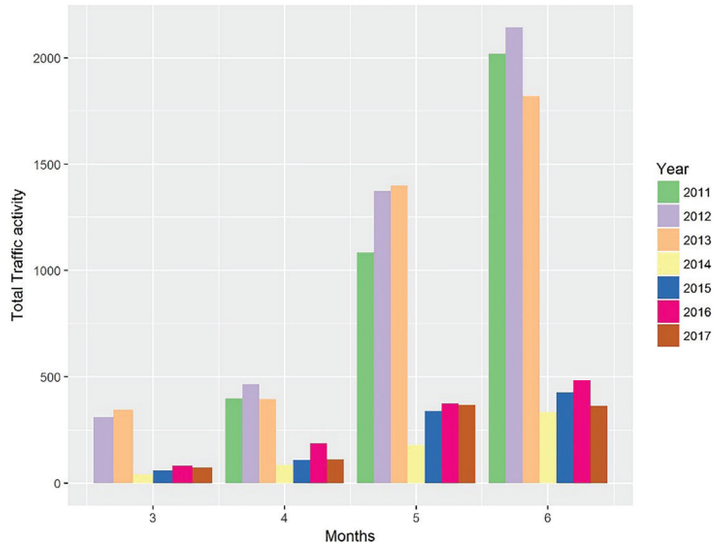


Figure 2. Monthly Bow Valley Parkway usage during the nocturnal restriction period (8pm to 8am) from 2011 to 2017. Months are designated numerically, i.e. March is 3. The restriction took effect in 2014.

In general, hourly traffic activity declined rapidly following the introduction of the mandatory restriction. For example during the first hour of the restricted period (20:00-21:00) traffic activity decreased by 50% as compared to the previous hour (19:00 -20:00) (Figure 3). Whilst in the second hour of the restricted period (21:00-22:00) traffic activity dropped sharply with a reduction in 92% of vehicle activity as compared to the proceeding hour. This pattern did not occur in years when the travel restriction was voluntary. Non-compliant vehicle counts include Parks Canada operational and enforcement vehicles.

Two patterns in traffic use are evident when comparing hourly average traffic use between the voluntary and mandatory restriction periods (Figure 3).

- Firstly, vehicle use increased during the day (8am – 8pm) following the implementation of the mandatory restriction (2014 – 2017). Before the mandatory vehicle restriction (2011-2014) the maximum average number of vehicle per hour was ~ 175. This increased to a maximum of ~250 vehicles per hour after the mandatory vehicle restriction was implemented.
- Secondly during the restriction period (8pm -8am) vehicle activity decreased from an average of 6.7 vehicles per hour (2011-2013) to 2.1 vehicles per hour during the mandatory restriction (2014-2016).

Enforcement of the restriction period by Parks Canada continues to ensure that visitors are adhering to the mandatory vehicle restriction. In 2017, Warden Service staff investigated 39 incidents and processed 16 charges.

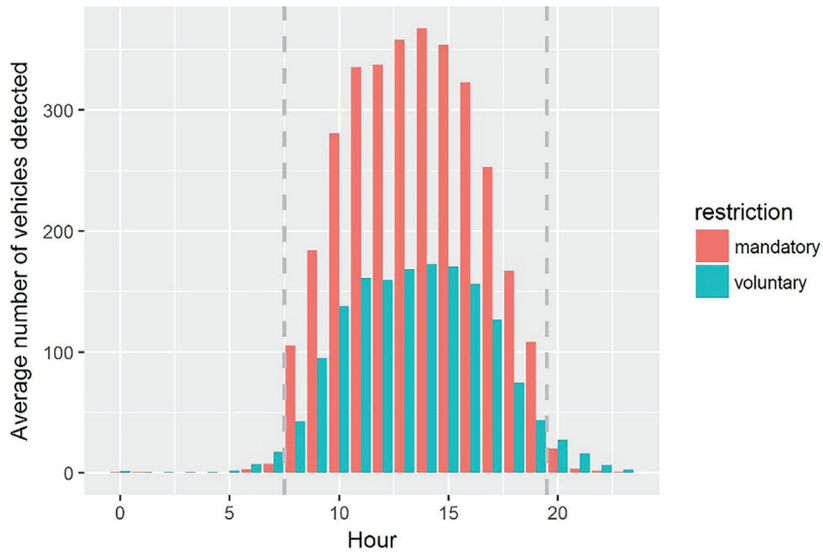


Figure 3. Average vehicle use per hour along the Bow Valley Parkway during the voluntary restriction (2011 – 2013) and during the mandatory restriction (2014-2017).

A comparison of hourly vehicle traffic activity during the restricted period also indicates notable changes in use before and after the introduction of the mandatory restriction (2014) (Figure 4). Total traffic counts during the voluntary restriction (2011-2013) showed traffic activity was evident at all hours with the highest activity recorded at 20:00. Traffic activity was consistently lower during each of the restricted hours (8 pm-8 am) when comparing the voluntary and mandatory restriction periods (Figure 4).

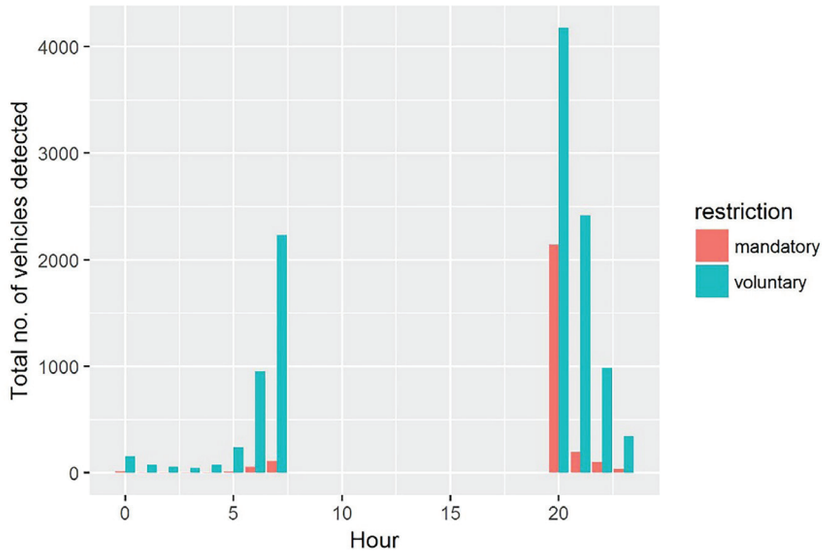


Figure 4. Total vehicle use along the Bow Valley Parkway for three years prior to (2011 – 2013) and after (2014 – 2016) implementing the mandatory travel restriction. Vehicle detections when the road was open (08:00 – 20:00) are not shown.

2 Golf Course Road

Annual vehicle usage:

Patterns in vehicle usage over the entire year highlight the reduction in traffic volume on the Golf Course Road during the vehicle travel restriction period of Nov 1 to May 1 (Figure 5). Data collected from 2015 and 2016 show highest vehicle traffic occurs in July and August.

In 2016 high traffic numbers were also recorded in September with over 30,000 vehicles recorded over the month (Figure 5.).

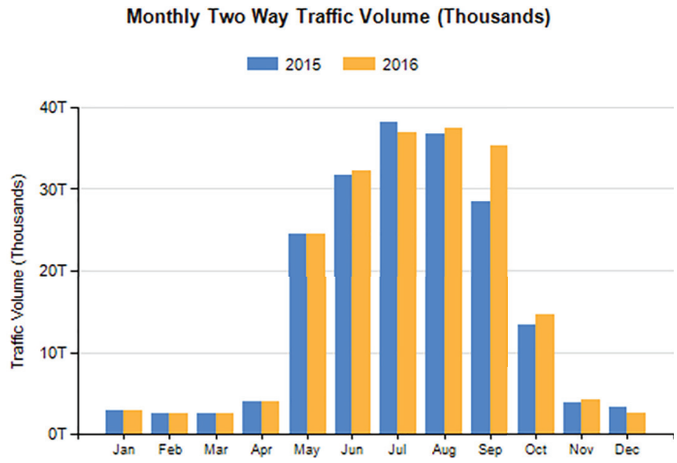


Figure 5. Traffic volume on the Golf Course Road (2015 to 2016) per month.

During the restriction period monthly vehicle use was below 5,000 per month with total traffic counts for the entire restriction period below 10,000.

Vehicle Travel Restriction period: Total traffic during the Vehicle Travel Restriction was similar for the manual swing gate and hand lock in 2015/2016 (8082 counts) and the automated drop down and card swipe gate in 2016/2017 (8139 counts).

During the restricted period (Nov-March 4pm-9pm and April 8pm-8am) the two most frequent road users were the Fairmont Chateau Banff Springs Golf Course and Town of Banff (Figure 6) with minimal use by Parks Canada resource conservation, land use planning and law enforcement staff.

During 2016/2017, when the swipe card/swing gate was in place, the town of Banff staff used the Golf Course Road on 1,656 occasions with an average of 15 visits per day with ~6 (40%) occurring within the restricted period. Fairmont staff accessed the road on 2,894 occasions with an average of 25 visits per day and ~9 visits (36%) occurring within the restricted period. During this time a 'visit' indicates each entrance occurrence (vehicle exits were not recorded) which may consist of one or more vehicles per entrance.

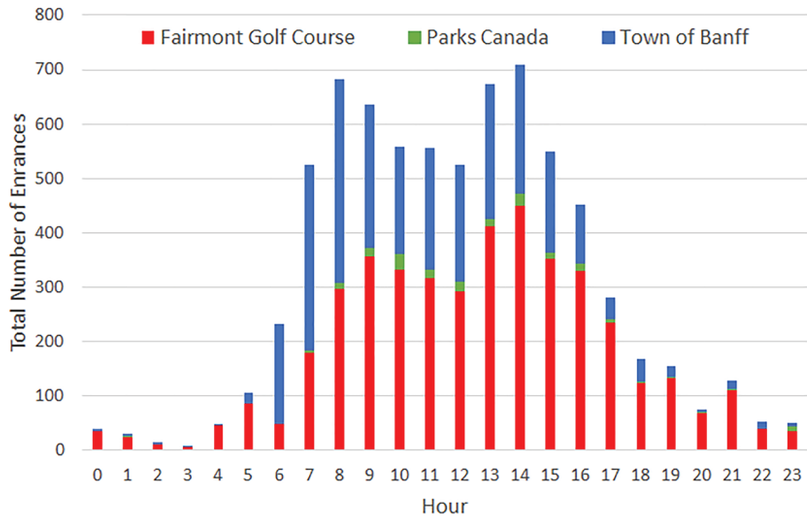


Figure 6. Total Golf Course road usage (hourly totals) by organization 2016 – 2017 during the restricted vehicle activity closure.

Over the restriction period the majority of vehicle uses occurred between 7am and 4pm (Figure 6.) with the lowest use period recorded from midnight to 4 am (< 50 vehicles per hour).

3 Norquay Road

Total traffic usage on the Norquay road increased from 224,350 (2009) to 322,903 (2016) based on annual two-way traffic counts. The year-to-year change in vehicle usage is presented in Figure 7. Note in 2011 and 2012 counter data along the Norquay road were not recorded due to a counter malfunction.

The percent change in vehicle usage along the Norquay road varied from 1% to ~10%. Visitor use of the Norquay Road between 2014 and 2016 increased at a similar but slightly lower rate as compared to total visitation within the park (Fig. 7). It is likely that the overall decline in visitor attendance in 2013 was related to severe flooding in that year.

Daily Threshold Limits:

Based on Mt Norquay Ski Area Site Guidelines for Development and Use Environmental Assessment (Parks Canada, 2011), a target threshold of 25 vehicle 'events' per hour was set for the crepuscular/evening hours in June - August (6 pm to 9 am) and in September and October (5pm to 9 am). Traffic counter results show that this threshold was exceeded during 10 – 16% of the total hours within the target time period in the peak of summer and 7 – 11% of the total target hours in late summer (Table 1). The total hours with vehicle events greater than target, increased each year from 2014 to 2016. This may be in part to the patterns of generally increasing park vehicle attendance as seen in Figure 7. The greatest period in which the threshold was exceeded occurred between June and August 2016 where greater than 25 vehicle events were exceeded on 226 hours.

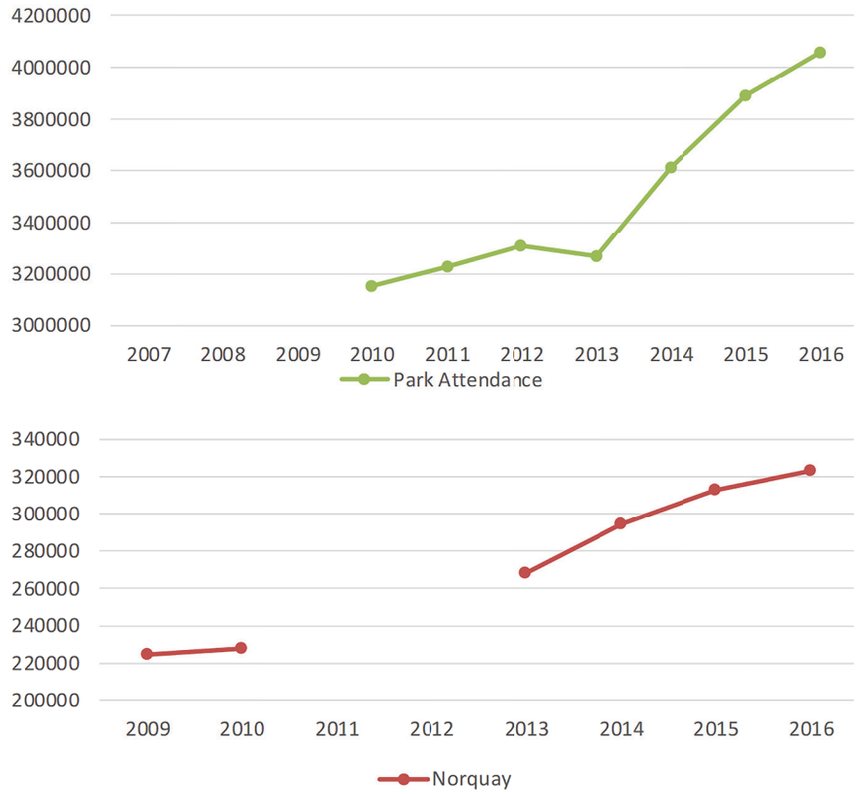


Figure 7. Total Park Attendance (2010-2016) and vehicle use along the Norquay road (2009-2016). Note: Data were not collected in 2011 and 2012 along the Norquay Road due to a counter malfunction.

Table 1. Total and percentage of hours during which the threshold (25 cars per hour) was exceeded along the Norquay road from 2014 to 2016.

Year	Date	Total hours Exceeded	% Hours Exceeded Threshold
2016	Jun 1 - Aug 31 6pm - 9am	226	16
2015	Jun 1 - Aug 31 6pm - 9am	205	15
2014	Jun 1 - Aug 31 6pm - 9am	144	10
2016	Sep 1 - Oct 31 5pm - 9am	112	11
2015	Sep 1 - Oct 31 5pm - 9am	85	9
2014	Sep 1 - Oct 31 5pm - 9am	66	7

Discussion

Managing the impacts of vehicular activity on wildlife is important especially within wildlife corridors or at important times or in key habitat locations. Traffic counters provide a useful tool to understand the patterns of vehicle activity and to assess the effectiveness of management actions taken.

The results from the monitoring program along the Bow Valley Parkway highlight changes in human use over time. Vehicular activity results clearly show that changing the parameters of the travel restriction from voluntary to mandatory resulted in a significant reduction in vehicle use during the restriction's crepuscular and evening time periods. The increased traffic midday may reflect a shift in time of use, but more likely reflects overall increases in total use during this time period. This pattern emphasizes the importance of proactively managing visitor use when numbers are relatively low because this allows for minimal impacts to visitors. Further research documenting wildlife responses to these reduced vehicle levels are documented in the Bow Valley Parkway Travel Restriction elsewhere in this Technical Summaries report.

Vehicle activity was reduced along the Golf Course Road during the restricted vehicle travel period. However, we were not able to determine the extent of decrease prior to gate restrictions due to a lack of pre-restriction monitoring. Winter conditions, such as snow or seasonal differences may have also contributed. We saw minimal difference in usage between gate types in 2015 (manual swing gate/hand lock) and 2016 (auto-drop gate/card lock). However, the new card lock system allows for the clear identification of activity levels and user groups. This information will be important in understanding the scope of operational use of the road.

Furthermore results show activity is largely concentrated in the middle of the day with less vehicles accessing the area during the crepuscular/evening periods.

Traffic data from the Norquay road illustrated that the established vehicle targets were exceeded by varying degrees across the monitoring period. It is worth noting that "Norquay" traffic also includes park visitors who may only be accessing the "green spot" lookout. The exceedances of the vehicle targets has the potential to negatively influence wildlife use of and movement through the area. Other transportation solutions may be considered in order to reduce vehicle traffic and meet established targets.

Acknowledgements/Partners

Rob Osiowy, Integrated Land Use Planning and Policy, Banff National Park

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
T: 250-347-6171
E: *derek.petersen@pc.gc.ca*

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Wastewater Treatment Plant Monitoring

Introduction

Maintaining the ecological integrity of ecosystems is a key mandate of Parks Canada. Riverine systems may be adversely affected by human activity from non-point and point sources. One point source within Banff National Park is the effluent discharged from waste water treatment plants. Effluent that is treated and then discharged into riverine systems has the potential to increase nutrient concentrations which can stimulate growth of algae on the riverbeds and indirectly cause changes in benthic macro invertebrate (BMI) communities (Bowman et al., 2005a,b). Two wastewater treatment plants operate in Banff National Park that discharge treated effluent directly into the Bow River. These are a Parks Canada operated plant at the village of Lake Louise and a Town of Banff operated plant located just downstream of the town near the Banff golf course. A third privately operated wastewater plant at Sunshine Village ski hill discharges effluent into Sunshine Creek, which flows to Healy Creek, Brewster Creek and eventually the Bow River. All other systems in Banff National Park discharge to ground (septic field), or are pumped and transported to a wastewater treatment plant.

To identify the influence that human activity has on river systems, scientists use biological communities (e.g., benthic algae, benthic macro invertebrates, fish) to monitor the condition of surface waters (i.e. biomonitoring; Reynoldson et al. 1997). Monitoring programs based on riverine water chemistry and benthic macro invertebrates have been ongoing in Banff National Park since 1998 to determine the management effectiveness of the Banff and Lake Louise wastewater treatment plants (e.g. Bowman 2014).

From 1998 to 2013 the data collection for the monitoring program followed a modified Rapid Bio assessment protocol (Bowman, 2001) and was analysed using a *Test-Site Analysis* (Bowman and Somers 2006). The analysis compares a test site or sites downstream of the wastewater treatment plant to a reference site upstream of the wastewater treatment plant. Metrics for comparison were chosen based on how well they discriminated between upstream and downstream sites.

In 2014, the monitoring program was replaced by a Reference Condition Approach (RCA) model developed for the Mountain National Parks using the Canadian Aquatic Bio monitoring Network (CABIN) protocol to align with the parks' stream condition monitoring. The CABIN network is maintained by Environment Canada to support the collection, assessment, reporting and distribution of biological monitoring information.

Biological assessments using the Reference Condition Approach evaluate water quality by comparing the biological community at a test site to that at numerous reference sites. When the

structure of the benthic macro invertebrate community at the test sites falls within the range of natural variation at the suite of reference sites, it is deemed to be in reference condition. Conversely, if the structure of the benthic macro invertebrate community at the test sites falls outside of the range of natural variation at the suite of reference sites it is deemed to be divergent (e.g. outside of reference condition). The mountain national parks developed a predictive reference condition model in 2011 (Bailey and Reynoldson, 2011).

Here we report on the last decade of monitoring the Bow River (2006-2016) in the vicinity of the Lake Louise and Banff wastewater treatment plants. The two monitoring methods, test-site analysis and Reference Condition Approach, follow different collection protocols and the raw data cannot be directly compared. Therefore we report on the two methods separately.

Objectives

Monitoring Question

Are the Lake Louise and Banff wastewater treatment plants affecting/influencing water quality in the Bow River downstream of the effluent discharge pipe?

Metric

Test-Site Analysis (2006-2013)

The metrics selected for use in monitoring were based on the chemical and biological attributes that best discriminated between upstream reference and downstream impaired sites across the locations sampled. The chemical metrics included concentrations of total phosphorus and dissolved inorganic nitrogen. The biological metrics included abundance and nutrient content of benthic algae and the composition of benthic macro invertebrate communities (total abundance, % mayflies, and % chironomids).

CABIN Reference Condition Approach (2014-2016)

The metric for the Reference Condition Approach following the CABIN protocol is an ordination from a multivariate analysis based on the mountain national parks reference condition model. Sites can either be classified as similar or within reference, divergent or highly divergent from the reference condition model.

Thresholds

Test-Site Analysis

Metric values for each site in each year were compared to the metric values at the reference site using *Test Site Analysis* (Bowman and Somers 2006) to classify the sites into good ($p > 0.90$), fair ($0.90 > p > 0.1$), or poor ($0.1 > p$) condition.

CABIN Reference Condition Approach

Thresholds are based whether the sites are found to be within reference condition. The sites are classified as either poor (highly divergent), fair (divergent) and good (within reference).

Methods

The modified Rapid Bio assessment protocol (2006-2013) and RCA (2014- Present) programs monitored three locations for the Lake Louise and Banff wastewater treatment plants.

Lake Louise

- **US** – located 7 km upstream of the wastewater treatment plant and the Trans-Canada highway to monitor natural annual conditions of the river.
- **DS-1** – located 2 km downstream of the wastewater treatment plant.
- **DS-2** – located 13 km downstream of the wastewater treatment plant.

Banff

- **US** – located 0.5 km upstream of the wastewater treatment plant and approximately 5km downstream from the Water Survey Hydrometric Station.
- **DS-1** – located approximately 1 km downstream of the wastewater treatment plant.
- **DS-2** – located approximately 8 km downstream of the wastewater treatment plant at the east gates/park boundary.

From 2006 through 2013 researchers used the test-site analysis protocol (Bowman and Somers 2006) to determine the condition of each site and a Mann-Kendall trend test to determine the trend in condition over time up and downstream of Lake Louise and Banff wastewater treatment plants. They used a single site upstream as a reference and selected survey sites with similar physical characteristics. Researchers recorded field water quality measurements and collected water samples for laboratory analysis. They collected benthic macro invertebrate samples using three replicated 250 µm U-net collections. Detailed field methods are described in Bowman and Somers (2006).

Following the test-site analysis approach, we used a Reference Condition Approach following the CABIN biomonitoring protocol. Detailed CABIN field methods are available on the Environment Canada website: *http://publications.gc.ca/site/eng/422979/publication.html*. The U-net method was replace by the 3 minute travelling kicknet (400 µm). Bowman (2016) conducted a study to determine the variability between the two benthic macro invertebrate collection methods and determined the two methods were not directly comparable, therefore, the time series of data were started a new in 2014 for LLYK and 2015 for Banff.

Results

Lake Louise 2006 to 2013

Table 1 shows individual site classifications, using the Test Site Analysis, across all years from 2006-2013. The upstream site was classified as "good" (i.e. >90% probability site matches reference conditions). The site 2 km downstream of the wastewater treatment plant (i.e. DN-1) was classified as "poor" (i.e. <1% probability site matches reference conditions) and the site 13 km of the wastewater treatment plant was "good" again. This suggests a local impairment for at least 2 km downstream of the wastewater treatment plant, but conditions return back to reference by 13km downstream of the wastewater treatment plant

The slope from the Mann-Kendall Test indicates direction and average magnitude of change over time and the p-value specifies whether the trend is statistically significant (i.e., $p < 0.05$). The trend test for these metrics over time suggested that the upstream site was stable from 2006 to 2013 while the UP-1 and UP-2 sites were improving.

Table 1. The slope and p value from a Mann-Kendall Trend Test and for metrics upstream and at two locations downstream of the Lake Louise wastewater treatment plant from 2006 to 2013.

	Total P		DIN		Chlorophyll		BMI Abundance		% Mayflies		% Chiron.		Condition & Trend
	slope	p	slope	p	slope	p	slope	p	slope	p	slope	p	
US	0.2	0.19	1.6	0.39	0.0	0.69	-49.0	0.06	1.1	0.14	-0.6	0.20	Stable
DS-1	0.1	0.59	-0.1	1.00	**-4.1**	**0.01**	**-1759.0**	**0.00**	**1.9**	**0.01**	**-2.4**	**0.04**	Improving
DS-2	-	-	-	-	-0.2	0.34	**-186.9**	**0.01**	**1.4**	**0.02**	-1.6	0.11	Improving

Lake Louise 2014 to 2016

Table 2 shows individual site classifications, based on a comparison with the CABIN Reference Condition Approach, across all years from 2014-2016. The upstream site was within reference condition in 2014 and 2015, but mildly divergent in 2016. DS-1 was divergent in 2014 and highly divergent in 2015 and 2016. DS-2 was within reference in 2014 and 2015, but divergent in 2016. While additional years of data would be helpful for identifying trends, there is some evidence that sites are digressing in recent years. For example, benthic macro invertebrate abundance at DN-1 nearly doubles in from 2014 to 2015, and again from 2015 to 2016. The proportion of mayflies, an indicator of stream health, decreased from 2014 to 2016, while the proportion of chironomids (an indicator of impaired stream health) increased.

Table 2. Status summary of the three monitoring sites on the Bow River near Lake Louise, using the Mountain National Park reference model.

	US	DS-1	DS-2
2014	Within Reference	Divergent	Within Reference
2015	Within Reference	Highly Divergent	Within Reference
2016	Divergent	Highly Divergent	Divergent

Banff 2006 to 2013

Table 3 shows individual site classifications, using the Test Site Analysis, across all years from 2006-2013. The site upstream of the wastewater treatment plant was classified as "good" (i.e. >90% probability site matches reference conditions). The site 1 km downstream of the wastewater treatment plant (i.e. DN-1) was classified as "fair" (i.e. <90% probability site matches reference conditions) and the site 8 km of the wastewater treatment plant was "good" again. This suggests a local impairment for at least 1 km downstream of the wastewater treatment plant, but conditions return back to being in reference before 8 km downstream of the wastewater treatment plant

Changes in metric values over time at each site were evaluated with a Mann-Kendall Test. The trend test for these metrics over time suggested that US, DS-1 and Ds-2 were all stable across years from 2006-2013.

Table 3. The slope and p value from a Mann-Kendall Trend Test and for metrics upstream and at two locations downstream of the Banff wastewater treatment plant from 2006 to 2013. Overall Condition looks at significant trends in metrics and Bowman classification of ecological integrity (Green=Good; Yellow=Fair; Red=Poor).

	Total P		DIN		Chlorophyll		BMI Abundance		% Mayflies		% Chiron.		Condition & Trend
	slope	p	slope	p	slope	p	slope	p	slope	p	slope	p	
US	0.31	0.45	-0.83	0.55	-0.12	0.26	-54.67	0.27	0.36	1.00	-1.98	0.27	Stable
DS-1	0.67	0.62	-7.50	0.55	-2.21	0.17	-491.17	0.02	-1.34	0.39	-4.52	0.39	Stable
DS-2	0.09	0.90			0.00	1.00	-72.08	0.39	-3.04	0.05	-1.98	0.27	Stable

Banff 2015 and 2016

Table 4 shows individual site classifications, based on a comparison to the CABIN Reference Condition Approach, across all years from 2015 and 2016. The upstream site (US) was in reference in 2015, but highly divergent in 2016 (Table 4). DS-1 was divergent in both years (Table

4). DS-2 was more likely to be within reference, likely because it is 8 km downstream of any human use. The wastewater treatment plant effluent appears to be influencing benthic macro invertebrate abundance and composition immediately downstream of the wastewater treatment plant. For example, when compared to US, DS-1 and had elevated benthic macro invertebrate abundances. Whereas %Chironomids and %Mayflies at DS-2 were similar to US.

Table 4. Status summary of eight sites monitored in 2014-2016 using the Mountain National Park reference model.

Year	US	DS-1	Ds-2
2015	Within reference	Highly divergent	Divergent
2016	Highly divergent	Highly divergent	Within Reference

Discussion

Monitoring results from 2006-2013 demonstrated the effect of waste water effluent on benthic macro invertebrate communities in both Lake Louise and Banff. During this monitoring period, water quality at both US sites were consistently "good" according to the Test Site Analysis (Bowman 2016). Some impairment was seen at sites immediately downstream of both wastewater treatment plants. For example, Lake Louise water quality was deemed "poor" and Banff water quality deemed "fair" at both DS-1 sites. However, water quality returned to reference condition at both sites further downstream of the wastewater treatment plant (13 km downstream for Lake Louise and 8 km downstream in Banff).

A similar pattern was seen in both regions from 2014-2016 using the CABIN Reference Condition Approach. Both analyses suggest a local impairment downstream of both wastewater treatment plants. These sites were deemed "divergent" or "highly divergent" on the RCA scale. Again, the Reference Condition Approach identified that water quality returned to reference condition at further downstream sites with some anomalies (see below).

The Reference Condition Approach analysis from 2014-2016 did show some deviation from the expected pattern:

1. For Lake Louise, US was "divergent" in the latest year of the RCA analysis (2016). The site is approximately 400 m downstream of a railway crossing, immediately adjacent to an intermittently active construction yard, and approximately 50 m upstream of the TransCanada Highway. It is likely that the Bow River at this location is being affected by one or all of these developments and is therefore not considered pristine in the most recent year of monitoring results.
2. For Banff, US was "highly divergent" in 2016. This may be related to a larger zone of influence from upstream effects of the Town of Banff surface runoff during that year (See *Storm Water Management* in this State of Park Report Technical Summary).

The lake Louise DS-1 site was undergoing a general recovery trend from 2006 to 2013. This could have been the result of upgrades to the wastewater treatment plant in 2003. However, in 2015, DS-1 went from "divergent" to "highly divergent" and DS-2 went from "within reference" to "divergent" in 2016. This suggests a potential reversal of the recovery of macroinvertebrate communities seen from 2006-2013.

There is no evidence that local impairment from the Banff wastewater treatment plant is getting worse. Annual monitoring of both wastewater treatment plants will continue using the CABIN protocol and the Mountain National Parks reference condition model.

Acknowledgements/Partners

This monitoring program is not possible without the strong partnership with Environment and Climate Change Canada, in particular, Stephanie Strachan, Environmental Monitoring Scientist for Pacific, Athabasca Arctic Watershed. Garry Scrimgeour was instrumental in design and coordination of the 2007 and 2008 field campaign across seven mountain parks to complete the reference collection and subsequent predictive model development. Ghost Consulting completed the Mountain Park Model. Michelle Bowman conducted the water quality monitoring of the wastewater treatment plant until 2013.

Analysis: Jocelyn Hirose, Fonya Irvine, Wanli Wu. GIS Support: Josh Keitel. Taxonomist: Susan Salter. Water Chemistry Environment Canada Pacific Lab. Field collection 2015-2016. Shelley Humphries, Sierra Sullivan, Jocelyn Hirose, Megan Sakuma, Tina Deenik, Kyle Nelson, Fonya Irvine, Megan Goudie, Matt Rempel and Sophie Deluca.

Contact

Shelley Humphries, Aquaticc Ecologist
Lake Louise Yoho and Kootenay Field Unit
T: 250-347-6159
E: *shelley.humphries@pc.gc.ca*

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Whirling Disease Management

Introduction

Whirling disease was detected in fish from Banff National Park in August 2016. This was the first recorded case in Canada. Whirling disease is caused by an invasive myxozoan parasite, *Myxobolus cerebralis* (*Mc*), which is not native to North America (Sarker et al. 2015). It can cause physical deformities in salmonids and sometimes mortality (Figure 1; Sarker et al. 2015). Whirling disease is a "reportable disease" but does not affect people, other mammals, or even other species of fish outside the salmon family (trout, char, whitefish).



Figure 1. A juvenile salmonid from Johnson Lake in Banff, exhibiting symptoms of whirling disease, a black and bent tail.

Higher elevation water bodies in Banff National Park are home to the federally listed westslope cutthroat trout (Fisheries and Oceans Canada 2013) and provincially listed bull trout (COSEWIC 2012). Protecting these species from whirling disease is of critical importance to Parks Canada.

There are a number of potential vectors for transmitting whirling disease to new lakes/streams. Three vectors (fish, mud and water) can infect new water via: improperly disposed of fish; illegal stocking of fish; avian transport; transport of mud and water on boats and angling gear and watercraft; natural fish movement. In response to the disease, Parks Canada developed and implemented a 4 point action plan.

Objectives

1 Delineate – the distribution of whirling disease within Banff National Park.

2 Educate – Parks Canada staff and the public about whirling disease and prevention.

3 Prevent – the disease from spreading from areas that tested positive.

4 Protect – high elevation habitats of threatened species such as westslope cutthroat trout.

Methods

To delineate the spatial range of the infection, we lethally sampled salmonid fishes, by using electrofishing to collect those between 100-180 mm long. Testing was done using genomics and all positive results were later confirmed by the Canadian Food Inspection Agency (CFIA).

Education about the disease included print media, interpretation, signs and web material (Figure 2). We worked closely with provincial counterparts in Alberta and the CFIA to communicate effectively about this reportable disease, and to coordinate research and inventory efforts.

To prevent further spread of whirling disease, we briefly implemented area closures to prevent the human vectors from entering whirling disease-positive waters at Johnson Lake Reservoir, and established voluntary boat-wash stations to educate visitors and reduce potential vectors. We also implemented "catch and release only" on all park waters, except Minnewanka, to reduce the likelihood that whirling disease will be spread through the movement of dead fish, as fish are the most probable vector.

To protect native fish species, we closed public access to a number of pristine "core" waterbodies to reduce the likelihood of whirling disease spreading to these important pure westslope cutthroat trout populations. We are also completing a risk analysis of infection for high elevation westslope cutthroat trout by sampling for *T. tubifex* at key backcountry areas in Banff.

In 2017, Parks Canada started a fish eradication project to eradicate fish and subsequently whirling disease from the Johnson Lake reservoir. Without both fish and tubifex worms, to complete it's lifecyle, the disease cannot persist at Johnson Lake reservoir. This was a priority, not because we hoped to eliminate the disease entirely, but in an effort to reduce the probability of whirling disease spreading upstream to some very key westslope cutthroat trout areas in the Upper Cascade drainage.

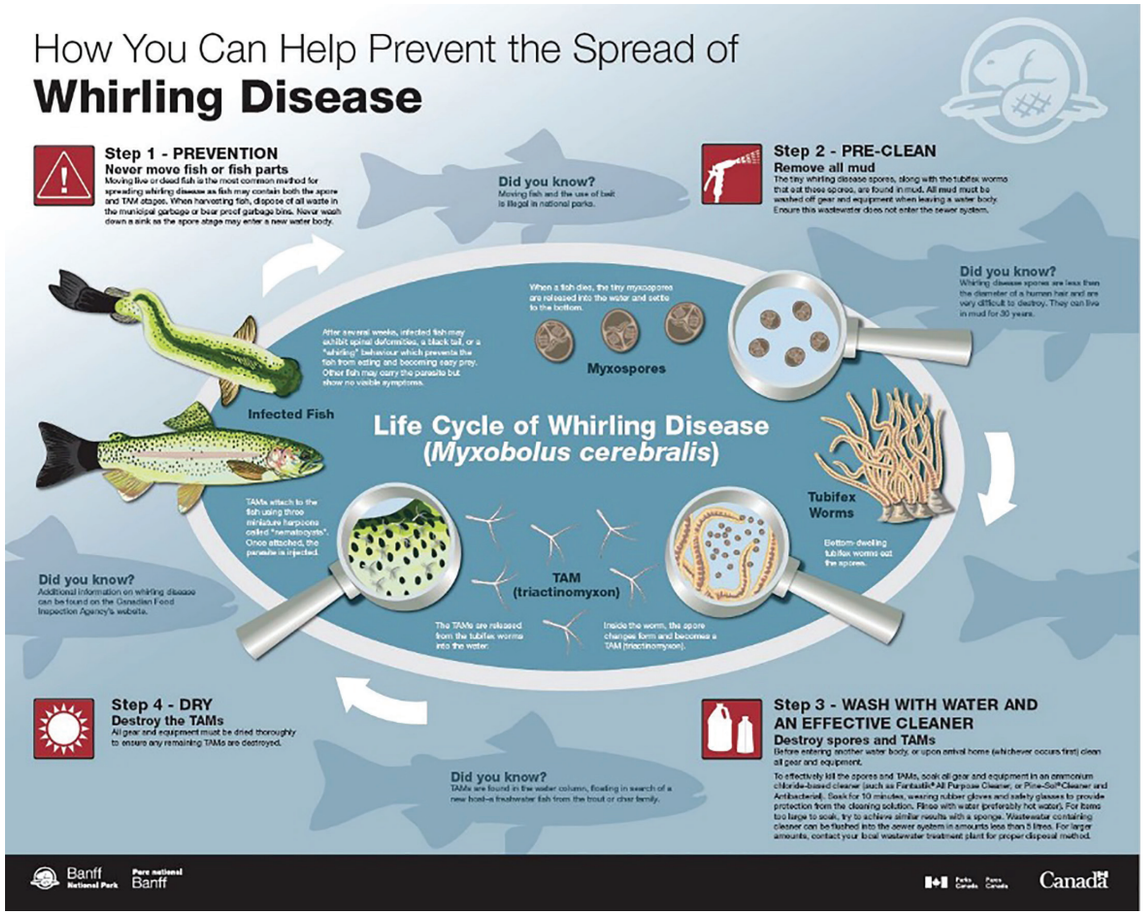


Figure 2. Whirling disease life cycle graphic developed by Banff National Park to help visitors understand how to prevent the spread of this non-native protozoan.

Results

We sampled 1508 fishes from many drainages throughout Banff National Park. We only detected whirling disease in Johnson Lake reservoir and the Bow River east (downstream) of Red Earth Creek in Banff National Park (Figure 3). However, because the affected area includes waters above Bow Falls, it is possible the entire upper Bow drainage is, or will soon be impacted.

We created and shared: a website page about the disease's life cycle and decontamination; educational inserts for the fishing brochure; media stories; and interpretive programming.

We initially closed Johnson Lake reservoir to people following the positive detection. The lake was subsequently re-opened during the winter of 2016/2017, because of positive detections throughout much of the Bow River watershed, however fishing is no longer permitted at Johnson Lake reservoir.

In 2017, Parks Canada removed 2,981 pounds of fish from Johnson Lake reservoir and 14,146

fish from the Johnson wetland through netting and electrofishing. During these removals, we documented brown trout in Johnson Lake reservoir, which were never lawfully stocked in this waterbody. Eradication work is ongoing in 2018.

We closed all pure westslope cutthroat trout populations in the Banff National Park (e.g. Marvel, Mystic, Sawback Creek and Lake, Cuthead Creek and Elk Lake). These populations will remain closed until we can assess the risk further. We are currently surveying the distribution of *T. tubifex* as a key risk factor for transmitting whirling disease. This is extremely challenging, as tubifex worms are patchy in their distribution, and therefore difficult to detect. If we are able to confirm that tubifex worms are not present in a waterbody, this eliminates the risk of whirling disease persisting, as one fish cannot infect another without the intermediate tubifex host.

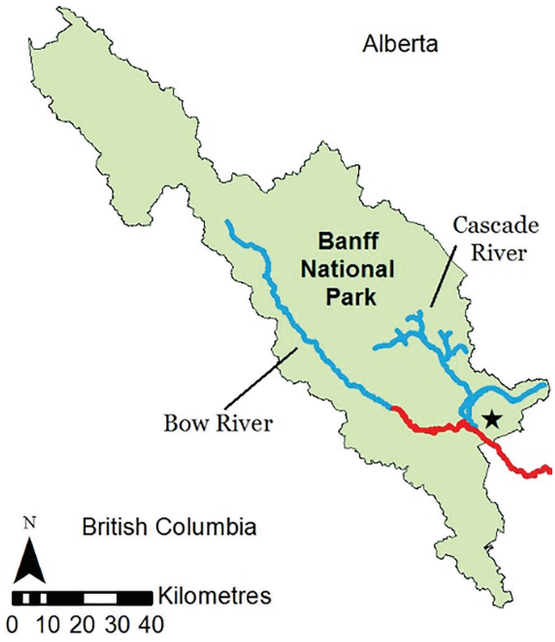


Figure 3. Map of Banff National park showing the main-stem Bow River and Cascade River. Areas that tested positive for whirling disease are highlighted in red. Johnson Lake reservoir is indicated by the star.

Discussion

Whirling disease was detected in Johnson Lake reservoir, Banff, AB, in August 2016. Parks Canada did extensive sampling to understand the distribution of the disease and only found positive results in Johnson Lake reservoir and the Bow River in Banff National Park (Figure 3). These water bodies are in the lowest elevation montane ecoregions in Banff National Park and are characterised, almost exclusively, by non-native fishes. The presence of non-native brown trout in Johnson Lake reservoir suggests that illegal fish stocking may have occurred in the past decade, as there is no record of brown trout ever being stocked in this waterbody. If so, this could be how whirling disease entered Banff National Park, as whirling disease has since been documented at several private fish farms in Alberta which may have been the source of brown trout lawfully purchased but then illegally introduced to Johnson Lake reservoir in Banff.

Higher elevation water bodies in Banff National Park are home to the federally listed westslope cutthroat trout (Fisheries and Oceans Canada 2013) and provincially listed bull trout (Alberta Sustainable Resource Development 2012). Protecting these species from whirling disease is of critical importance to Banff National Park. The proximity of Johnson Lake reservoir to the Cascade watershed is a concern to Parks Canada because the Cascade watershed contains almost half of the "core" populations in Banff National Park (Sawback Lake, Sawback Creek, Cuthead

Creek and Elk Lake; Figure 1). Because of this, Parks Canada took a precautionary approach and closed these "core" westslope cutthroat trout populations to all water-based activities (e.g. angling, boating, etc.), but will re-evaluate this following completion of a risk analyses which requires extensive inventorying to understand the current distribution of a key whirling disease host – the tubifex worm (*T. tubifex*).

Parks Canada is also evaluating its capacity to decontaminate potential vectors such as recreational equipment, angling equipment and construction equipment. Internal protocols for decontamination are achievable, but the effectiveness of education in mitigating various recreational and commercial/industrial vectors has not been evaluated. Parks Canada will continue collaborating with the province of Alberta to support regional education initiatives and with a broader-array of managers and researchers to share knowledge, conduct studies and mitigate effects.

Fish removals in Johnson Lake reservoir have proven challenging. Originally we planned to remove fish using mechanical methods (netting and electrofishing) and follow this up with a fall dewatering effort, however the contracting process for de-watering did not produce a successful candidate. Extensive fish removals have reduced risk by mitigating potential vectors (e.g. movement via piscivorous birds or illegal fishing), but will require considerably more effort to break the life cycle of whirling disease. Recent efforts have focussed on the wetland that flows into Johnson Lake reservoir in combination with winter netting under the ice.

Similar efforts on Cascade Creek, where whirling disease was also detected (just below Minnewanka Reservoir) may prove successful, as a combination of electrofishing and dewatering, that was already underway before whirling disease was discovered, has successfully removed non-native brook trout (whirling disease hosts) from this habitat.

Acknowledgements/Partners

University of Calgary
University of Alberta
Colorado Parks and Wildlife

Contact

Mark Taylor, Aquatic Ecologist
Banff Field Unit
T: (4030) 762-1418
E: *mark.taylor@pc.gc.ca*

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Wildlife Crossing Structures: Overpasses and Underpasses

Introduction

Roadways can act as a barrier for wildlife movement and migration in the Rocky Mountain National Parks. Of critical concern is the Trans-Canada Highway through Banff and Yoho National Parks. In 2016, average traffic volumes on the TCH were 22,688 vehicles per day, year-round, though the park; an increase of 6.1% from the previous year (with 34,356 per day in the July, an increase of 8.1% from 2015). As one of the most significant innovations in road ecology and public safety, Parks Canada developed wildlife crossing structures (both underpasses and overpasses) and exclusion fencing in the 1980's, as means to mitigate the impacts of wildlife/vehicle collisions and the barrier effects of the highway corridor (Figure 1).



Figure 1. Grizzly Bear using a wildlife underpass to pass under the TransCanada Highway in Banff National Park.

Objective

The objective of this project is to monitor the effectiveness of wildlife crossing structures along the TCH in Banff National Park (BNP) (Fig 2.) Specifically this monitoring uses remote cameras to detect and record large mammals (including carnivores, and ungulates) using the crossing structures. These data contribute to long term continuous research and monitoring within BNP that began in 1996 and was for many years designed and delivered by Dr. Tony Clevenger under contract to Parks Canada. In 2014, Parks Canada resumed monitoring these structures as an integrated part of a larger remote camera wildlife monitoring network.

Methods

Parks Canada Resource Management Officers monitor 44 wildlife crossing structures along the TCH using infrared motion-triggered remote cameras. The purpose is to quantify their effectiveness in maintaining habitat connectivity over time, for different species and life stages of animals. (Figure 2).

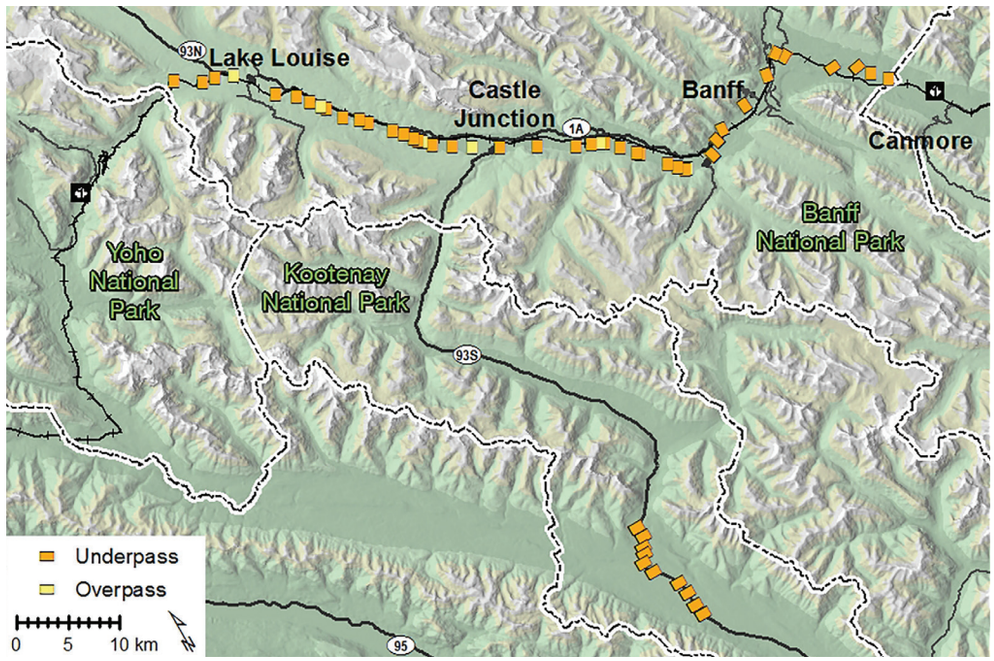


Figure 2. Trans-Canada Highway and Highway 93 South wildlife crossing structures (note north arrow in legend).

Results

Clevenger and Barrueto, (2014) summarized wildlife behavioral observations and the effectiveness of the TCH wildlife crossing structures over an 18-year period (1996 – 2014) as follows:

- Despite increased traffic volumes, Parks Canada highway mitigations significantly reduced wildlife vehicle collision rates which decreased on average by 80% (range 66-87%) for the combined mitigated sections over a 24-year period. Rates of ungulate mortality were reduced by 88%; however carnivore mortality decreased by only 18% when coyotes were excluded (Clevenger and Barrueto, 2014).
- Some species became more selective to crossing structure types over time (deer, wolf), while others were less selective (elk, black bear, coyote). Grizzly bear, cougar, elk, and moose initially used specific crossing structure types, but over time used a greater variety of types and sizes. Grizzly bears, especially females with cubs, showed a clear preference for overpass and open span structures, and underutilized smaller underpasses (4 x 7 m and smaller).

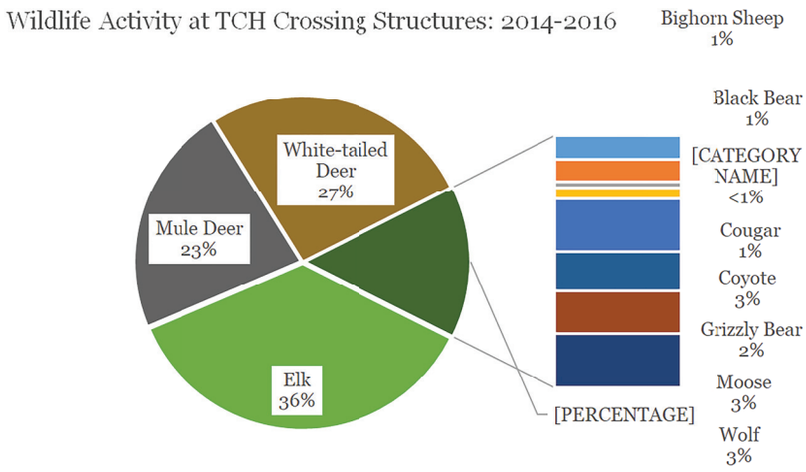


Figure 3. Percentage of wildlife activity by species for TCH Crossing Structures (2014-2016)

From 2014-2016, large ungulates were the predominant users of wildlife crossing structures along the TCH (Fig. 3). Deer and elk made up 86% of total crossings, cougar, coyote and wolf 7%, grizzly and black bear 3% and moose 2%, Bighorn Sheep 1%, with the remaining <1% comprised of Bobcat, Lynx and Red Fox.

Similar to the first 17 years of monitoring, recent data from 2014-2016 shows deer and elk continue to be the predominant users of the crossing structures (Table 1).

Table 1. Activity by species for TCH crossing structures 1996-2014 (led by Clevenger) and 2014-2016 (led by Parks Canada staff).

Species	1996-2014 (18 Yrs)		2014-2016 (3 Yrs)	
	Frequency	Percentage	Frequency	Percentage
Bear spp.	71	0.1%	0	0.0 %
Black bear	1,663	1.1%	268	1.3%
Grizzly bear	1,549	1.0%	476	2.3%
Cougar	1,627	1.1%	136	0.7%
Lynx	18	0.0%	7	0.0%
Coyote	8,749	5.8%	641	3.1%
Wolf	6,826	4.5%	668	3.2%
Wolverine	10	0.0%	0	0.0%
Deer	72,857	47.9%	10,229	49.2%
Elk	53,251	35.0%	7,558	36.3%
Moose	534	0.4%	524	2.5%
Bighorn sheep	4,999	3.3%	294	1.4%
Total	**152,154**		**20,801**	

Discussion

Our results suggest the patterns observed by Clevenger and Barrueto have continued for the period 2014-2016, with the highest use continuing to be attributed to deer and elk.

Recommendations

This long term monitoring program has yielded detailed data on use of wildlife crossing structures since its inception on the TransCanada Highway in 1996. Results have shown that many of the original objectives of the highway wildlife mitigations have been met; specifically that wildlife crossing structure 1) have reduced animal mortality and 2) have reduced the barrier effects of the highway by maintaining habitat connectivity. This initiative remains the longest and most consistent effort to monitor wildlife use of highway crossing structures in the world. The findings from these monitoring efforts have continued to inform ongoing highway mitigations both within Parks Canada and globally. The importance of this management effectiveness monitoring cannot be overstated, as the compelling and positive results from Banff National Park have helped other jurisdictions adopt similar approaches with little risk of failure, which is extremely important given the considerable costs of highway wildlife mitigations.

While many of the original monitoring questions regarding the effectiveness of the wildlife crossing structure have been addressed, continued monitoring will contribute to maintaining an invaluable long-term data set as well as providing a better understanding of crossing structure use by sensitive sub-alpine and alpine species (i.e. goats and wolverine) as highway mitigations approach the Continental Divide.

That said, there may be an opportunity to reduce the current monitoring effort (especially on the early phases of the TCH mitigations) therefore a review of the monitoring program's design should be undertaken.

Acknowledgements/Partners

Western Transportation Institute at Montana State University, Woodcock Foundation, Miistakis Institute, Parks Canada Highway Services Enterprise Unit. Parks Canada recognizes the considerable contribution of Dr. Tony Clevenger in consistently monitoring the effectiveness of these structures for so many years.

Contact

Derek Petersen, Monitoring Ecologist
Banff and Lake Louise, Yoho and Kootenay Field Units
T: (250) 347-6171
E: *derek.petersen@pc.gc.ca*

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Wildlife Health and Disease Surveillance Programs

Introduction

Wildlife health is a cumulative effect of biological, environmental, social, and economic factors acting on individuals and populations. As such, the health status of wildlife may be considered as an indicator of a species' capacity to cope with the combined effects of natural and anthropogenic challenges (Figure 1).

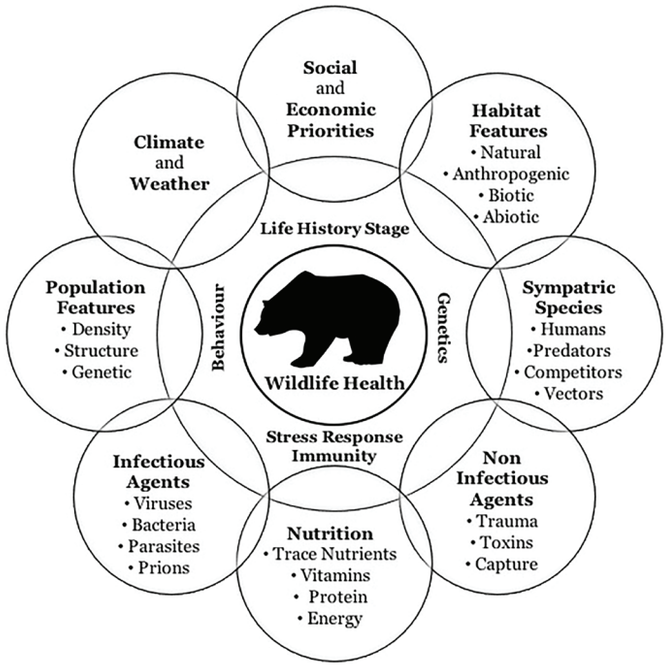


Figure 1. Determinants of wildlife health. External determinants of health (outer circles) interact with each other and internal biological characteristics (middle circle) to determine the health profile of wildlife (inner circle). This health profile is dynamic and may vary across time and space. It is directly linked to the fitness (survival and reproduction) of individual animals and the performance (survival and reproductive rates, juvenile recruitment) of wildlife populations as well as to the ability of each to cope with natural or anthropogenic challenges (Stephen 2014). B. Macbeth, Parks Canada.

The health status of wildlife has direct implications for the fitness of individual animals and wildlife population performance (Figure 1). Compromised health may threaten the long-term sustainability of a species which may adversely impact biodiversity and ecological integrity. In turn, compromised health may negatively affect management, conservation, or recovery programs for ecosystems or species-at-risk. It may also disrupt key cultural or socioeconomic relationships between wildlife, people, and the environment. In addition, some diseases carried or transmitted by wildlife can directly affect the health of people or domestic animals. The health of wildlife in National Parks may also affect wildlife management and conservation programs, socioeconomic considerations, and stakeholders outside park boundaries.

Factors that may directly or indirectly threaten the health of wildlife in Canada's National Parks such as climate change, emerging pathogens, and increasing human use are anticipated to increase into the foreseeable future. Understanding and tracking wildlife health will enhance

our knowledge of current or emerging threats to wildlife, humans, and ecosystems in Banff National Park. This will provide valuable information for risk analyses, decision making, action planning, and the implementation of more timely and effective programs to preserve or restore the park's ecological integrity. It will also support Parks Canada's broader mandate by fostering partnerships with internal and external stakeholders while enhancing the experience of park visitors and their connections to Canada's natural and cultural heritage.

Objectives

- Broadly integrate the consideration of wildlife health into wildlife research, management, and conservation programs in Banff National Park.
- Increase wildlife health research and disease surveillance to enhance understanding of current or emerging threats to wildlife, humans, or ecosystems in Banff National Park.
- Employ a cumulative effects model of wildlife health to develop more timely and effective management and conservation programs that will best protect wildlife, humans, and the ecological integrity of Banff National Park in the face of increasing natural and anthropogenic challenges.
- Consider wildlife health as part of the visitor experience in Banff National Park.
- Use wildlife health programming to foster multidisciplinary partnerships between Banff National Park and external stakeholders in wildlife management and conservation.

Methods

A combination of opportunistic and directed wildlife health research and disease surveillance programs are currently employed in Banff National Park. Opportunistic assessments are performed on all live animals captured and handled as part of any wildlife research, management, or conservation initiative in the park. All wildlife capture operations in Banff National Park are guided by a wildlife veterinarian, Parks Canada's Animal Care Committee, and implemented by Resource Conservation staff with extensive experience and current training in wildlife chemical immobilization and humane animal handling. In addition to a complete physical exam, researchers collect a standardized set of biological samples (e.g. blood, feces, hair) from each animal. These samples may be archived for future study, shared with external research partners, used to develop herd health baselines, or submitted to veterinary diagnostic laboratories as part of ongoing wildlife health and disease surveillance programs.

Opportunistic health assessmets and disease surveillance also occur whenever wildlife that is behaving abnormally, visibly sick, injured, or dead is encountered in the course of park operations or is reported by the public. For dead animals, the approach to further investigation is developed on a case by cases basis guided by the species in question, circumstances surrounding the report, and in consultation with a wildlife veterinarian. A complete necropsy and

comprehensive health and disease testing are always performed on any animal where the cause of death is unclear or disease is suspected. The health testing strategy for any unexplained wildlife mortality is directed by a Parks Canada Wildlife Health Specialist and where disease is suspected, intact carcassess may be submitted directly to a veterinary diagnostic laboratory for necropsy by a certified wildlife pathologist. Routine necropsies are also performed on any large carnivore and many ungulates killed as the result of road and rail collisions or destroyed due to human-wildlife conflict. In these cases, biological samples may be collected for further testing if signs of poor health or disease are noted. Selected samples from all wildlife necropsies (e.g. hair for DNA analysis, teeth for ageing) are always archived as part of species specific management and conservation programs.

The response to live wildlife that is injured, behaving abnormally, or visibly ill also varies depending on the circumstances of the report, the species in question, and the nature or severity of clinical signs exhibited by the affected animal. Sick or severely injured animals may be humanely euthanized if their welfare is compromised, recovery is unlikely, or if they exhibit signs of being affected by pathogens that could have broader implications for the conservation of the species in question or the health of other wildlife, humans, or domestic animals. In such cases, a necropsy and comprehensive health testing are performed as for wildlife found dead. If staff suspect or identify pathogens or other health determinants of potential significance, they may initiate a directed research or surveillance program in which the health status of the affected species is more thoroughly examined by capturing, sampling, testing, and monitoring live animals or increasing targeted disease surveillance in dead animals. Such programs are undertaken in collaboration with a wildlife veterinarian. Directed health research and disease surveillance programs for fish, Rocky Mountain bighorn sheep, and deer are currently underway in Banff National Park.

Although no significant health or disease related considerations have been identified to date, a formal Health Assessment and Monitoring Strategy is also an integral component of the Banff Bison Reintroduction Program (Parks Canada 2016). Likewise, targeted disease surveillance programs are integrated within conservation initiatives for some species-at-risk. For example, bats are tested for infection with *Pseudogymnoascus destructans*, the caustive agent of white-nose syndrome, a fatal fungal disease responsible for the widespread decline of numerous bat species in Eastern North America (Environment Canada 2015). Targeted surveillance also occurs for key zoonotic pathogens such as rabies.

For all wildlife health research and disease surveillance programs, the Resource Conservation Function in Banff National Park works closely with Parks Canada's national Wildlife Health Specialists and with other wildlife health experts from academic institutions, the Canadian Wildlife Health Cooperative (CWHC), the Government of Alberta, and the Government of British Columbia.

Results and Discussion

The Health Assessment and Monitoring Strategy for the Banff Bison Reintroduction Program is discussed elsewhere in this State of the Park Report as is the August, 2016 diagnosis of whirling disease in trout from Johnson Lake. Results presented here focus instead on ongoing health research and disease surveillance programs in Rocky Mountain bighorn sheep, deer, and bats in Banff National Park. Circumstances surrounding the initiation of these programs highlights the critical importance of closely integrating health research and disease surveillance into wildlife operations, management, and conservation in Banff National Park.

Banff National Park Rocky Mountain Bighorn Sheep Health Research Program

In June, 2015 an emaciated bighorn sheep ewe with extensive hair loss and skin crusting was reported on the Sunshine Village Road in Banff National Park (Figure 2). The appearance of this sheep was consistent with infection with *Psoroptes* sp., parasitic mange mites associated with the decline of some bighorn sheep populations in the USA and emerging as a disease of concern in some bighorn sheep populations in British Columbia (Muschenheim *et.al.* 1990, Hengeveld 2106). After consulting with a Parks Canada Wildlife Health Specialist and bighorn sheep health experts in other jurisdictions, the ewe was humanely euthanized and a necropsy was performed by a wildlife pathologist at the CWHC, Alberta. Biological samples were collected and submitted for comprehensive health screening following the bighorn sheep herd health monitoring protocols of the Western Association of Fish and Wildlife Agencies (WAFWA 2014).



Figure 2. An emaciated bighorn sheep ewe with severe skin disease from the Sunshine Village Road, Banff National Park. This case and other evidence of suboptimal health in some bighorn sheep bands from some front country herd ranges led to the initiation of an ongoing bighorn sheep health research program in Banff National Park in fall 2016. Photo: O. Slater, CWHC.

The sheep was afflicted with numerous and severe health issues, including immune system dysfunction, a heavy parasite burden, and multiple, localized bacterial infections (abscesses), all of which may have contributed to its poor body condition. *Psoroptes* sp. mites were not identified. In May, 2016, after extensive analyses, the CWHC determined that the skin lesions were most likely caused by a malignant catarrhal fever (MCF) virus, called Ovine Herpes Virus 2 (OvHV-2) (Slater *et. al.* 2017). MCF viruses are a group of herpes viruses that infect some domestic and wild ruminants. These viruses are generally adapted to one particular host species but may also infect and sometimes cause disease in other ungulates. OvHV-2 is a MCF virus commonly found in domestic

sheep but infection is usually subclinical (Slater *et. al.* 2017, O'Toole and Li 2014). OvHV-2 (or a similar MCF virus) has also been recorded in wild bighorn sheep and Dall's sheep in some parts of the USA, but has not been previously associated with significant clinical disease in these species (Slater *et. al.* 2017). Although relatively uncommon in free-ranging wildlife, OvHV-2 from domestic sheep can cause serious, fatal disease in other ruminants, most notably bison (O'Toole and Li 2014). OvHV-2 does not pose a risk to humans, horses or non-ruminant domestic pets.

The precise strain of OvHV-2 that infects bighorn sheep, its distribution in Banff National Park, and its potential effects on sheep and sympatric ungulates are not currently known (Slater *et. al.* 2017). Other bighorn sheep exhibiting similar but less extensive skin lesions, hair loss, and abnormal moult were noted in the Sunshine Village area during follow up monitoring that occurred while test results were pending for the index case. Similar lesions were also recorded, although less severe and in fewer individuals, in bighorn sheep from the Norquay, Highway 1A, and Lake Minnewanka herd ranges (Figure 3). In the same time period, multiple observations of bighorn sheep in poor body condition with chronic diarrhea were recorded in the Minnewanka herd range and anecdotal evidence of poor lamb recruitment was noted in the Sunshine Village herd range. Interestingly, in all herd ranges the apparent health status and productivity (i.e. ewe: lamb ratio) of different sheep bands within the same broader herd range appeared to be highly variable. This was most notable in the Minnewanka herd range where some sheep bands appeared exceptionally healthy and productive while others exhibited the opposite profile.

These findings and knowledge gaps surrounding the occurrence, distribution and potential importance of OvHV-2 in bighorn sheep served as the basis for the initiation of a directed bighorn sheep health research program in late summer 2016. This program is ongoing and its primary objectives are to: 1) establish herd health baselines for selected bighorn sheep ranges in Banff National Park, 2) determine the prevalence, distribution, and importance of OvHV-2 infections in bighorn sheep and sympatric ungulates (NB: potential risk to reintroduced bison), and 3) evaluate selected infectious and non-infectious health determinants as the potential cause of suboptimal health and productivity observed in some sheep bands in some herd ranges.

To date, we have live-captured and sampled 39 bighorn sheep for in-depth health testing using an assessment protocol modified after (WAFWA 2014). We have also collected samples from 4 bighorn sheep killed as a result of predation (n=1), collisions with vehicles (n=2), and rail strikes (n=1). Health testing is ongoing, however preliminary results indicate that bighorn sheep in Banff National Park are infected with diverse and heavy parasite burdens (Table 1). Overall, there is only limited evidence of exposure to respiratory viruses that may adversely affect this species (Table 1). All adult sheep tested to date are infected with OvHV-2. There is also evidence of infection with gastrointestinal coronavirus(es) in sheep from the Sunshine Village herd range. Importantly, key bighorn sheep pathogens such as *Mycoplasma ovipneumoniae* (Besserm *et. al.* 2013) and *Psoroptes* sp. (Muschenheim *et.al.* 1990, Hengeveld 2106) have not been identified in any individual tested to date. There is emerging evidence that trace nutrient abnormalities (e.g. copper deficiency, molybdenum excess) may exist in the Norquay herd range and that physiological stress levels may vary across bighorn sheep herd ranges (Table 1).

Table 1. Preliminary findings of surveillance for infectious and non-infectious health determinants in live-captured (n=25) and dead (n=2) bighorn sheep from Banff National Park 2015-2017. As of December 1, 2017, results are pending for some diagnostic tests and for archived samples from an additional n= 14 live-captured sheep and n=2 dead sheep.

Pathogen or Parasite	Diagnostic Test	Prevalence
Viruses		
OvHV-2 (Ovineherpesvirus-2, MCF)	Serology (Exposed) Blood PCR (Infected) Tissue PCR (Infected)	100% (n=17/17) 100% (n=17/17) 100% (n=1/1); see a
Coronaviruses (Bovine Coronavirus)	Serology (Exposed) Serology (Suspicious)	8% (n=2/25); all from Sunshine area 16% (n=4/25); all from Sunshine area
Alphaherpesviruses (Bovine Herpesvirus-1)	Serology (Suspicious) PCR Lung (Infected)	4% (n=1/26) 0% (n=0/1); see b
Pesitviruses (Border Disease Virus)	Serology (Exposed) PCR Lung (Infected)	Results Pending Results Pending
Paramyxoviruses (Parainfluenza Virus-3)	Serology (Suspicious) PCR Lung (Infected)	19% (n=5/26) 0% (n=0/1); see b
Paramyxoviruses (Bovine Respiratory Syncytial Virus)	Serology (Exposed) PCR Lung (Infected)	0% (n=0/26) 0% (n=0/1); see b
Bacteria		
Mycobacterium avium ssp. paratuberculosis (Johne's Disease)	Serology (Exposed) Fecal PCR (Infected) Fecal Culture (Infected) Tissue Culture (Infected)	0% (n=0/24) 0% (n=0/24) 0% (n=0/23) 0% (n=0/1); see a
Mycobacterium bovis (Bovine Tuberculosis)	Tissue Culture (Infected)	0% (n=0/1); see a
Mycoplasma ovipneumoniae	PCR Nasal Swab (Infected) Lung Culture (Infected)	0% (n=0/48) 0% (n=0/2); see a, b
Mycoplasma bovis	PCR Nasal Swab (Infected) Lung Culture (Infected)	0% (n=0/47) 50% (n=1/2); see a, b
Bibersteinia trehalosi	Lung Culture (Infected)	50% (n=1/2); see a, b
Trueperella pyogenes	Tissue Culture (Infected)	50% (n=1/2); see a, b
Ectoparasites		
Psoroptes sp.	Ear Swab (Infested) Serology (Exposed)	Results Pending Results Pending
Mite Eggs (sp. undetermined)	Fecal Flotation (Infested)	29% (n=7/24)
Gastrointestinal Nematodes		
Capillaria	Fecal Flotation (Infected)	12% (n=3/25)
Marshallagia	Fecal Flotation (Infected)	84% (n=21/25)
Nematodirinae	Fecal Flotation (Infected)	64% (n=16/25)
Trichuris	Fecal Flotation (Infected)	36% (n=9/25)
Gastrointestinal Coccidians, Flukes, and Tapeworms		
Eimeria sp. (Coccidians)	Fecal Flotation (Infected)	100% (n=25/25); 5 types identified
Cestodes (Tapeworms)	Fecal Flotation (Infected)	0% (n=0/25)
Trematodes (Flukes)	Sedimentation (Infected)	0% (n=0/25)

Pathogen or Parasite	Diagnostic Test	Prevalence
Lung and Tissue Dwelling Nematodes		
Protostrongylid Larvae (Tissue Dwelling Nematodes)	Baermann (Infected)	54% (n=13/24); probable Parelaphostrongylus odocoilei
Protostrongylus sp. (Lungworms)	Baermann (Infected)	96% (n=24/25)
Non-Infectious Determinants	Diagnostic Test	Result
Trace Nutrients		
Serology Co, Cu, Fe, Mn, Mo, Se, Zn	High Performance Liquid Chromatography (HPLC)	Results Pending
Liver Co, Cu, Fe, Mn, Mo, Se, Zn	High Performance Liquid Chromatography (HPLC)	1) Sunshine Ewe; see a: All Elements: Normal 2) Norquay Ewe; see b: Cu Deficient and Mo Elevated
Physiological Stress Levels		
Hair Cortisol Concentration Herd Mean + Range (pg/mg); see c	Enzyme-linked Immunosorbent Assay (ELISA)	1) Sunshine: 17.91 (13.58-23.47, n=11) 2) Highway 1A: 21.40 (17.80-23.80, n=3) 3) Norquay: 19.99 (11.05-25.50, n=8) 4) Minnewanka: 12.26 (7.93-20.45, n=4)

a) Result from necropsy of bighorn sheep ewe killed by a cougar on Norquay Road, Banff National Park. Mycoplasma bovis infection has not been previously recorded in bighorn sheep. However, result could not be confirmed with subsequent re-culture of lung tissue and PCR. No Bibersteinia or Trueperella infection recorded in this sheep. Not tested for Mycobacterium bovis.

b) Result from necropsy of bighorn sheep ewe euthanized on Sunshine Village Road, Banff National Park (Figure 2). Negative result for Mycobacterium bovis and Mycoplasma bovis infection. Trueperella associated with localized abscesses only. Bibersteinia positive. Bibersteinia has been previously associated with bighorn sheep pneumonia and mortality events elsewhere.

c) Variation in hair cortisol levels was explained by herd range (One-way ANOVA, $F_{3, 21} = 3.56$, $P=0.031$, n=4 Norquay, n=10 Sunshine, n=8 Minnewanka, n=3 Highway 1A). Cortisol levels in sheep the Norquay herd range were lower (Tukey-Kramer, $P<0.05$) than those measured in sheep from the 5-Mile and Minnewanka herd ranges but similar to those measured in the Sunshine Village herd range (Tukey-Kramer, $P>0.05$). There was no difference (Tukey- Kramer, $P>0.05$) in cortisol levels measured in sheep from the Sunshine, 5-Mile and Minnewanka herd ranges. Preliminary results, caution re: broader interpretation due to small sample size.

We tagged all live-captured sheep with a permanent, individually numbered marker identifying their herd range at the time of capture. Some ewes tagged in fall 2016 have now been opportunistically monitored through a complete reproductive cycle. All tagged ewes re-sighted in spring 2017 had young of year lambs and one individual from the Minnewanka herd range had twins. However, only tagged ewes from the Minnewanka and Norquay herd ranges retained lambs through to fall 2017. These preliminary findings may reflect higher predation rates, poor health, or a combination of both factors in the Sunshine Village herd range. Most tagged sheep have been re-sighted at or near their capture location. However, one mature ram tagged on the Norquay herd range in fall 2016 was re-sighted on Highway 1A in spring, 2017 approximately 16 km (straight line distance) from where it was captured.



Figure 3. Bighorn sheep herd ranges currently being studied as part of the Banff National Park Bighorn Sheep Health Research Program. A) Sunshine Village Road, B) Highway 1A (5-Mile Bridge to Hillsdale Split), C) Norquay, D) Minnewanka.

Bighorn sheep are an ecologically important species in Banff National Park and sheep viewing is also regularly cited as an important visitor experience. Bighorn sheep populations in the park also contribute to the genetic diversity and abundance of those on provincial lands in Alberta and BC where the species is an economically important big game animal. Poor health is universally recognized as a key determinant of bighorn sheep productivity and population sustainability (e.g. Muschenheim *et.al.* 1990, Hengeveld 2106, Besserm 2013, Miller *et. al.* 2012). The ongoing bighorn sheep health assessment program will inform and enhance sheep management and conservation efforts in Banff National Park and beyond. In addition to the implementation of a formal, long-term health monitoring program, radio-collaring based studies are recommended to more accurately determine natality, survival, reproductive rates, and juvenile recruitment of bighorn sheep in Banff National Park. Collaring studies would also inform bighorn sheep habitat use and movement patterns which are directly



Figure 4. All live-captured bighorn sheep are given permanent ear tags that designate their herd range at the time of capture. More accurately monitoring the health, productivity, and movement patterns of radio-collared and tagged sheep is recommended to enhance Banff National Park's ongoing sheep health assessment program. This ram's tag designates it as the tenth bighorn sheep captured in the Sunshine Village (SSV) herd range. Photo: B. Macbeth, Parks Canada.

linked to sheep health and conservation. Both lines of inquiry should be investigated in selected front and backcountry bighorn sheep herds and in areas where the range of bighorn sheep and reintroduced bison may overlap. A collaborative effort with bighorn sheep research programs on provincial lands and in other National Parks is warranted.

Diagnosis of Epizootic Haemorrhagic Disease (EHD) in a White-tailed Deer in Banff National Park

On July 8, 2017 a mature white-tailed deer buck was found dead adjacent to the Bow River, upstream of the Blue Canoe Docks in Banff National Park. A review of the carcass and case history by a wildlife veterinarian determined that, although health related factors were the likely cause of death, there was no evidence to suggest broader risk to staff, the public, livestock, or other wildlife at the time of collection (e.g. anthrax, rabies etc.). As such, the carcass was retained for necropsy and comprehensive health testing at a later date and an intensified ungulate health surveillance program was initiated in the area.

A complete necropsy was performed on October 15, 2017 as part of an annual elective wildlife health rotation in Banff National Park for fourth year veterinary students from the University of Calgary's Faculty of Veterinary Medicine. The deer was in poor body condition and in addition to other lesions, had evidence of haemorrhagic enteritis (bleeding into the gut) and diffuse haemorrhage in the muscles of the hindquarters, signs consistent with an infectious agent as the probable cause of death. Based on these findings and two other unexplained white tailed deer mortalities (one fawn and one adult doe) identified in the same general area over the summer we requested that the deer was tested for Epizootic Haemorrhagic Disease (EHD).

EHD is an acute, infectious, and often fatal viral disease of some wild ruminants often characterized by sudden death with signs of extensive haemorrhage in multiple organs (Iowa State University 2016). White-tailed deer are the species most susceptible to infection and EHD outbreaks may have significant population level effects in this species (Iowa State University 2016). Although subclinical infection is more common, clinical disease (and sometimes death) is occasionally reported in other wild ungulates including, bighorn sheep, elk, mule deer, bison, and pronghorn antelope. EHD virus can also infect domestic ruminants (cattle, sheep, goats, alpacas, llamas) but only rarely causes serious clinical disease in these species. EHD does not infect horses or domestic and wild carnivores. EHD is not zoonotic and does not pose a risk to human health(Iowa State University 2016).

On October 20, 2017 a diagnosis of EHD was confirmed in the white-tailed deer buck using a PCR-based testing protocol. Although PCR is highly accurate (false positives are unlikely), ancillary confirmatory testing (full genetic sequencing of the virus) is currently underway at the National Microbiology Lab in Winnipeg, Manitoba. Final testing results also remain pending for the n=2 other white-tailed deer mortalities as well as for an adult female elk that died with signs of haemorrhagic enteritis near the Marsh Loop Trail on October 19, 2017. The cause of death in these four cases may or may not be related.

The diagnosis of EHD in a white-tailed deer from Banff is significant as this is the first record of this important wildlife disease in the park and there is potential for population level effects in the some ungulate (NB: white-tailed deer) populations if an outbreak occurred.

EHD is transmitted by a specific type of biting midge (*Culicoides* sp.) and outbreaks tend to occur in late summer or early fall in hot, dry weather which promotes midge population survival and concentrates susceptible ungulates in areas where midges occur (e.g. drying wetlands) (Iowa State University 2016, Pybus *et. al.* 2013). EHD is relatively common in white-tailed deer in some parts of the Southeastern USA. Large outbreaks of severe, fatal disease are more common in Northern states where deer populations are not regularly exposed to the virus. In Southern states, where deer have been historically exposed to the virus, outbreaks are usually less severe with fewer animals dying overall, mortalities recorded more sporadically, and more animals recovering from infection.

EHD is rarely reported in Canada and, to date, EHD has only been recorded in far Southern areas of Alberta, BC (Okanagan Valley), and Saskatchewan along the USA border. Outbreaks causing significant mortality events have occurred in Canadian white-tailed deer, mule deer, pronghorn antelope, and bighorn sheep. The last known EHD outbreak in Southern Alberta occurred in 2013 (Pybus *et. al.* 2013). In 2017, EHD was detected for the first time in two white-tailed deer from Southern Ontario. As such, findings in Banff may also represent the most northerly diagnosis of EHD ever recorded. This may be related the unusually hot and dry summer of 2017, although no cases of EHD were diagnosed on provincial lands in Alberta or in BC in 2017. It may also be related to climate change or to a unique epidemiological scenario promoted by unusually warm environmental conditions within the greater Banff hot springs ecosystem.

A directed ungulate health surveillance program was initiated in November, 2017 in order to better understand the historical occurrence, epidemiology, and potential impacts of EHD on ungulates in Banff National Park. Parks staff are live-capturing and collecting blood from a small number of mule deer, white-tailed deer, and bighorn sheep in the vicinity of the Town of Banff, Cave and Basin, and the Vermillion Lakes to test for exposure to EHD (Figure 5). We will also evaluate archived blood samples collected as part of the ongoing bighorn sheep health research program and elk management activities. In addition, we've implemented an enhanced sample collection protocol and EHD surveillance testing for rail or road struck ungulates. To date we've captured and sampled n=10 mule deer in the Town of Banff. Test results are pending as of December 2017. This research program will support Banff National Park and Parks Canada' broader mandate to understand and preserve the ecological integrity of our protected areas. The diagnosis of EHD also highlights the importance of continued wildlife health research and disease surveillance in the park.

Health Surveillance, White Nose Syndrome, and Rabies Testing in Bats in Banff National Park

Little brown and Northern myotis are two endangered bat species inhabiting Banff National Park (Environment Canada 2015). White-nose syndrome, a fatal bat disease caused by the fungus *Pseudogymnoascus destructans*, is believed to be responsible for the recent and catastrophic decline of these species across much of their range in Eastern North America (Environment Canada 2015). White-nose syndrome has not yet been recorded in Alberta but is expanding westward at a rapid pace. White-nose syndrome surveillance is a key component of Banff National Park's ongoing bat research and conservation programs. Bats are also recognized as an important carrier of rabies virus and targeted surveillance for this important zoonotic pathogen occurs whenever abnormally behaving or dead bats that may have come into contact with people or their pets are reported. Comprehensive health testing also occurs whenever unexplained bat mortalities are recorded.



Figure 5. A mule deer buck live-captured in the Fenlands area of the Town of Banff, Banff National Park as part of a directed ungulate health assessment program to evaluate exposure to epizootic haemorrhagic disease (EHD) in ungulates living near the area where EHD was diagnosed in a white-tailed deer in summer 2017. Photo: B. Macbeth, Parks Canada.

In June, 2017 Banff Resource Conservation staff received a report of multiple dead and dying bats in a church in the Town of Banff. Subsequent investigation identified a maternal colony likely containing little brown and Northern myotis. Over a three-week period we recovered carcasses of n=16 juvenile and mature bats and submitted these to the Canadian Wildlife Health Cooperative, Alberta for comprehensive health testing. Given the probability of human exposure, we also submitted a subset of n=6 carcasses to the Canadian Food Inspection Agency Laboratory in Lethbridge, AB for rabies testing after consultation with the Government of Alberta's Public Health Veterinarian. As of December 2017, final necropsy and health testing results for these cases remain pending, however all bats have tested negative for WNS and rabies. A single little brown myotis found dead at the Lake Minnewanaka warden cabin in July, 2017 also tested negative for WNS.

From August to early September, 2017, Banff Resource Conservation staff received four reports of silver-haired bats behaving abnormally in human use areas. All cases were promptly investigated and all bats were submitted to veterinary diagnostic laboratories for rabies testing. Three bats were tested at the Canadian Food Inspection Agency Laboratory in Lethbridge, Alberta and one bat was tested at the Canadian Wildlife Health Cooperative, Alberta. Three of the four bats tested positive for rabies. Two positive cases were diagnosed at the CFIA lab and one at the CWHC lab. Two positive cases were identified in the hamlet of Lake Louise and the third at

the Cave and Basin National Historic Site (Figure 6). Direct human-bat contact occurred in one case and two people received rabies post exposure prophylaxis treatment. Further consultation with bat health and rabies experts from the Government of Alberta and elsewhere indicated that the number, timing, and concentration of rabies positive cases, while somewhat high, were within normal limits. Nonetheless, continued rabies testing for any bat behaving abnormally or coming into direct contact with people or pets is warranted. These cases also highlight the need for continued staff vigilance and training in recognizing and addressing zoonotic disease risks associated with bats and other wildlife. Banff National Park's Resource Conservation Function is currently working with a Parks Canada Wildlife Health Specialist to develop a more comprehensive bat rabies testing protocol for use by operational field staff.

Acknowledgements/Partners

Prepared by Bryan Macbeth. Dr. Todd Shury, Wildlife Health Specialist, Parks Canada Agency; Dr. Owen Slater, Dr. Padraig Duignan, Dr. Sam Sharpe, Dr. Susan Kutz, and Mr. Collin Letain, Canadian Wildlife Health Cooperative (CHWC), Alberta Node and University of Calgary Faculty of Veterinary Medicine; Dr. Helen Schwantje, Provincial Wildlife Veterinarian, Government of British Columbia; Dr. Margo Pybus, Wildlife Disease Specialist Government of Alberta; Dr. Darcia Kostiuk, Public Health Veterinarian, Government of Alberta; Dr. Hong Li and Dr. Christina Cunha, Animal Disease Research Unit, USDA, and Department of Microbiology and Pathology, Washington State University; Dr. Tom Besser, Department of Microbiology and Pathology, Washington State University; Dr. Anne Justice-Allen, Wildlife Health Program Manager, Arizona Game and Fish Department, and Dr. Peregrine Wolff, Wildlife Veterinarian, Nevada Department of Wildlife are acknowledged for their assistance and advice provided during the course of wildlife health research and disease surveillance programs highlighted in this report.

Contact

Dr. Bryan MacBeth,
Wildlife Health Monitoring and
Species of Special Concern Ecologist
Banff Field Unit
T: (403) 493-6787
E:*bryan.macbeth@canada.ca*



Figure 6. A silver-haired bat found behaving abnormally at the Cave and Basin National Historic Site in Banff National Park in August, 2017. This bat and two other silver-haired bats from Banff National Park tested positive for rabies in 2017. Photo: A. Athwal, Parks Canada.

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Operational Programs

Introduction

Readers may wonder why this section on "Operational Programs" is included in a technical report that is primarily focused on ecological monitoring and restoration. We include this section because many of our operational programs include the emergency response capacity for managing interactions between visitors and the natural environments of Banff.

By closely monitoring changes in the scope, timing or magnitude of these emergency responses, we can better identify proactive strategies to reduce risk to visitors *and* improve ecological integrity. For example understanding trends in Emergency Dispatch call volumes, the types of visitor activities that result in search and rescue responses, or negative human/wildlife encounters, and even tracking changes in the use of horses to conduct work in the backcountry (rather than helicopters) all provide useful measures that, over time, allow us to better manage Banff National Park.

In the following section, we provide a decade of summary data from some of our key operational programs that exist within the Resource Conservation Function.

Emergency Dispatch Program

Introduction

The purpose of the Emergency Dispatch program is to provide 24-hour emergency and non-emergency communication and dispatch services for Parks Canada. This involves the ability to receive emergency calls, complaints, and reports from the public; coordinate response efforts within and between agencies; and monitor the safe and effective deployment of staff. These roles are critical to all operational programs: Visitor Safety, Law Enforcement, Wildlife Conflict, Fire Suppression, Resource Management, Highways, Visitor Experience (Campgrounds and Gates), and Assets (Trades) etc.

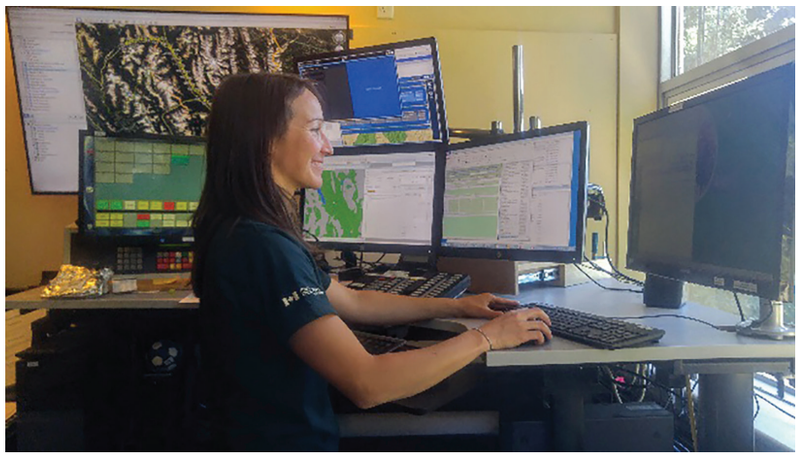


Figure 1. Banff Park Emergency Dispatcher working at consol.

The two Parks Canada Dispatch Centers are located in Banff and Jasper respectively. Banff Dispatch is a fully bilingual dispatch center providing full services in both French and English.

Objectives

1 To deliver dispatch services to nine national parks:

- **a** Banff, Yoho, Kootenay, and Waterton (Western Canada)
- **b** Mingan, Forillon, La Mauricie/Western Quebec Field Unit, Saguenay-St. Lawrence, Quebec Waterways (Eastern Canada)

2 To provide the following services:

- **a** Emergency response call-taking and dispatching for:
- **b** Search and Rescue (mountain rescues, avalanches, water rescues etc.)
- **c** Law Enforcement (National Park Act, Highway Traffic Act)
- **d** Wildlife Conflict (wildlife encounters/attacks)
- **e** Fire Suppression (wildland fires)
- **f** Environmental Protection (toxic spills, pollution incidents)
- **g** Highway Incidents (motor vehicle collisions, road closures)
- **h** Multi-agency and cross-boundary emergency response coordination.
- **i** Law enforcement information and safety checks for Park Wardens.
- **j** Occupational health and safety (OHS) checks for park staff in the field.
- **k** Flight watch for helicopter traffic in Banff, Yoho, and Kootenay National Parks.
- **l** Mountain parks road condition updates on the Alberta ATIS and Drive BC websites.
- **m** Road closure coordination/notifications and electronic highway sign updates.

Methods

- Monitor 9 incoming phone lines (emergency and non-emergency), 12 VHF, and 6 VOIP radio channels.
- Log all communications in the Computer Aided Dispatch (CAD) System.
- Perform law enforcement queries on the RCMP CPIC system.
- Enter data in the Bear/Wildlife Monitoring and IEM (Incident Event Management) systems.
- Monitor timers for OHS and law enforcement safety checks.

Results

Call Volume/Activity

- 2017 Total Dispatch Call Volume/ Activity: **174,532**
- Dispatch Call volume/Activity per Field Unit:
- 51% Banff Field Unit
- 40% LLYK Field Unit
- 5% Waterton Field Unit
- 4% Quebec Field Units

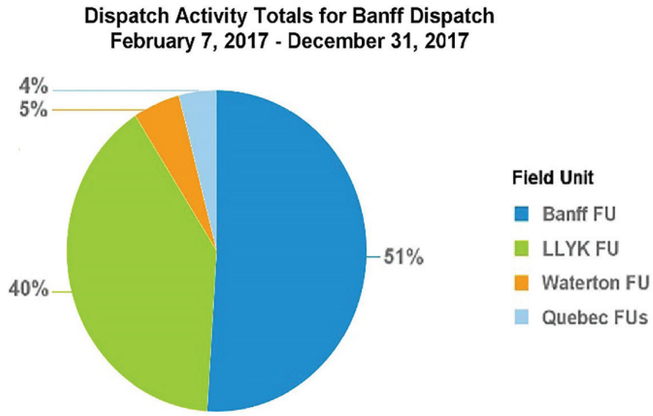


Figure 2. Field Unit Activity Totals for Banff Emergency Dispatch.

Banff Dispatch experienced a significant increase in dispatch call volume and activity during the Canada 150 year. The metrics of the new CAD system cannot be compared directly to the previous reporting system but provide a benchmark for future call volume/dispatch activity stats.

The increase in call volume, required Banff to operate an additional third Dispatch CAD station from May to October and a fourth station in early July to manage air traffic and fire crew activity for the Verdant Creek Fire.

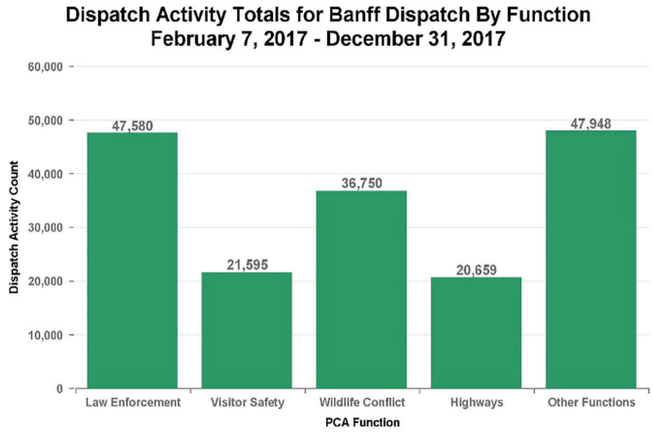


Figure 3. Functional Activity totals for Banff Emergency Dispatch

Dispatch Upgrades

- The Intergraph/Hexagon CAD system (Computer Aided Dispatch) has been operational in both the Parks Canada Dispatch Centers (Banff and Jasper) since January 2017 (Jasper) and February 2017 (Banff).
- Successful interfacing of the IEM system (Incident Event Management) with CAD for Law Enforcement, Wildlife Conflict and Visitor Safety has been completed.
- Review of all Parks Canada Dispatch Policies & Procedures and their integration into the CAD system is in progress.
- Dispatch governance and levels of services for the Parks Canada Agency are currently under review.

Acknowledgements/Partners

Other national parks, Kananaskis Country, Alberta and B.C. ambulance services, STARS, local helicopter companies, Banff Mineral Springs and Canmore Hospital, RCMP, Provincial search and rescue agencies, Canadian Coast Guard, Alberta and B.C. Transportation.

Contact

Mark Merchant, Dispatch Manager
Parks Canada Emergency Dispatch
Banff National Park Field Unit
P: (403) 762-1404
E: *mark.merchant@pc.gc.ca*

Equine Program

Introduction

The Parks Canada equine program provides an efficient and sustainable method for staff to safely travel and complete their work in the backcountry. The use of horses is an excellent alternative to less sustainable modes of transportation, and it allows for increased staff presence in backcountry areas. Horses are also able to pack bulky equipment into remote areas of the park that would otherwise need to be transported by helicopter.



Figure 1. Park Warden Steve Anderson safely crossing a river on horseback.

The 2010 Banff National Park Management Plan requires Parks Canada to restrict the use of helicopters in the East Slopes and North Saskatchewan areas of Banff National Park to fire operations, search and rescue, and other emergencies. These areas can be very difficult to access on foot due to the absence of footbridges on many of the main river drainages. Therefore, an effective equine program is critical to maintain safe and efficient backcountry access for Parks Canada staff. Conversely, in some areas of Banff National Park, such as Egypt Lake, horses are prohibited. This is to provide visitors and the ecosystem with some reprieve from the impacts of horse use.

Parks horses and riders also feature prominently in the annual Town of Banff Canada Day Parade and the prestigious Calgary Stampeded Parade where Parks Canada has won, several times, for the best commercial horse party.

Objectives

To provide a safe and effective means for staff to access and work in remote areas of the Mountain National Parks. Horses have the unique ability to safely carry riders, equipment, and supplies into remote and rugged terrain in a quiet and efficient manner, with minimal environmental impact.

Methods

All staff that have a meaningful need for using horses to meet operational requirements in the backcountry are provided with adequate training by the Field Unit Equine Specialist to ensure competency and safety. The training model currently in place to certify staff for independent backcountry travel with horses includes a 3 day Basic course, a 5 day Backcountry course, mentored horse use, and a final certification assessment that is performed by a senior horseperson (Equine Specialist or Ya Ha Tinda Ranch staff). Staff with notable expertise are appointed as mentors to assist in the safe, efficient development of new users' equine skills. These individuals are re-assessed annually for competency and safety in practice.

Banff Field Unit

Work trips requiring equine support are coordinated through the Equine Specialist, and horses are dispatched according to the operational requirements and staff needs. The Equine Specialist also coordinates equipment and logistics as needed to support work needs. When not in work, horses are cared for by the Equine Specialist at the Banff barn facilities. Maintaining the highest standard of care possible has remained a top management goal for the Parks Canada equine program, and this is delivered through active management of horses' needs and coordination with licensed care providers (i.e. veterinarians and farriers) whenever needed.

Lake Louise, Yoho and Kootenay Field Unit

Work trips requiring equine support are scheduled by a horse program coordinator who is a mentor. Daily horse care, facility and feed maintenance, and trucking tasks are shared by experienced staff across various sections in an integrated care program. When not in the backcountry, the horses are cared for at the Yoho Ranch and receive services from licensed care providers, such as veterinarians and farriers, whenever needed.



Figure 2. Horses at the Ya Ha Tinda Ranch. Photo: Michelle Macullo.

Ya Ha Tinda Ranch

Horses are purchased and trained by three specialized staff at the Ya Ha Tinda Ranch for use in the Banff, LLYK, Jasper, Waterton, and Grasslands Field Units. These horses are also kept at the Ya Ha Tinda Ranch over the winter season, or when there is no operational need for them to be kept at Field Unit facilities. In addition to these duties, Ya Ha Tinda Ranch staff also provide support to the Field Units' equine programs where needed. For example, Ya Ha Tinda Ranch staff provided 39 days of assistance with Field Units' staff training and continuing professional development in 2017. Finally, Ya Ha Tinda Ranch staff work with Field Unit Equine Specialists to annually assess the suitability of all horses currently working in the Mountain Parks. Horses are assessed for work suitability based on age, relevant injuries/illnesses, training needs, work performance, and/or relevant behavioural concerns. Horses no longer meeting the needs of the Field Units are surplused at the end of the season and replaced, so as to maintain operational efficiency.

Results

Banff Field Unit

The Banff equine program has continued to successfully improve the efficiency of backcountry work performed by facilitating safe accessibility to many remote areas of the Banff Field Unit that would otherwise require helicopter or additional infrastructure support. Twenty-two horses were used by the Banff Field Unit to support backcountry work in 2017, and the majority of this work was performed by Resource Conservation staff. Main projects in 2017 included Ecological Integrity Monitoring tasks such as camera servicing, travel to and from Bison management areas such as the soft-release Windy pasture and experimental fence sites, and vegetation surveys. Horses were also used to support Law Enforcement boundary patrols, Assets trail building and maintenance, and Visitor Experience participation in parades and interpretive programs.

The following table reflects horse use statistics for work projects in 2017, as well as averages based on the last 5 years (data unavailable prior to 2013):

Table 1. Summary of equine activity in the Banff Field Unit

	2016	2017	5 Year Average
Herd size	20	22	19
Number of backcountry trips	36	30	31
Average number of horses per trip	5	4	4
Total number of backcountry horse days	1052	910	847
Average number of backcountry horse days per horse	53	41	44
Total number of frontcountry horse days	280	264	220
Average number of work days per horse/season *	67	53	56

*Includes backcountry work, day patrols, and staff training

Of the 910 backcountry work days spent using horses in 2017, 296 days were dedicated to projects within the Wildlife and Bison teams. The Ecological Integrity Monitoring function performed 277 days of equine supported work, and Law Enforcement patrols accounted for 204 days of backcountry horse use. Assets used horses to support trail work for 133 days of their season. Visitor Experience also received equine support for a Mounted Color Party entry in the Banff Canada Day parade and the Calgary Stampede parade. Equine support was also provided to Visitor Experience in one of the 'Trailblazers of the Rockies' presentations that took place at the Tunnel Mountain Campground theatre. Two horses were brought in at the end of the show by experienced Resource Conservation staff, and visitors were given the opportunity to meet the horses and learn about the work that they perform in Parks currently. Please refer to these functions directly for more information on projects currently supported through backcountry horse use.

Lake Louise, Yoho and Kootenay Field Unit

The LLYK Field Unit uses 6 horses to support work of various sections including Resource Conservation, Law Enforcement, and Assets. Main projects in 2017 that benefitted from equine support include Ecological Integrity Monitoring tasks such as camera servicing and wildlife occupancy surveillance, Law Enforcement backcountry patrols, and Assets assessment and maintenance of backcountry trails and infrastructure. Two LLYK horses also regularly participate in Canada Day parades and the Calgary Stampede Parade, assisting the Banff Field Unit in this Visitor Experience effort. When possible operationally, LLYK shares horses with the Banff field unit to support additional work when needed. For example, in 2017, LLYK horses were used on 6 Banff Field Unit backcountry trips.

The following table reflects horse use statistics for work projects in in the last two years. Data unavailable for multi-year averages:

Table 2. Summary of equine activity in the Lake Louise, Yoho and Kootenay Field Unit

	2016	2017
Herd size	6	6
Number of backcountry trips	17	15
Average number of horses per trip	4	4
Total number of backcountry horse days	218	183
Average number of backcountry horse days per horse	36	31
Total number of frontcountry horse days	60	50
Average number of work days per horse/season *	46	39

*Includes backcountry work, day patrols, and staff training

Ya Ha Tinda Ranch

With the discontinuation of the Parks Canada horse breeding program, various models for purchasing and training horses have been experimented with over the last decade. Purchasing horses as weanlings and training them from a young age has proven to be the most effective means of equine procurement to date, and these horses are typically ready to be dispatched for work in the Mountain Parks Field Units at the approximate age of 4 years old. While this does require having an increased number of horses in training annually, the quality of horses produced is much higher than horses purchased for training at an older age. This increased quality greatly reduces the safety risks of staff using horses, and protecting staff safety is one of our top management priorities.

The Ya Ha Tinda Ranch also currently holds a contract agreement with Alberta Parks and other federal departments to winter horses and/or train staff. This contract produces notable revenue, and has been a successful relationship to date. See the following table for further details:

Table 3. Summary of equine activity at the Ya Ha Tinda Ranch

	2017
Total Number of Horses Owned and Managed	94
Horses Currently in Work	58
Horses Currently in Training	29
Horses Currently Retiring	5
Ranch Horses	2
Horses Kept by Ranch on Contract with External Agencies	16
Revenue Produced through External Agency Contracts	$26,100

Discussion

To date, using horses to safely access remote areas of the Banff Field Unit, to provide an efficient, environmentally responsible transportation method, and to increase staff presence in the backcountry has proven to be successful. Projects benefitting from equine support have continually increased in growth and prevalence over the last 5 years. An increased need for equine support has already been expressed by users for 2018, indicating that this trend can be expected to continue.

Banff Field Unit

This projected growth means that infrastructure supporting the care and management of horses in the Banff Field Unit will likely benefit from some improvements. Increased demands on horse use, increased staff training needs, and increased logistics support may also benefit from

additional supporting staff. Currently, all horse use is coordinated and supported by an individual staff member. The addition of a supporting position (e.g. qualified student) within the Banff Field Unit that is dedicated to logistic support and horse care would greatly increase the efficiency of the program, ensure safe growth, and protect the standard of care that we currently maintain.

Lake Louise, Yoho and Kootenay Field Unit

The infrastructure currently in place at the Yoho Ranch is adequate for supporting current horse use, however maintenance of the ranch house (historical building), barn and road will be required in the future. When the TransCanada highway gets twinned through Yoho National Park, the ranch will need access from both lanes of traffic. Parks Canada, Canadian Pacific, and ATCO all use the access road to manage infrastructure in the Yoho Ranch area. The Lake Louise Ranch is also in adequate condition and currently supports horses on a temporary basis, as dictated by logistical demands.

Backcountry infrastructure maintenance is currently required in LLYK, including the corrals at Pipestone, Fish Lakes and Isabella cabins. Additionally, meadows that once supported equine and wildlife grazing would greatly benefit from prescribed burns, so as to restore condition that has been previously lost to fire suppression.

The LLYK Field Unit currently does not have an Equine Specialist to provide staff training professional equine expertise, and has instead relied on Resource Conservation staff with support from the equine specialists in the Banff Field Unit. Efforts to increase the long-term sustainability of this program would be beneficial.

Ya Ha Tinda Ranch

Improved infrastructure aimed at supporting Ya Ha Tinda Ranch staff in horse training efforts is necessary as well. The increased demand for safe, trained horses to use in Field Units means that Ranch staff need to be able to utilize as many days as possible for training. Currently, many training days are lost to extreme weather temperatures and conditions that are otherwise unsafe for work. Building an indoor riding arena at the Ya Ha Tinda Ranch would therefore greatly increase the efficiency of the horse training that is currently required to meet operational needs within the Mountain Parks. This would also allow for a safer, more controlled environment when training horses and staff, potentially leading to decreased risk of incidents and/or injury.

Please contact the following individuals for further information regarding the Mountain Parks Equine Program.

Contact

Ginny Crosby, Equine Specialist
Banff Field Unit
P: (403) 431-1322
E: *ginny.crosby@pc.gc.ca*

Rick Smith, Ya Ha Tinda Ranch Manager
Banff Field Unit
P: (403) 621-1128
E: *rickw.smith@pc.gc.ca*

Anne Forshner, A/ Equine Program Coordinator
Lake Louise, Yoho and Kootenay Field Unit
P: (403) 431-1795
E: *anne.forshner@pc.gc.ca*

Human-Wildlife Conflict and Coexistence Program

Introduction

Human-wildlife conflict (HWC) can be a visitor safety issue and a stressor on wildlife populations in our national parks. Wildlife viewing is one of the most popular visitor activities. A positive encounter with a large mammal such as a bear, elk, deer, moose, coyote, cougar or wolf is often the highlight of a visitor's trip. Effective management practices can reduce the frequency and seriousness of encounters between humans and wildlife, while supporting wildlife populations and positive wildlife viewing experiences. Increasingly, proactive efforts now focus on enhancing Human-Wildlife Coexistence.



Figure 1. Bow Valley wolf feeding on garbage that was improperly deposited in a trade-waste bin in Banff National Park.

Objectives

The primary goal of Human Wildlife Conflict and Coexistence (HWC^2) management is to mitigate risk by preventing and resolving conflict between people and wildlife.

Methods

Parks Canada uses preventive methods such as public education, stakeholder consultation, facility design, attractant management, exclusion fencing, and proactive seasonal warnings, closures and travel restrictions to minimize risks of conflict. When necessary we also undertake reactive management actions: hazing, aversive conditioning, public warnings, closures and travel restrictions, wildlife immobilization, carcass management, tracking/monitoring (GPS, radio telemetry), deploying remote cameras, euthanasia, and necropsy.

To haze wildlife we use escalating negative stimuli such as voice commands, chalk balls, cracker/screamer shells or rubber bullets, to move an animal away from a conflict situation. Wildlife management staff use the least force necessary to move an animal. Sometimes we also need to

implement more intensive management strategies such as aversive conditioning to discourage a specifi c animal from concerning behaviour, such as persistent forays into the town sites or campgrounds. During aversive conditioning, wildlife management staff use telemetry to continuously monitor a specifi c animal of concern, allowing staff to consistently haze the animal every time it exhibits the undesirable behaviour.

Parks Canada uses a tracking system to record data about every wildlife related incident attended to by a Resource Management Offi cer. This tracking system provides data on the nature of the incident and provides a complete record of the actions taken by Parks Canada personnel. With these records, managers are able to assess trends in the incident data and assess the effi cacy of management actions to ensure the safety of visitors and wildlife.

Results

Over the past 10 years (2008-2017) Resource Management Officers responded to 13,261 human wildlife conflict incidents in Banff National Park, with a 7% average annual increase (Figure 2). Warnings and closures (as reactive management strategies) occurred annually depending on the frequency of human wildlife conflict incidents and their relative risk to visitor or wildlife safety (Figure 2). Over the past 10 years, preventive wildlife management in Banff National Park has included an increasing number of proactive Restricted Activity Orders (RAO's) (Figure 2). Restricted Activity Orders limit the use of an area to specific activities by visitors and are now, most often, posted annually on a seasonal basis (e.g. Minnewanka Area Seasonal Trail Restriction).

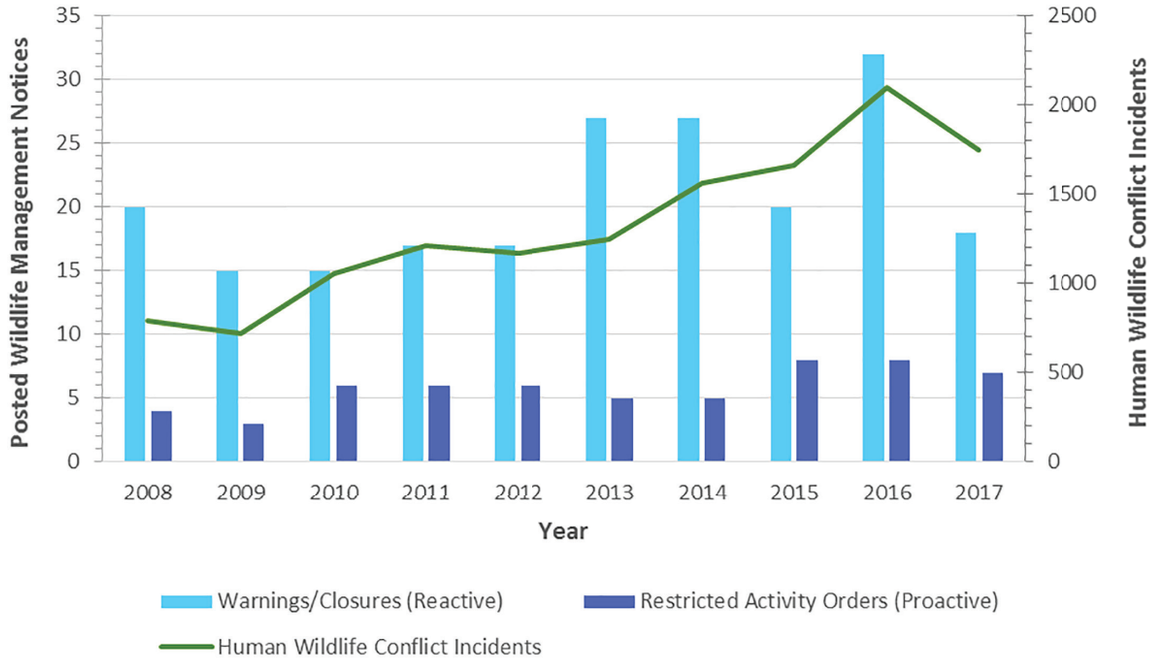


Figure 2. Annual count of human wildlife conflict incidents and posted warnings, closures, restricted activity orders in Banff National Park, 2008 – 2017.

Staff spent considerable hours attending to wildlife activity in the vicinity of the town sites (Banff and Lake Louise) and other areas of high visitor use (campgrounds, picnic sites, golf course, etc.). Other common incident response types include wildlife mortalities, injured wildlife, and wildlife jams along the transportation corridors (Trans-Canada Highway, Bow Valley Parkway, Highways 93N, CP railway, and secondary roads).

Between 2008 and 2017, 40% of HWC incidents pertained to bear species; 2,725 incidents related to black bears and 2,569 to grizzly bears (Figure 3). Of all bear related incidents, 110 were documented as aggressive encounters, where the bear displayed some type of aggressive behaviour which could range from the animal approaching, vocalizing or even bluff charging (without contact). In the same 10 year period there were only 2 contact encounters where a bear physically made contact with a visitor (resulting in non-life-threatening injuries).

Elk related incidents represented 27% of total human wildlife conflict incidents (Figure 3) and were most common in proximity to the town of Banff. Human-elk conflict management is addressed in more detail in the Bow Valley Elk Management chapter of this document.

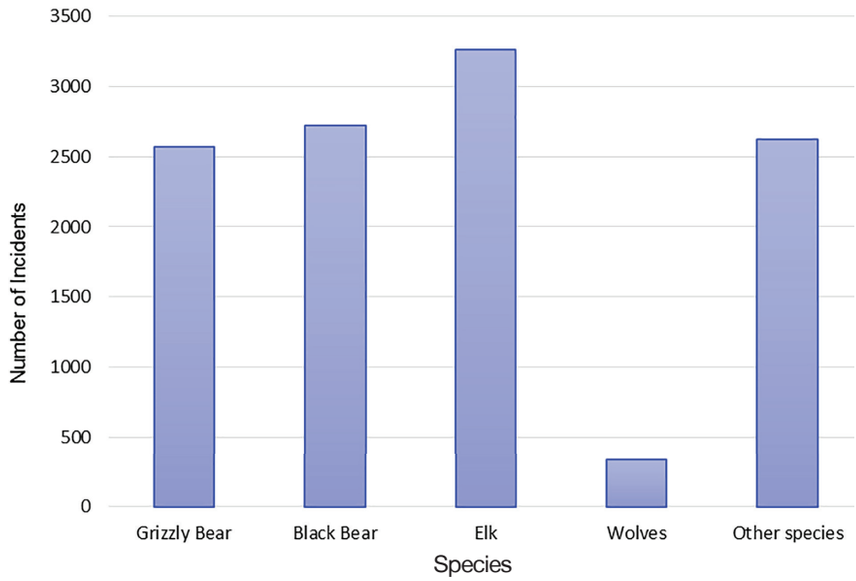


Figure 3. Number of human wildlife conflict incidents by species in Banff National Park, 2008-2017.

Discussion

The annual trend of increasing human wildlife conflict incidents (Figure 2) illustrates a considerable spike in recorded incidents for 2016. Two factors are attributed to this increase; a higher than normal buffalo berry crop and the active management of food conditioned wolves in proximity to high human use areas in the lower Bow Valley.

The productive berry crop in 2016 was especially evident in the Lake Louise area where the frequency of bear incidents were higher than normal through July and August. Seasonal bear

activity/incidents typically peak in this area of Banff National Park during the month of June but the abundant buffalo berries kept bears in the valley bottom later than usual where they were more likely to encounter visitors. In the Lake Louise area, there were 562 bear related incidents in 2016 compared to 291 incidents in 2015.

Banff National Park had 134 wolf related incidents in 2016 compared to 42 incidents in 2015. This increase was attributed to food conditioned and habituated behaviour of the Bow Valley wolf pack, generating numerous management incident responses (e.g. warnings, hazing, capture/radio collaring, and visitor education/communication) from spring through fall of 2016.

The HWC program relies heavily upon the integrated support of other functions to achieve its goals. The Wildlife Guardian Program in particular (managed through the Visitor Experience Function) helped to manage numerous roadside wildlife encounters throughout the 10 year period. Wildlife Guardians mitigated potentially unsafe traffic situations and educated visitors with regards to safe, respectful and sustainable wildlife viewing on a daily basis throughout the summer months.

One of the key issues during the last 10 years has been the number of incidents of habituated wildlife (wolves and bears) obtaining human food or garbage. Wildlife that have received human food have a high chance of becoming food conditioned, at which point they present a high risk to potentially attack and injure visitors. A number of factors may be contributing to an increase in these incidents but combating this increase will require an integrated approach of education (both before visitors arrive and of visitors on site) and enforcement. Innovative approaches to effectively reaching visitors will be necessary to reduce the chance of food conditioning into the future.

Acknowledgements/Partners

Resource Conservation relies heavily on Visitor Experience staff such as Wildlife Guardians and Interpreters to reach visitors with wildlife safety messages. Parks Canada Resource Conservation staff (Brian Spreadbury) assisted with data analysis.

Contact

Saundi Norris, Acting Human-Wildlife Conflict Specialist
Banff Field Unit
P: 403-431-0174
E: *saundi.norris@pc.gc.ca*

Jon Stuart-Smith, Acting Human-Wildlife Conflict Specialist
Lake Louis, Yoho and Kootenay Field Unit
P: 403-522-1232
E: *jon.stuart-smith@pc.gc.ca*

Wildlife Management for Special Events

Introduction

Special events help Parks Canada to connect with both participants and spectators amidst a world class wilderness setting. While on course, participants are likely to encounter charismatic wildlife - an experience topping the list of most visitors.

Given the large number and competitive focus of participants, the wide expanse of course routes, and the prevalence of roadside wildlife in Banff National Park, efforts towards mitigating human-wildlife interactions are necessary. Resource Management Officers are involved in monitoring special events to ensure the safety of visitors/participants and limit the disturbance and displacement of wildlife.



Figure 1. Gatorade spilt along the Bow Valley Parkway during 2017 Banff Marathon. Photo Laura Rance/Parks Canada.



Figure 2. Grizzly bear 148 at Fenlands DUA on Banff Marathon Race day 2017. Photo by Laura Rance/Parks Canada.

Objectives

- To minimize disturbance, displacement, and mortality risks to wildlife from special events.
- To prevent or limit the risks of negative human-wildlife interactions between event participants and wildlife.
- To respond rapidly to human-wildlife interactions to ensure the safety of the participants and wildlife.
- To educate event organisers and participants to increase public awareness of wildlife safety practices.
- Eliminate litter and wildlife attractant concerns related to event activity.

Methods

For the last several years, one member of the wildlife management section of the Resource Conservation department has been designated as a liaison with the Visitor Experience department for communicating important wildlife safety information to event organizers. The following list contains methods used to mitigate risks of negative Human/Wildlife Interactions during Parks Canada approved events:

- A wildlife response plan was customised for each event. Each plan outlined pre-race requirements, communication needs, waste management guidelines, and response protocols agreed upon by Parks Canada and event organiser.
- In 2017 a wildlife response plan template was developed in cooperation with Visitor Experience. This template can be quickly and easily customised to large or small scale, route-oriented or stationary special events.
- Parks Canada continued to work with event organizers to improve contingency planning for adapting to, and avoiding, wildlife activity.
- We provided event organizers with regular wildlife updates, based on relevant observation and collar data, prior to events.
- We identified wildlife safety information, including Parks Canada website links, to be provided to participants, volunteers and staff by the event organiser prior to event day.
- In conversation with Park Managers, we advised on implementation of contingency plans and alternate routes as wildlife conflict issues became evident prior to event day.
- Resource Management Officers provided event day support including proactive patrols, monitoring, and response to human-wildlife incidents. The number of wildlife staff dedicated to the event depended on the event location and wildlife activity leading up to the event day.
- We provided recommendations for improvement, regarding wildlife considerations, to Visitor Experience, event organisers and stakeholders by way of post event reporting and event debriefs. A post event report template was created in 2017 to improve consistency in event reporting.

Results

No human-wildlife interactions (HWI's) resulted in contact or injury during special events from 2013-2017. Thirty seven percent of the total management responses reduced disturbance to wildlife through changes to route location or timing; 30% of management responses could have displaced wildlife or changed their travel routes (monitoring wildlife near course routes), 16% of management responses followed regular daily operational protocols in established management zones (hazing wildlife) and 17% of reported human-wildlife interactions during race events were unattended by Parks Canada staff (Figure 3).

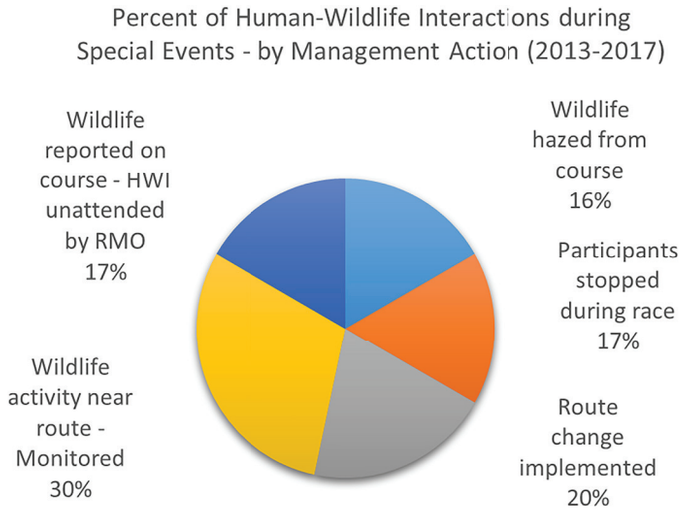


Figure 3. A breakdown of human-wildlife interactions during special events from 2013-2017 by management action. Note that hazing wildlife only occurred in areas where this is the normal protocol (e.g. in town).

Human wildlife interactions during special events between 2013 and 2017 involved 10 different species. The greatest percentage of interactions involved elk (34%). Black bears and grizzly bears comprised 29% and 15% of interactions respectively. Eleven percent of interactions pertained to wolf activity, while the remaining 11% involved bighorn sheep, cougar, coyote, fox, moose or deer (Figure 4).

In the last 10 years, the nature of special events changed from a focus on large scale (> 1000 participants) road-based, race-style events to smaller scale (200-500 participants) races and stationary events in 2017.

The average number of human wildlife interactions per event, however, remained relatively constant (Figures 5 and 6.)

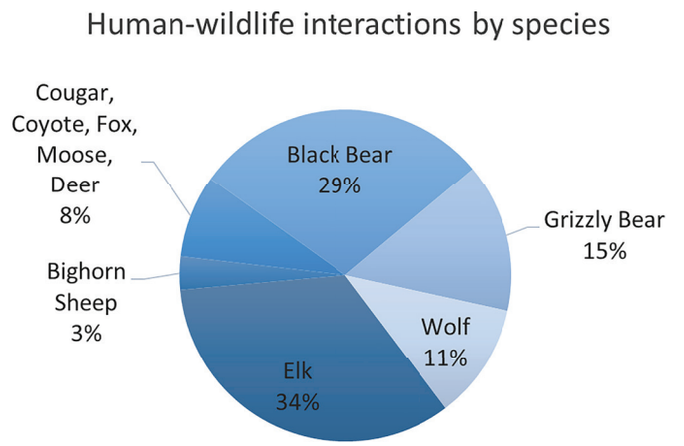


Figure 4. Species presence during special events resulting in human-wildlife interactions. Interactions may or may not have been attended by Parks Canada staff. (2013-2017.)

Large scale events peaked in Banff Field Unit from 2010 to 2015. Banff Marathon and Winterstart are currently the only large scale race events that are scheduled to continue in 2018 (Table 2.)

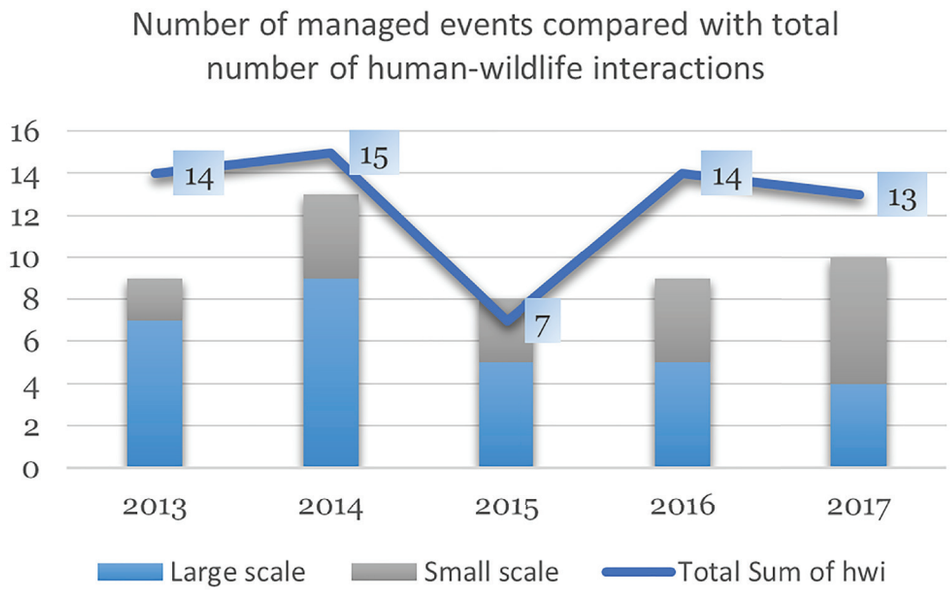


Figure 5. Number of events per year compared with total number of human-wildlife interactions during events (2013-2017.) The "small scale" designation included stationary events. Data prior to 2013 was inconsistent and could not be included for comparison.

New small scale events introduced in 2017 included Bioblitz, a volunteer based field data collection day (200 participants), and Illuminations, a light and sound experience at Lake Minnewanka (600-900 participants over 4 nights).

Stationary events were grouped with small scale events based on the limited area affected. A small scale cross country ski race, the Lake Louise to Banff Loppet, is a historic event and has been running for many years. A portion of the route deviated from existing trails, roads, and linear features and crossed through the middle of important wildlife habitat. The route was changed in 2015/2016 to avoid this area.

Table 1. Average number of human-wildlife interactions per event, all managed events (2013-2017.)

Year	2013	2014	2015	2016	2017
Average	1.56	1.15	0.88	1.56	1.3

Table 2. Trend of Large Scale Special Events from 2006 to 2018. Blue fill indicates which years the event occurred or are planned for 2018

Trend of large scale special events 2006-2018													
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Skin Game	■					■							
Dragon Boat Festival			■	■	■	■	■						
Winterstart 5 Mile Run	■	■	■	■	■	■	■	■	■	■	■	■	■
Melissa's	■	■	■	■	■	■	■	■	■	■	■	■	
Bike Fest				■	■	■	■	■	■				
Suburu Triathlon					■	■	■	■	■	■			
GranFondo							■	■	■	■	■		
Banff Marathon									■	■	■	■	■

Specific waste management concerns were identified during special events. During the GranFondo in 2013, for example, gel packs, bar wrappers, banana peels and other items were left on the course long after most riders were clear of the area. Wildlife staff removed litter from the course. During the Banff Marathon in 2016 gel packs and plastic cups were left in piles at km markers, significant volumes of Gatorade spillage was observed at aid stations, and cups were seen being thrown off the trail by runners. Solutions included the following mitigations: Banff Marathon was required to flush aid station areas with water; Event organisers now agree to monitor the routes during and immediately after the last participant for picking up litter; Participant education with regards to waste management is required as a component of the wildlife response plan; Aid station set up has improved to facilitate waste capture; Melissa's Road race eliminated all attractants at aid stations and provided only water. As a result, incidents of unattended wildlife attractants was reduced.

The Resource Conservation department dedicated 202, 209, 277, and 259 hours to special events from 2014 - 2017 respectively. Staff time included: reviewing wildlife response plans; meetings with Visitor Experience, stakeholders and event organisers; pre-event and event day monitoring; post event reporting.

As of winter 2017, Jasper National Park has adopted the newly developed wildlife response plan template for special events in their park moving forward.

Discussion

Special event management addressed strategic goals set in the 2008 State of the park report. Effective management will help maintain viable wildlife populations and improve habitat connectivity by reducing habituation to unique disturbances (runners and cyclists,) and by mitigating

the effects of potential travel barriers presented by event activity. Special event management also aims to reduce human caused mortality of grizzly bears by mitigating potential for negative interactions and effectively managing wildlife attractants.

It is unclear if special events in Banff Field Unit contributed to, or reduced wildlife disturbance overall. As shown in the results, 37% of management actions implemented helped reduce disturbance to wildlife. These actions included the implementation of pre-determined contingency plans, start time delays, or stopping participants during the race to avoid locations of abundant or persistent wildlife activity. Seventeen percent of management actions included hazing wildlife in pre-established management zones where wildlife are typically hazed as a part of regular daily operations. Yet, there was a more concentrated effort to continuously patrol event routes throughout event days than during regular daily operations, so this is difficult to evaluate. Thirty-seven percent of human-wildlife interactions potentially contributed to wildlife disturbance: monitoring wildlife adjacent to the course may prevent natural movement patterns, and unattended wildlife on course may contribute to habituation. A number of events, however, required road closures. Road closures prevented regular traffic use, thereby reducing wildlife jams and associated habituation.

The uncertainty stemming from wildlife activity caused considerable stress to event organisers. Improved wildlife response plans and contingency planning improved communication and understanding between Parks Canada and event organizers. Good contingency planning reduced the likelihood of event cancelation and improved the goal of reducing wildlife disturbance. Some events, however, had few contingency options. The GranFondo, for example used most paved roads in the Banff Field Unit including the Bow Valley Parkway to Lake Louise. No pre-event day contingency routes were available which resulted in significant course interruptions during this event on multiple occasions. Future events that have multiple contingencies will help meet both Parks Canada and event organizer's goals.

Management of large scale events was relatively consistent between 2013 and 2017. The Skins game in 2006 and 2011, and the Dragon Boat festival were the first events where wildlife staff were dedicated to reducing human-wildlife conflict for the duration of the event. Both events, however, had poor wildlife attractant management. Thus, Park Canada decided to focus energy on reducing wildlife-conflict issues for future events. The 2012 GranFondo was the first event to have a complete wildlife response plan to address wildlife concerns.

Parks Canada wildlife staff did not attend some of the smaller scale events for a number of reasons. A number of small scale events (Golden Triangle, Jasper to Banff relay, Terry Fox run and various parades, for example) were not attended because Resource Conservation staff were unaware of them or the event did not apply for a permit through Visitor Experience. Events that took place on Town of Banff land did not always go through the Parks Canada for approval process. For example, resource management officers responded to concerns about wildlife attractant after the 2017 Santa Parade, because candy was distributed along the parade route magpies and ravens were observed accessing this attractant. Improved communication and protocols could reduce wildlife-conflict issues associated with small scale events.

A number of factors influenced the likelihood of negative human-wildlife interactions during special events including time of year, time of day, location, nature of activity, size of area impacted by event, and number of participants. Comprehensive wildlife response plans that include these factors and contingencies will help reduce wildlife-conflict incidents associated with special events.

Acknowledgements/Partners

Prepared by Laura Rance and Mike Grande.

Contact

Jesse Whittington,Wildlife Ecologist
Banff Field Unit
P: (403)-763-8865
E: *jesse.whittington@pc.gc.ca*

Visitor Safety Program

Introduction

The Visitor Safety Program in Banff, Yoho, and Kootenay National Parks consists of ten staff working seamlessly across the two field units (including an avalanche search dog and handler), and having four main areas of responsibility.



Figure 1. A visitor safety specialist accesses a stranded climber using the BOOST External Human Cargo System.

- **Public Avalanche Forecasting**

  During the winter we produce daily public avalanche hazard bulletins for back-country users. The bulletin describes the avalanche hazard, summarizes the main issues in the snowpack, and offers travel advice.

- **Highways Avalanche Forecasting and Control**

  During the winter months we monitor and forecast the avalanche hazard affecting the highways and roads in Banff, Yoho, and Kootenay National Parks. When necessary the roads are closed and we conduct avalanche control.

- **Search and Rescue**

  We provide a full time professional search and rescue response. This includes lost person searches and evacuation of injured persons. Our staff are trained in mountain rescue, swift water rescue and advanced first aid. We lead search and rescue in Banff, Yoho, and Kootenay National Parks, and occasionally provide support on neighboring provincial lands and to northern national parks, through mutual aid arrangements.

- **Accident Prevention and Outreach**

  We provide a variety of prevention and outreach programing to help reduce the likelihood and severity of accidents. This includes signage, safety messaging on social media and on the Web, brochures, and targeted presentations at hotels and community centers. The goal with this program is to give the public timely and salient information so that they are better prepared to make their own decisions while recreating in the back-country.

Banff National Park visitor safety specialist do not lead or actively participate in dive rescue (we request support from the Calgary Fire Department), or Cave Rescue (volunteer organizations in BC), and normally only play a support role when responding to downed aircraft which is lead across Canada by the Department of National Defense.

Results

Public Avalanche Forecasting

Over the winter, we produced 300 public avalanche hazard bulletins for Banff, Kootenay and Yoho National Park regions.

Highway Avalanche Forecasting and Control

Of the past six years, 2017 was the most intensive winters for avalanche control (Table 1). We completed 33 avalanche control missions and short duration road closures over 28 days to protect the Trans-Canada Highway, Highway 93 South & North, the Field Back Road, and the Sunshine Ski Area Road. There was an extended closure of the TCH due to an unpredictable serac failure entraining snow that filled a protective berm and spilled onto the open highway. Highway 93 N was also closed for an extended period after a controlled avalanche from Mt. Hector buried the road in wet debris on May 5, 2017.

Table 1. Six year trend in Avalanche Control Missions for Banff, Yoho, and Kootenay highways and roads

	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Number of days helicopter avalanche control conducted	16	13	22	9	11	28
Number of times Gasex exploders were used	8	4	6	3	4	7
Number of explosives deployed	219 (2,700 kg)	177 (2,213 kg)	320 (4,000 Kg)	129 (1,613 Kg)	201 (2,513 Kg)	315 (3,938 Kg)

Search and Rescue

In 2017 we experienced the busiest year on record perhaps due to higher visitation with good weather throughout the summer and free entry into National Parks (Figure 2). Visitors request help most often by cell phone (38%) and then by a third party (15%). Many visitors were helped by visitor safety via coaching over the phone using a combination of smart phone or satellite communicator devices and google earth technology to accurately determine the party's location and coach them to self-rescue verbally or through texting.

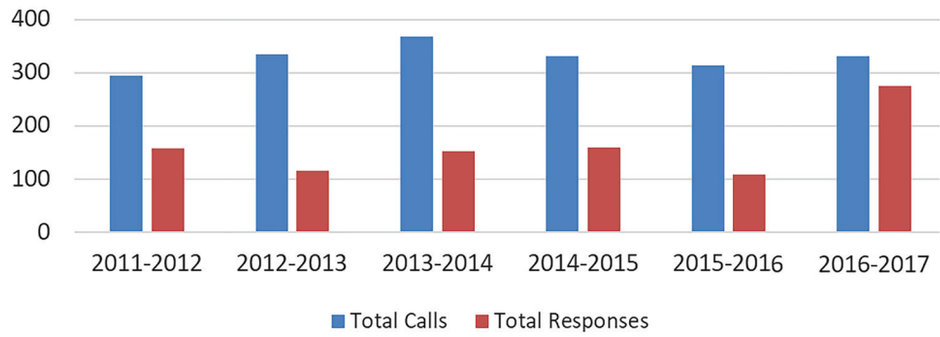


Figure 2. Six year trend of visitor safety total calls and responses for BFU and LLYKFU combined. The year spans from November 1-October 31

As in past, almost half of the responses were to hikers (45%), followed by scramblers (12%), back country skier/boarders (8%) and then mountaineers (6 %). The most common injury is a slip/fall on the trail resulting in a sprained or fractured lower leg. There were approximately 15 rescues for medical concerns. Emergency Medical Services Advanced Care Paramedics were flown to the scene with our staff for 12 of these cases. Use of helicopters continues to be a major method of response and patient evacuation within our parks (Figure 3). Compared to the previous 5 years, last year we did the highest number of technical rescues (8) where ropes were required to access and rescue the subject.

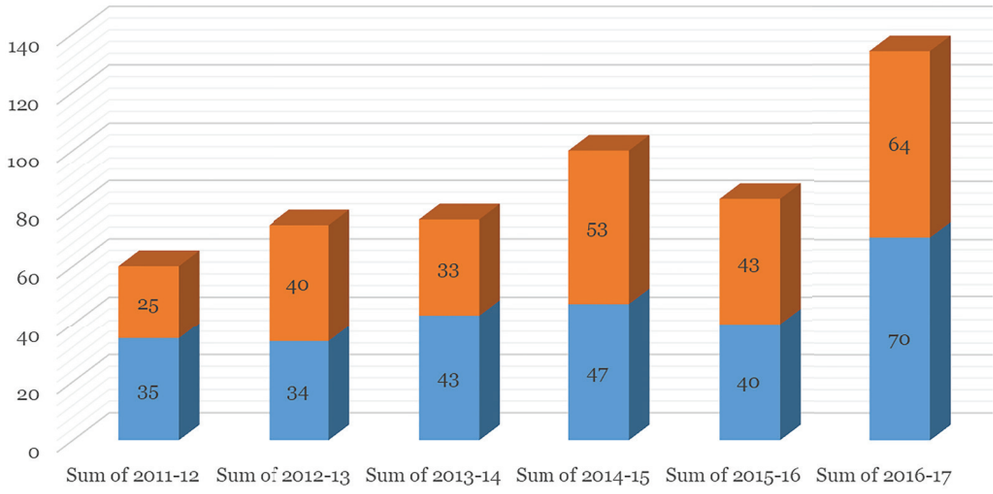


Figure 3. Six year trend of visitor safety helicopter use for BFU and LLYKFU combined over the past six years. The year spans from November 1 to October 31.

Some of the more notable responses/incidents included:

- Rescue at 5,000 m on Mt. Logan in Kluane for a party of 3 suffering with altitude sickness, both our and Jasper VS staff and medical directors advised and responded in support of the Kluane team who completed the rescue via helicopter.

- Technical and overnight rescue of an injured kayaker in the Yoho Canyon and a scrambler on Mt. Fairview.
- Search and recovery of 2 snowshoers on Mt. Hector approach during a period of high avalanche hazard where control on highway paths also had to be done by our team.
- Technical rescue on 2 climbers on Direttissma on Mt. Yamnuska after a near miss involving the Kananaskis public safety team
- Technical rescue of a skier stuck on some cliffs within Sunshine ski area

The Parks Canada dog (Cazz) and handler team were requested for a total of 26 visitor safety calls, including 3 searches for potentially despondent visitors. The team also did 6 roadside validation tests for CARDA, taught an advanced CARDA course, 2 introduction to avalanche searching courses, and evaluated RCMP dog handlers in avalanche profile and ski ability.

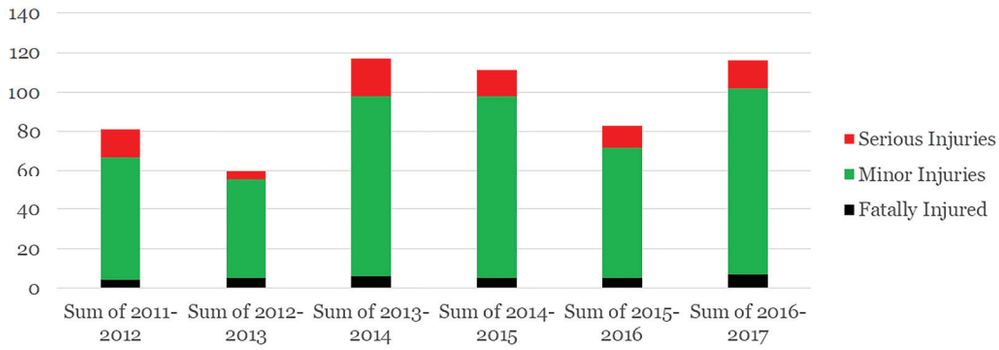


Figure 4. The number of patients with minor, serious, or fatal injuries in BFU & LLYK combined over the past 6 years. The year spans from November 1 – October 31.

Acknowledgements/Partners

Other national parks, Kananaskis Country, local ambulance services, STARS, Banff Mineral Springs Hospital, RCMP, other provincial search and rescue agencies. Medical Director: Dr. K. McLaughlin

Contact

Brian Webster, Visitor Safety Manager
Banff and Lake Louise, Yoho & Kootenay National Park Field Units
P: (403) 762.1401
E: *brian.webster@pc.gc.ca*

Appendix 1. Publications and Presentations contributed by the Resource Conservation Function in Banff National Park from 2010 to present

Peer Reviewed Publications

(Including in prep., in review, and in press)

B.G. Sullivan, M.K. Taylor, C. Carli, W. Taylor, R.J. Lennox, and S.J. Cooke. *In review*. Partial dam removal restores bull trout (*Salvelinus confluentus*) passage using a nature-like stream. River Research and Applications XX: XX-XX.

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Rear Cover Photo: A natural fishway, resulting from the partial removal of the 40 Mile dam, now provides connectivity for bull trout; allowing them to access over 35 km of headwater spawning habitat for the first time in more than 65 years.



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