Alberta Bull Trout Recovery Plan

Alberta Species at Risk Recovery Plan No. #46

Alberta

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Recovery Planning in Alberta

Albertans are fortunate to share their province with an impressive diversity of wild species. Populations of most species of plants and animals are healthy and secure. However, a small number of species are either naturally rare or are now imperiled because of human activities or natural processes. Alberta Species at Risk recovery plans establish a basis for cooperation among government, Indigenous communities, industry, conservation groups, landowners, and other stakeholders to ensure these species and populations are restored or maintained for future generations of Albertans.

Alberta has a robust provincial recovery program to support its commitment to the federal/ provincial *Accord for the Protection of Species at Risk* and the *National Framework for the Conservation of Species at Risk*, and its requirements established under Alberta's *Wildlife Act* and the federal *Species at Risk Act*. An overall goal of the program is to restore species identified as *Threatened* or *Endangered* to viable, naturally self-sustaining populations within Alberta.

The Government of Alberta is committed to providing opportunities for Indigenous communities, stakeholders, and the Alberta public to provide their perspectives and influence plan content during the recovery planning process. The process for how Albertans are engaged can vary based on the socio-economic and conservation issues and the level of interest expressed. Draft recovery plans undergo a review by the Fish and Wildlife Policy Branch and are then posted online for public comment for at least 30 days. Following public review, Alberta's Endangered Species Conservation Committee reviews draft plans and provides recommendations on their acceptability to the Minister of Environment and Protected Areas. Plans accepted and approved for implementation by the Minister are published as a provincial government recovery plan. Approved plans are a summary of the Ministry of Environment and Protected Area's commitment to work with involved stakeholders to coordinate and implement conservation actions necessary to restore or maintain vulnerable species.

Recovery plans include two main sections: (1) a situational analysis that highlights the species' distribution and population trends, threats, and conservation actions to date; and (2) a recovery section that outlines goals, objectives, associated broader strategies, and specific priority actions required to maintain or recover *Threatened* or *Endangered* species. Each approved recovery plan undergoes regular review and at that time progress on implementation is evaluated. Implementation of each plan is subject to internal and external resource availability.

Recovery plans will be systematically reviewed every five years. Where there are large changes in the goals, objectives, or strategy sections due to a new understanding or circumstance, a plan may need to be redrafted, consulted on, reviewed by the Endangered Species Conservation Committee, and the changes approved by the Minister.

Executive Summary

Background: Bull trout (*Salvelinus confluentus*) in Alberta was designated as a *Species of Special Concern* in 2002 and as Threatened in 2014 under Alberta's *Wildlife Act*. The Saskatchewan-Nelson bull trout population was scheduled as Threatened in 2019 under the federal *Species at Risk Act* (SARA) which includes the headwaters of the North and South Saskatchewan River basins in Alberta. The Western Arctic populations of bull trout are scheduled under SARA as Special Concern (2019) which encompasses parts of the Athabasca and Peace River basins in Alberta.

Concern about the conservation status of bull trout began many years prior to the species being listed as Threatened. A multi-stakeholder Bull Trout Task Force was active between 1993 and 1997 and a management and recovery plan were created in 1994. A provincial status report was produced in 2002 and updated in 2009. A Bull Trout Conservation Management Plan was released in 2012.

Population Status: Bull trout were commonly encountered and widely distributed within most major river basins in Alberta prior to European settlement. The species range extended from the mountains and foothills out into the parkland and prairies, being reported as far east as Lethbridge in the Oldman River, Carseland in the Bow River, Morrin in the Red Deer River and Edmonton in the North Saskatchewan River basin.

Populations of bull trout in 19 of 88 local watersheds (HUC 8) have become functionally extirpated (i.e., no or very few individuals exist), and bull trout no longer occupy the lower main stems of the Athabasca, North Saskatchewan, Red Deer, Bow and Oldman rivers. The abundance, distribution and size structure of the majority of populations within local watersheds (n=62) are poor relative to past angler accounts and when compared to the few remaining well-functioning populations (n=7) that occur in protected and/or remote areas. A province-wide zero bag limit for bull trout was instituted in 1995. It is unclear as to what extent bull trout populations have responded positively to these regulation changes due to insufficient monitoring data. In addition, the response to this regulation change was likely obscured by other factors such as habitat degradation and fragmentation, competition from introduced species, and accidental as well as illegal harvest.

Threats: A long list of threats have been identified in past status assessments related to the increasing cumulative impacts of industrial and recreational activities as well as competition from introduced fish species. A cumulative effects model developed by the Government of Alberta (GoA) was used to assess the relative importance of each threat. The cumulative effects model identifies that water quality (phosphorous and sediment inputs), mortality from poaching and incidentally from catch and release angling, and barriers to fish passage associated with road crossings are likely the most common, key threats limiting bull trout populations in their natural range. These predictions are hypotheses to be tested during recovery implementation as part of an adaptive management approach to recovery.

Alberta Environment and Parks (AEP) has developed a system for assessing the status of fish populations, called the **Fish Sustainability Index**. Current populations are compared to an observed or modelled-theoretical reference population, unaffected by human influences such as fishing mortality, habitat loss, change in habitat quality, competition with exotic species, and human-caused barriers to fish passage. The current population is assigned a risk of extirpation score from 1 (high risk) to 5 (very low risk).

Recovery Area: The specific geographic area of where the objectives are being applied is called the Recovery Area and encompasses all the watersheds that are currently occupied by bull trout (Figure ES1). The excluded area is in the eastern part of the distribution where some combination of dams that block movement and/or significant land use change (e.g., cultivation, industrial development, urban development) has made it unrealistic to consider restoration.

Assessing Recovery Potential: To better characterize what is technically possible, the cumulative effects model, combined with expert opinion, was used to assess recovery potential in each local watershed in the Recovery Area. The potential system capacity for bull trout was characterized as if important threats such as sedimentation, angling related mortality, and

human-caused barriers to fish passage were mitigated (Figure ES1). Within the Recovery Area, there are changes that are very difficult to reverse such as hydroelectric dams, conversion to agricultural land, urban development, and water withdrawals for irrigation, so these changes were not considered for remediation. Socio-economic factors (cost and public acceptance) were also not factored into scenario development.

Recovery Objectives

- Maintain or improve current population status in the Core, Potential Core and Support (Figure ES1) populations (10 years).
- Improve adult and immature Fish Sustainability Index (FSI) score by one FSI level in at least one watershed within the Core or Potential Core watersheds within each of the basins (i.e. Peace, Athabasca, North Saskatchewan, Red Deer, Bow and Oldman) in the Eastern Slopes (five years). These are termed 'recovery watersheds' in this plan.
- Add at least two more new restoration projects in each major river basin to improve FSI score in at least two watersheds within the Core or Potential Core watersheds (10 years).

Strategic Approaches for Recovery

The three high-priority strategic approaches are described below.

- The plan puts a high priority on education to ensure that Albertans are aware, supportive and engaged in recovery efforts for native trout.
- The plan also proposes that all wide-ranging threats be addressed by updating and refining current land and recreational management practices in order to improve the outcomes for bull trout.
- To date, Alberta has only had mixed success in recovering local populations and what success there has been has primarily been in systems that have a lake. A critical next step is demonstrating the feasibility of recovering local populations of bull trout in riverine systems that are part of Alberta's busy working landscape. Initial recovery activities will be prioritized within at least one recovery watershed within each river basin (i.e. Peace, Athabasca, North Saskatchewan, Red Deer, Bow and Oldman). In particular, it will be important to evaluate the identified wide-ranging threats.

Integrated Program Delivery: There are now three species of native trout—bull trout, westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and Athabasca rainbow trout (*Oncorhynchus mykiss*)—that are provincially and federally listed as either Threatened or Endangered. Westslope cutthroat trout and Athabasca rainbow trout have specific hybridization concerns but share many conservation issues as bull trout and they co-occur in many of the same streams. There are also other cold-water native fish such as Arctic grayling (*Thymallus arcticus*), mountain whitefish (*Prosopium williamsoni*), and pygmy whitefish (*Prosopium coulterii*) that should be considered in this programing. In order to deliver an integrated program, Fisheries Management in Alberta has developed the Native Trout Recovery Program and this will be the primary delivery mechanism for the Bull Trout Recovery Plan.

FIGURE ES1. Assessment of the recovery potential of local watersheds within the bull trout Recovery Area. Note that the Upper Crowsnest and the Upper Ram watersheds were split at waterfalls to better characterize bull trout population status upstream and downstream of the waterfall. Inset map shows HUC 10s within a HUC 8 watershed.

Predicted Recovery Category	HUC 8 Count
Core	18
Potential Core	12
Support	28
Likely Unrecoverable	11
Extirpated	2
Total =	71

Legend

- Alberta Boundary
- Bull Trout Recovery Area
- National Parks
- Historically Unoccupied

Predicted Recovery Category

- Core
- Potential Core
- Support
- Likely Unrecoverable
- Extirpated

Classification: Public
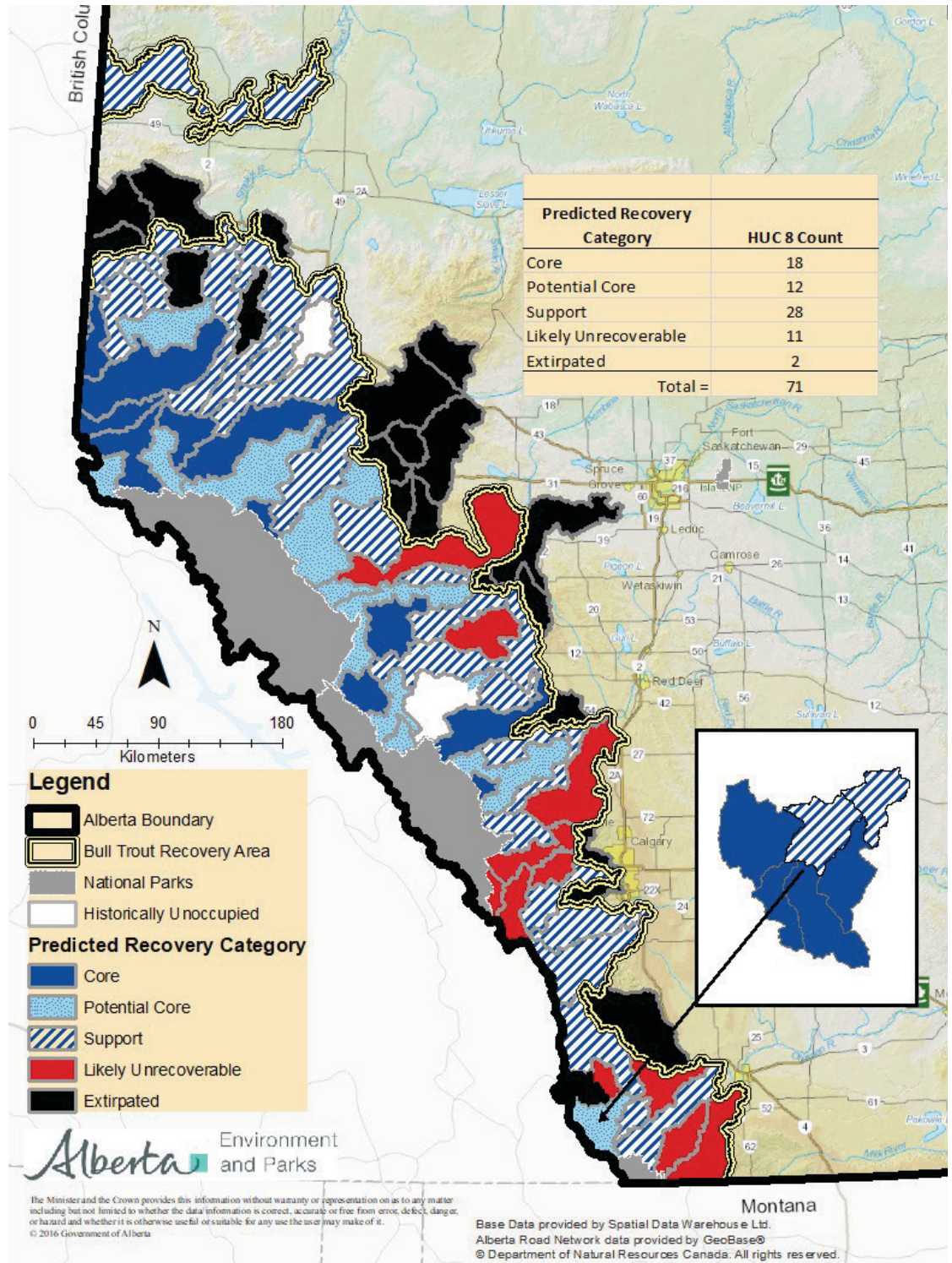
1. Introduction

Bull trout (*Salvelinus confluentus*) are Alberta's provincial fish. They are a cold-water species that primarily occurs throughout streams of Alberta's Eastern Slopes, the mountains and foothills along the west side of the province. They are related to other char species (e.g., lake trout (*Salvelinus namaycush*) and Arctic char (Salvelinus alpinus) although they are commonly referred to as 'trout' as opposed to 'char'. Bull trout were once a widespread and abundant sportfish; however, there have been concerns about the status of bull trout populations in Alberta for many decades (Figure 1). Various conservation measures have been implemented, including the development of the Bull Trout Conservation Management Plan (Berry 1994). The Endangered Species Conservation Committee recommended that bull trout populations in Alberta be listed as Threatened in 2010 due to declines in distribution and population size and continued threats from habitat alteration and introduced species. The recommended status change was accepted by the Government of Alberta (GoA) in August 2014, and bull trout are currently listed as Threatened under Alberta's *Wildlife Act* and Wildlife Regulation. The federal Committee on the Status of Wildlife in Canada (COSEWIC) has assessed the Saskatchewan-Nelson population (in Alberta this population is within the North and South Saskatchewan river basins) of bull trout as Threatened (COSEWIC 2012). This population was scheduled as Threatened in 2019 under the federal *Species at Risk Act* (SARA) by the Department of Fisheries and Oceans Canada (DFO) and a federal recovery strategy for this population was released in September 2020. The rest of the Alberta bull trout population is part of the Western Arctic population and has been listed as Special Concern under SARA in 2019.

A major past initiative related to bull trout management and recovery was the formation of the Bull Trout Task Force (1993 – 1997). This task force consisted of concerned stakeholders (i.e., conservation organizations, private and academic fishery biologists) and government agencies (e.g., Alberta Fisheries Management Division, Parks Canada and the Department of Fisheries and Oceans). The Bull Trout Task Force had a mandate to take an active role in bull trout management issues and undertook many initiatives designed to increase public support for bull trout recovery efforts throughout the province (Brewin 1997). Several public awareness initiatives, including designation of the bull trout as an official emblem of Alberta, poster and signage campaigns, public service announcements, promotion of bull trout conservation in the media and education contests, were deemed to be successful in creating public support (Brewin 1997). Brewin (1997) also stated that many of the initiatives that led to increased awareness, and support for recovery efforts, were initiated by the Bull Trout Task Force or its non-government organizations before government policies or regulations were approved and implemented. Wide-spread public support for recovery efforts and cooperation between government and non-government organizations led government agencies to enact new regulations (Brewin 1997). He states that the cooperative partnership of the organizations on the task force and the emphasis placed on public awareness initiatives should serve as a useful model for others dealing with other traditionally controversial issues and wanting to facilitate cooperative management solutions (Brewin 1997). In the United States, populations of bull trout in Montana, Washington, Idaho and Oregon have been listed as Threatened since 1999. The United States revised their draft plan in 2014 and included a new strategic approach that used a threat assessment tool to better assess and inform how to target threats at the recovery unit scale (USFWS 2014). This was felt to be important because bull trout occur over a wide area and key threats can vary amongst recovery units.

In 2012, the Alberta Bull Trout Conservation Management Plan (ASRD 2012) was updated. The updated plan was a comprehensive review of limiting factors and has a list of recommended recovery actions. During review of the plan's past scoping and recovery efforts, issues similar to those identified in the United States draft bull trout plan (USFWS 2014) were identified. Specifically, a tool was needed to assess the relative importance of potential threats and these threats needed to be assessed at the local watershed scale and at the major river basin scale. It was also recognized that the recovery potential of each local watershed needed to be assessed so that recovery activities could be targeted where there was the greatest likelihood of achieving a significant improvement in conservation status. There was the need to understand the thresholds where threats became important limiting factors and recognition that recovery actions should be structured to maximize learning opportunity by better characterizing these thresholds using an adaptive management approach (see section 3.4.3).

To address these needs this recovery plan was developed using a cumulative effects model. This was a novel approach that has generated considerable interest and controversy. The model was reviewed by the DFO Science sector in 2019. One of the summary points was that this model assessed system capacity (i.e., potential for the system to support adult individuals), and provides a method for assessing threats and generating hypotheses to inform and direct adaptive management actions. There was also recognition that this model allows for the investigation of trade-offs under alternative scenarios of threats and/or recovery actions. The model was designed to be flexible and could use many types of information (quantitative and semi-quantitative sources like expert and local knowledge) to assess threats based on the information available.

In 2018 fisheries biologists proposed to test the model as part of a series of adaptive management experiments for native trout in an Alberta Fisheries Management program called North-Central Native Trout Recovery. During consultations, stakeholders' concerns about the prominence that sportfishing closures were playing in the project generated considerable controversy and resulted in the Minister of Environment and Parks ordering the Office of the Chief Scientist to conduct a third-party science review.

The third-party science review conclusions (Roche et al. 2019) generally supported using a quantitative approach to assessing threats and using model outputs as hypotheses to inform management, and validating model prediction in recovery action implementation. There were concerns about the quality of information used in the input variables and the approach that was used for calculating additive effects. Incomplete knowledge of threats is common in species recovery planning. The intention is that by combining the cumulative effects model with an adaptive management approach our understanding of the significance of each threat and how they interact will increase over time. This will improve our ability to accurately diagnose the key threats in each local watershed, identify opportunities for recovery and to prescribe cost-effective recovery measures.

Roche et al. (2019) also highlighted concerns about how stakeholders were engaged and made a clear recommendation that active participation of stakeholders is necessary to formulate and implement effective policy and management action. This plan is responsive to the concerns from the third-party review by proposing a staged approach. The bull trout plan is the first stage which provides a strategic framework for recovery. Provincial stakeholder representatives contributed to developing this strategic framework. The second stage is to develop a native trout action plan that will include recovery prescriptions for local watersheds (see strategy 6.2 and section 7.2 for additional details). It is at this stage that regional interest groups such as anglers, Watershed Planning and Advisory Councils, rural municipalities, directly affected private land managers, program delivery partners, and Indigenous communities would be involved in developing and implementing local watershed recovery actions.

FIGURE 1. Timeline of bull trout status assessments, management plans and sportfishing regulation changes to present.

1976
Total fishing closures on some spawning and rearing areas

1994
Alberta Bull Trout Management and Recovery Plan

1990
Bait bans

1995
Province-wide zero-bag limit

2012
Alberta Bull Trout Conservation Management Plan

2009
Bull Trout Status Report update

2019
Bull Trout SK-Nelson populations listed as Threatened in federal *Species at Risk Act*

2014
Listed as Threatened (Alberta *Wildlife Act)*

1920s – 1980s
Bull Trout viewed as a piscivorous "junk fish". Heavy exploitation, targeted eradication, and increasing habitat degradation and loss

1984
Reductions in bag limit from five to two fish per day

1993-1997
Bull Trout Task Force

2002
Listed under the Alberta *Wildlife Act* as a Species of Special Concern

Bull Trout Status Report

2013
Bull Trout Fish Sustainbility Index completed

2010
Recommended as a threatened species in Alberta by the ESCC

2. Process for Plan Development

A nine-member advisory committee co-led by Jessica Reilly (later replaced by Adrian Meinke) and Pat Fargey assisted in reviewing plan content over a series of three conference calls and three in-person meetings from November 2015 to February 2019. A revised draft was reviewed by the committee in November/December 2019. Nicole Pilgrim joined the team in August 2019 to assist with editing and revision of the plan. Representation on the committee included Lorne Fitch (Cows and Fish), Rick Bonar (Alberta Forest Products Association), Peter Rodger (Department of Fisheries and Oceans Canada), Mark Taylor (Parks Canada Agency), Darryl Smith (Alberta Fish and Game Association), Lesley Peterson (Trout Unlimited Canada), Joanna Skrajny (Alberta Wilderness Association), Katie Morrison (Canadian Parks and Wilderness Society) and Meaghan Kearns/Luke Donnelly (Canadian Association of Petroleum Producers). Other people/groups were invited but declined to participate.

The plan was distributed for internal GoA review in November and December 2019. A draft of the plan was posted for public review May 13 to June 13, 2021, soliciting feedback through a questionnaire. Feedback was reviewed, and if appropriate, incorporated into the plan. The draft plan was also sent to Indigenous communities that have territories that overlap with bull trout range.

3. Situational Analysis

Bull trout biology, conservation status and recovery/management history were reported in the Alberta Bull Trout Conservation and Management Plan (ASRD 2012), Alberta Bull Trout Status Report (ASRD and ACA 2009), and the federal status report (COSEWIC 2012), recovery potential assessment (DFO 2017) and recovery strategy (DFO 2020a). The focus of the situational analysis is on new information and analysis directly relevant to the current conservation context, recovery goals and objectives, and recovery strategies contained in this document.

3.1   Key Natural History Characteristics

Bull trout in Alberta express three different life history strategies. Each life history strategy is described below to provide added context for consideration when evaluating population threats, recovery goals, and strategies. Although life history strategies are an important part of bull trout biology, it is also important to note that a previous study found no significant genetic differences between migratory and non-migratory individuals that co-occur, suggesting that a local population (e.g. HUC 8) can be managed as a single reproductive unit (Homel et al. 2008).

- Stream-resident bull trout populations permanently reside in the small, cold tributary streams in which they start their life cycle. Home ranges are typically small, with fish moving within tributary stream networks to access spawning sites or deeper pools to overwinter. Stream-resident bull trout are strongly associated with pool habitat and instream and overhead cover. Stream-resident bull trout typically exhibit lower growth rates than migratory populations (described below) and do not attain large body sizes, seldom exceeding 30 cm in length.

- Migratory river bull trout (fluvial) populations occupy rivers and major tributaries (fluvial), moving into smaller tributaries to spawn and rear as juveniles. These populations are migratory, and can travel up to 250 km in order to access spawning grounds (Burrows et al. 2001), or 150 km to disperse as juveniles to alternate rearing streams (Warnock 2008). Adult body length is typically in the 40 – 60 cm range (approximately 2 kg), with 60 – 80+ cm (2 – 5+ kg) possible (AEP, unpublished data). The majority of Alberta's Eastern Slopes rivers still contain fluvial bull trout populations.

- Migratory lake bull trout (adfluvial) populations reside in lakes and move into tributaries to spawn. Lakes can vary from small high mountain lakes (e.g., Pinto Lake) to large lower elevation lakes and reservoirs (e.g., Kananaskis Lakes and Oldman River Reservoir). Migration for spawning may vary from short movements to inlet/outlet streams to longer movements to more distant spawning areas before returning to overwinter in the lake or reservoir. Adfluvial populations can attain the largest body size (71 – 91 cm) (Behnke 2002) of the three life history types. This is the least common life history type in Alberta.

3.2 Population Status

Synopsis:

- Bull trout were commonly encountered and widely distributed within most major river basins in Alberta prior to European settlement, and ranged from the mountains and foothills out into the parkland and prairies. They were reported as far east as Lethbridge in the Oldman River, Carseland in the Bow River, Morrin in the Red Deer River and Edmonton in the North Saskatchewan River basin.

- Populations of bull trout in 19 watersheds (HUC[1] 8) have been lost since the 1950s, and bull trout no longer occupy the lower mainstems of the Athabasca, North Saskatchewan, Red Deer, Bow and Oldman rivers. The abundance, distribution and size structure of the majority of populations within HUC 8 watersheds (n=62) are poor relative to past angler accounts and when compared to the few remaining well-functioning populations (n=7) that occur in protected and/or remote areas.

Key Concepts

Basin: Refers to the portions of the Oldman River, Bow River, Red Deer River, North Saskatchewan River, Athabasca River and Peace River catchment basins that contain bull trout.

Watershed: A smaller area within a basin that collects water that is then delivered to a larger stream or river. It is a useful way of subdividing up the large catchment basins because populations of bull trout are generally restricted within watersheds and many of the proposed recovery actions are organized at the watershed scale.

Hydrologic Unit Codes (HUC): A standardized way of subdividing basins into smaller, nesting watershed units that are labelled with a unique numerical code. For example, a HUC 8 watershed is a useful scale to look at bull trout populations as this size encapsulates medium sized rivers and can be at an appropriate scale to capture the migratory life history strategy. There are many HUC 8 watersheds within a basin. If it were desirable to look at populations at a finer scale, then a HUC 8 watershed could be subdivided into several HUC 10 watersheds (the bigger number the finer the scale).

3.2.1 Fish Sustainability Index (FSI)

The GoA has developed a system for assessing the status of fish populations, called the Fish Sustainability Index (MacPherson et al. 2014). Populations are compared to an observed or modelled-theoretical reference population, unaffected by human influences such as fishing mortality, habitat loss, change in habitat quality, competition with exotic species, and human-caused barriers to fish passage.

FSI translates differences between the assessed population and the theoretical reference population using a scale of zero to five, and represent four different risk categories. A score of one corresponds to a population that is least sustainable and much lower density than from the reference population, and a five corresponds to a population that is most sustainable and similar or greater than the reference population. A zero represents a population that has become locally extinct (i.e. functionally extirpated). The FSI score is typically color coded (Figure 2). This ranking system follows those used by international conservation agencies (e.g., Williams et al. 2007 and NatureServe) and is based on the approach that Fredenberg et al. (2005) used to assess the conservation status of local populations. It is also useful for identifying populations that will need management interventions to manage threats in order to improve their conservation status.

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[1] https://geodiscover.alberta.ca/geoportal/rest/metadata/item/243f7273de0a435f8099f193f81662b3/html.

Bull trout populations were assessed at the HUC 8 watershed level. This scale generally encompasses genetically distinct spawning aggregations from smaller streams that share main stem rivers and exhibit low levels of genetic exchange. The HUC 8 watershed level includes both river life history strategies (i.e., stream- resident and migratory) and may also include migratory lake populations. While 17 different population metrics are assessed using the FSI approach[2], the key metric used for bull trout recovery planning is **adult population density**. Bull trout FSI scores were determined for 88 HUC 8 watersheds that represent the recent species distribution (i.e., after 1900) in Alberta[3], FSI scores were not assigned to the lower reaches of mainstem rivers that no longer support bull trout populations.

A low FSI score does not necessarily imply that a population has declined in population size. The assessment does imply that lower-density populations (perhaps because of natural limitations such as water temperature) are expected to be at a higher risk of not being self-sustaining than are populations at higher density. To understand how a population has changed through time and investigate recovery potential, fishery scientists scored both historical and current adult densities relative to the theoretical reference condition, and then compare differences in the scores. For example, population A may have a historical adult density score of 4, and a current score of 2, whereas population B may have a historical adult density score of 2 and a current score of 2. Both populations are considered at high risk, but population A may have the potential to recover to a low risk state. Historical densities were based on early fishery surveys and accounts of local residents for bull trout and represent a general timeframe of post-European settlement to the 1950s. Henceforth in this document, historical distribution refers only to the changes in population status that have occurred since the 1950s.

[2] https://www.alberta.ca/fsi-metrics-and-mapping.aspx

[3] https://www.alberta.ca/bull-trout-fsi.aspx

3.2.2 Bull Trout Population Changes Since the 1950s

There have been dramatic changes in the populations of bull trout in Alberta (Figure 3 and Figure 4). Historically, 60 of 88 HUC 8 populations (68%) were considered to be at low or very low risk, based on adult density. In contrast, only seven HUC 8 populations (8%) share this status currently. All seven are in federal or provincial protected areas except for the Upper North Saskatchewan River HUC 8. Similarly, the number of very high- or high-risk populations (HUC 8) has shifted from 14 (16%) historically, to 48 (54%) today. A further 19 (22%) are functionally extirpated. The cause of these widespread declines has been attributed to habitat fragmentation and degradation, angling pressure and the stocking of non-native fish (Post and Johnston 2002; ASRD and ACA 2009).

A province-wide zero bag limit for bull trout was instituted in 1995. There is limited information that suggests that some local bull trout populations might have responded positively to these regulation changes however, in general it is difficult to evaluate because of insufficient monitoring data (Post and Johnston 2002; ARSD and ACA 2009). In addition, the response to this regulation change was likely obscured by other factors such as the legacy and ongoing effects of habitat degradation and fragmentation, competition from introduced species, and accidental as well as illegal harvest.

The few localized success stories of bull trout recovery in Alberta resulted from additional fishing restrictions (e.g., seasonal closures, bait bans, etc.) and mostly for lake migratory populations. For example, the population of bull trout in Lower Kananaskis Lake increased by a factor of 28 times in a 10-year period when spawning tributary closure, bait ban and zero harvest sportfishing regulations were implemented and angler effort significantly declined (Johnston et al. 2007; Johnston et al. 2011). Autumn fishing closures (spawning season) were attributed as the main reason for improvements in fish density and size in the Athabasca River in Jasper National Park (Hughson and Sullivan 2015). There was a fivefold increase in bull trout abundance between 1970 and 2001 in Harrison Lake in Banff National Park after closure of an access road in 1988 and implementation of catch-and-release regulations in 1994 (Parker et al. 2007). The bull trout population in Jacques Lake in Jasper National Park appears to have recovered following an eight-year complete angling closure (Sullivan 2014).

FIGURE 3. The bull trout Fish Sustainability Index (FSI) scores within the historical (i.e. pre-1950s) distribution compared to the current population status (n=88 HUC 8 watersheds) (ASRD 2012).
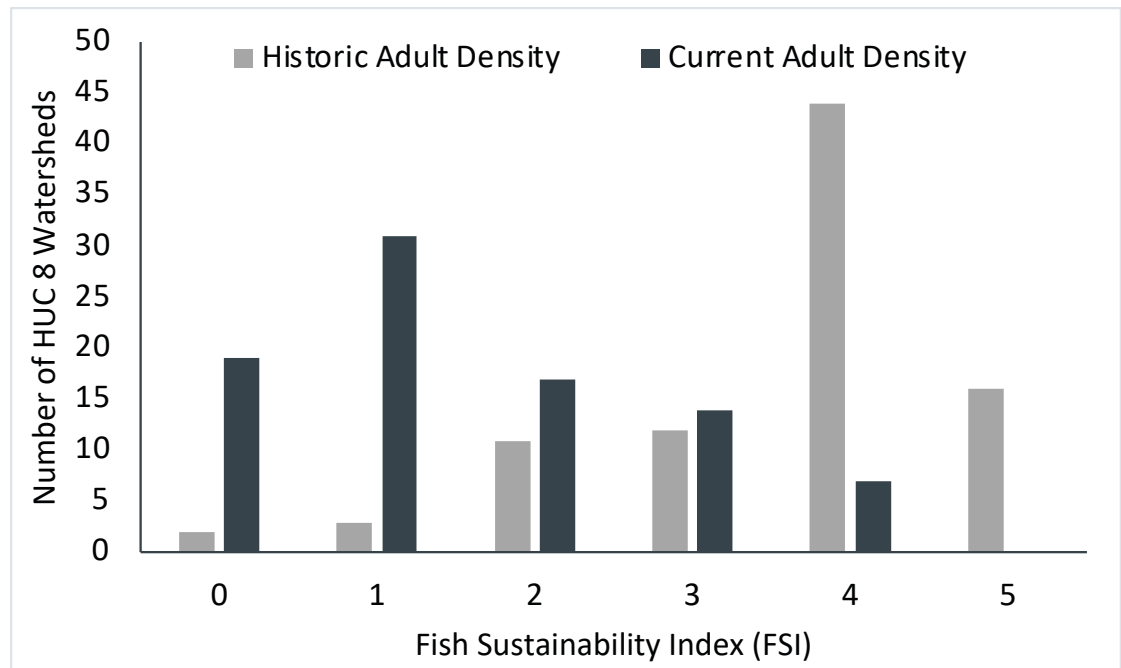
FIGURE 4. Comparison of the historical (i.e. pre-1950s) and current populations status in local watersheds (n=88 HUC 8) using Fish Sustainability Index scores[4].
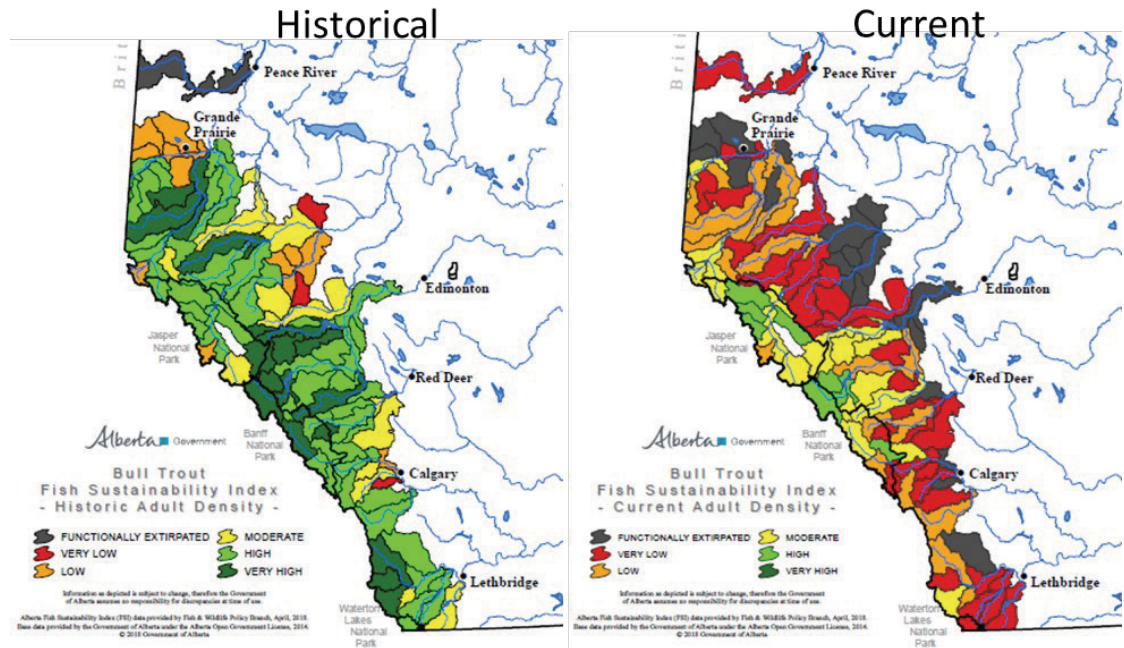
3.3 Historical Perspective: Land Use Management and Fisheries Policy

Synopsis

Past government policies:

- influenced the pattern of land settlement which resulted in many permanent changes in land use in the eastern edge of the historical distribution of bull trout;
- did not identify the conservation of native salmonids such as bull trout as a priority in the management of sportfishing; and,
- resulted in an intense period of development in much of the historical distribution of bull trout. Only more recently has there been an understanding of what the cumulative effect of this development has been on bull trout and other native trout and that native trout need to be considered a valued ecosystem component in natural resource planning and management.

In 1948, the provincial government divided the province into the Green and White areas. Public lands in the Green Area were to be managed primarily for forest production, watershed protection, fish and wildlife management, and recreation. Permanent settlement was excluded in the Green Area, except on legally subdivided lands, as were agricultural uses other than grazing. In contrast, the White Area was designated for settlement and agriculture. Approximately 26% of the historical distribution of bull trout occurs in the White Area, 60% in the Green Area, and 14% in national parks. The Eastern Slopes of Alberta are critically important for the water supply to major cities and industry. Combined with the area's abundance of natural resources and recreational values, the Eastern Slopes has been and continues to be a focus of concern.

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[4] https://www.alberta.ca/bull-trout-fsi.aspx

In Alberta, the responsibility for the management and allocation of natural resources in the Green Area is distributed amongst many different provincial and federal departments and agencies. In the early 1970s, there was a recognition that this matrix management of natural resources had the potential for duplication of effort and conflict amongst different departments and branches as each endeavored to maximize the benefits under its mandate (Marczyk 1985). The Eastern Slopes Policy (GoA 1984) was a high-profile policy shift to improve the management of public resources under provincial jurisdiction using an early version of the Integrated Resource Management approach. This approach carries on with refinements to the present day (Marczyk 1985; GoA 2018). The policy contains objectives and intentions related to the wise use and protection of natural resources. The main action was to develop integrated land use plans with different management zones and to encourage input from different government departments and agencies through a referral process when new development proposals emerged.

Fishery management had a high profile in the Eastern Slopes Policy (GoA 1984) and had the following regional objectives:

1. To protect aquatic habitat and ensure high water quality.

2. To establish optimal instream flow for fish through modification of land-water use practices.

3. To recognize sportfishing as the principal use of the fishery resources in the Eastern Slopes.

4. To maintain naturally reproducing salmonid (trout, char, grayling and whitefish) populations in the region and to expand these fish resources into presently vacant and appropriate aquatic habitat.

5. To supplement or enhance game fish stocks by stocking when natural reproduction does not occur or is limited.

While sportfishing and maintaining naturally reproducing fish populations, were clearly valued in the Eastern Slopes Policy, the conservation of native salmonids was not an explicit objective. Since the Eastern Slopes policy was approved in 1984, stocking of non-native trout has continued although the trend has been a reduction in the stocking of flowing water and to use sterile non-native trout (pers. comm. J. Wagner Provincial Fish Culture Specialist, Alberta Environment and Parks).

The purpose of the Eastern Slopes Policy was to encourage the orderly extraction of natural resources. The preface by Hon. Don Sparrow, Associate Minister of Public Lands and Wildlife, makes it clear that the intention was to "provide for the maximum delivery of the full range of values and opportunities" and that "no legitimate proposals will be categorically rejected" (GoA 1984). The expansion of the road network (Figure 5) illustrates the growth of natural resource extraction, since roads are typically a prerequisite for resource removal in industries like mining, timber harvest, and oil and gas activities. Road density is also a reasonable proxy measure of recreational access, with roads opening up previously remote areas that were once accessible only by foot or horseback. Historical angler interviews provide numerous examples of declining catch rates and smaller fish, which the anglers attribute to increased fishing pressure following road construction (e.g., Fitch 1997; Bryski 1999; Masterman and Stelfox 2010). Based on the expanding road network, the pattern of enhanced economic and recreational activity in the Eastern Slopes began in the 1950s and continues until present day with higher rates of development occurring in the more southerly basins. A colour-graded map of current road densities shows increasing density of roads moving east from the continental divide in Figure 6. The pattern of decline in bull trout populations approximates the timing and pattern of development in the Eastern Slopes.

FIGURE 5. Road density change over time in the major river basins in the Bull Trout Recovery Area as calculated using the software ALCES (A Landscape Cumulative Effects Simulator https://www.alces.ca/). The solid line indicates the average value while the greyed area indicates the standard error among the watersheds (HUC 8) within the basin.

Classification: Public
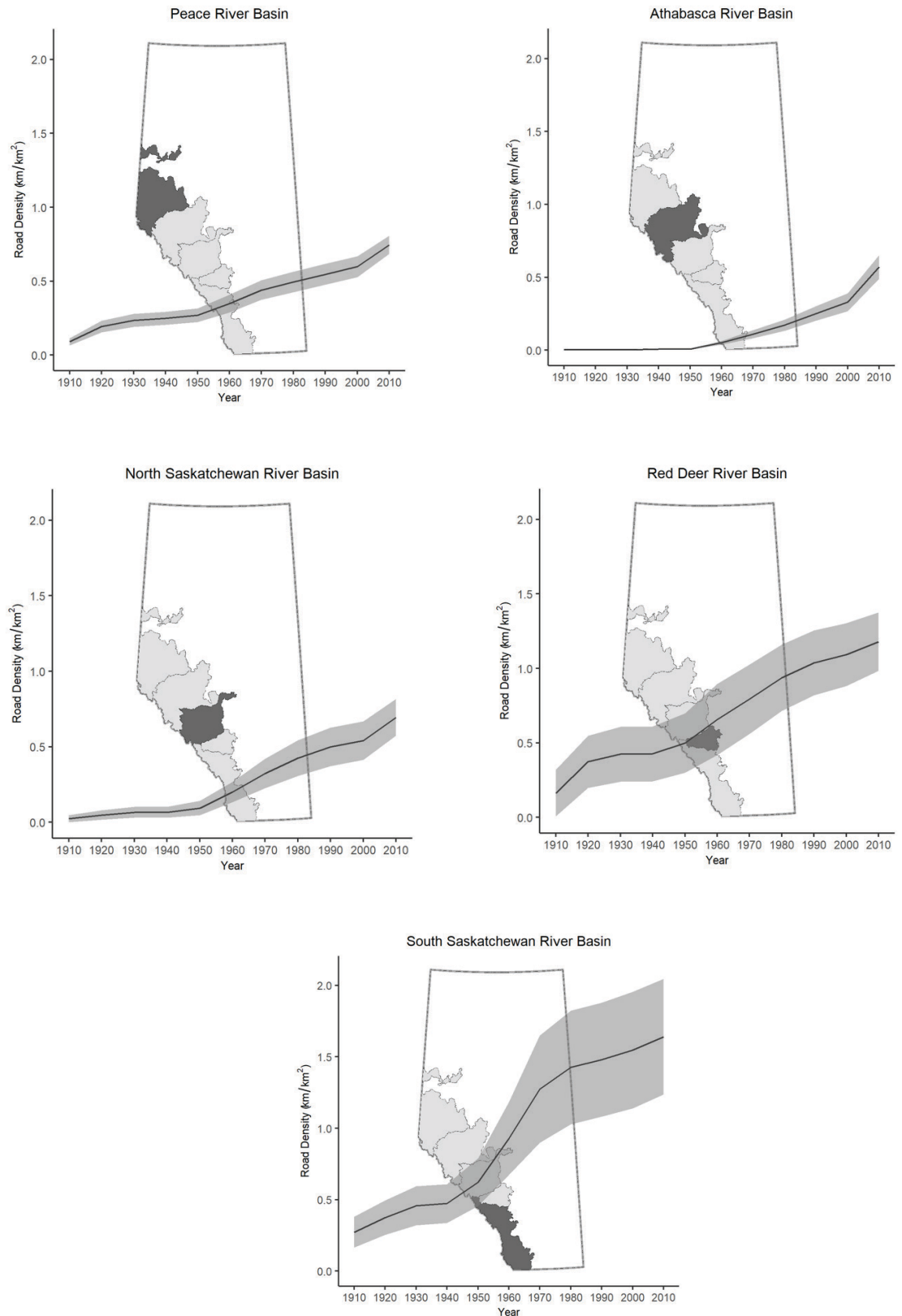
FIGURE 6. Bull trout Fish Sustainability Index score (2013) in relation to road density within the Green Area (cross hatch) and White Area (no cross hatch).

Classification: Public
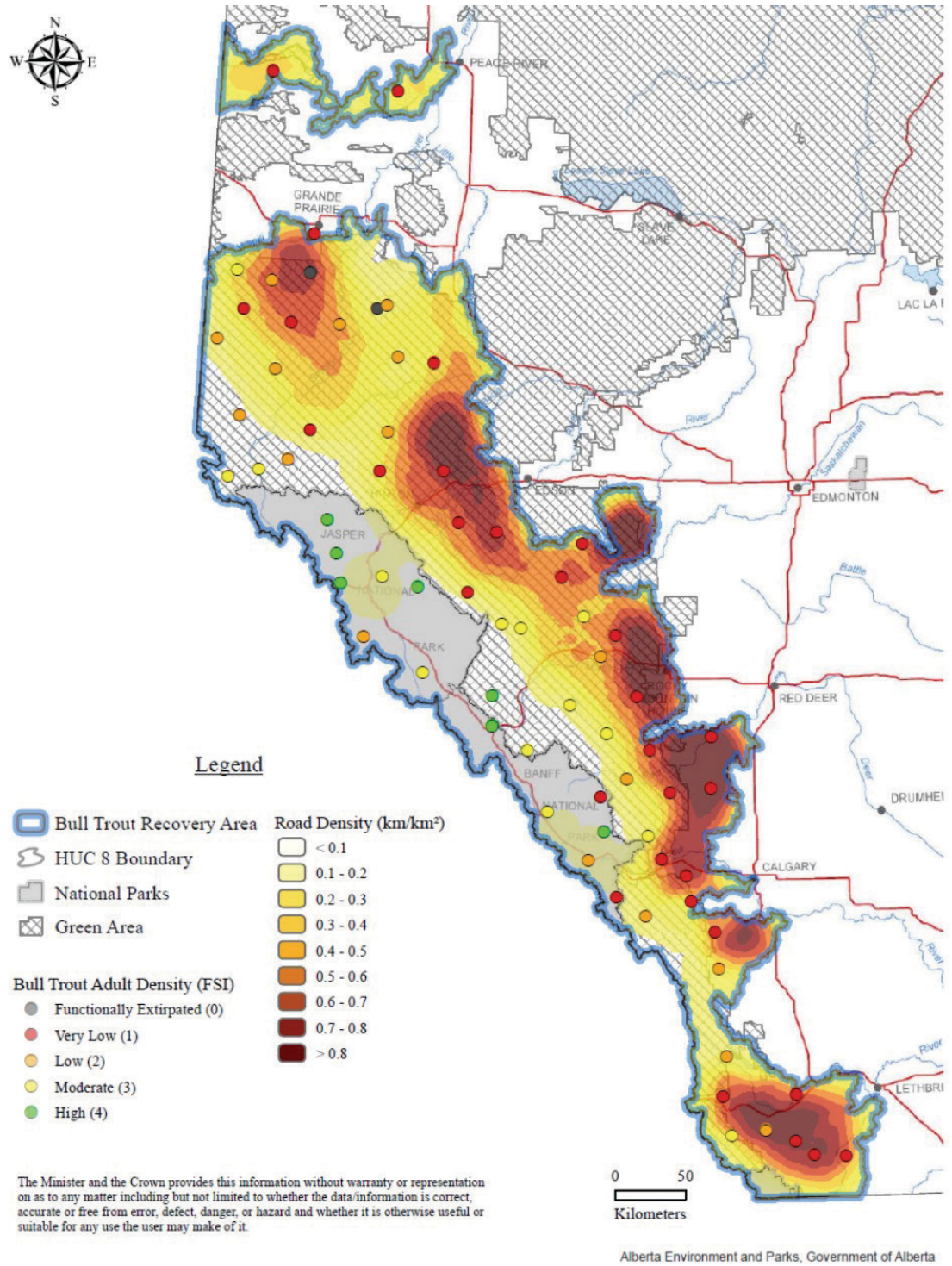
By the 1990s, there were concerns that the integrated management system in Alberta and the Eastern Slopes Policy were not dealing effectively with the environmental consequences of the rapid pace of development and that cumulative impacts were not being appropriately considered in project approvals or in land use planning (Kennett 2002; Davidson and MacKendrick 2004). The development of the *Alberta Land Stewardship Act* (2009) and the Land-use Framework[5] addressing air, water, land and biodiversity was a response to these concerns. The *Alberta Land Stewardship Act* (2009) supports the Land-use Framework and establishes the legal basis for the development of regional plans and associated environmental management frameworks for the purpose of providing for the policy integration, direction and clarity needed to help make decisions that collectively reflect and support the needs and values of Albertans. It also provides for the development of subregional plans, as needed, to resolve specific issues.

The first approved regional plan that addressed part of the Eastern Slopes was the South Saskatchewan Regional Plan (GoA 2014). Westslope cutthroat trout, another threatened native trout species (Table 1), was mentioned only once in the plan and bull trout was not mentioned at all. Bull trout are also not mentioned in the Master Schedule of Standards and Conditions[6], which provides the conditions to mitigate impacts to the environment that apply to new developments on public lands.

More recently, there is increased attention being given to fish species at risk. For example, the Fish Conservation and Management Strategy for Alberta (AESRD 2014) prioritizes conservation of native fish populations, and westslope cutthroat trout are included as a valued ecosystem component within the Livingstone-Porcupine Hills Recreation Management Plan and the Livingstone-Porcupine Hills Land Footprint Management Plan (Alberta Environment and Parks 2018a, 2018b). Historically, the lack of priority given to the conservation of native fish in policy and the imperfect understanding of the cumulative impact of the increased pace of natural resource extractions were likely a key factors contributing to the increasing number of fish species of conservation concern in the Eastern Slopes of Alberta (Table 1).

TABLE 1. Provincial (Alberta's *Wildlife Act*) and federal (*Species at Risk Act*) status of Eastern Slopes fish.

Species	Provincial Status	Federal Status
Westslope Cutthroat Trout	Threatened (2009)	Threatened (2013)
Athabasca Rainbow Trout	Threatened (2009)	Endangered (2019)
Bull Trout	Threatened (2014)	Threatened (2019) (Saskatchewan-Nelson rivers populations) Special Concern (2019) (Western Arctic populations)
Arctic Grayling	Species of Special Concern (2009)	Not assessed
Pygmy Whitefish	Threatened (2014)	Listed as Special Concern (Waterton Lake, 2016) by COSEWIC

3.4 A New Approach to Assessing Threats

Synopsis

- Models are commonly used to conceptualize natural resource management problems to determine which factors are likely most important in the system and to identify effective intervention points to achieve improved outcomes.
- Alberta fishery scientists developed a cumulative effects model that can be used to develop and test hypotheses on the importance of different threats and this has been used to identify key threats at the basin and HUC 8 watershed scales.

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[5] https://landuse.alberta.ca/CumulativeEffects/CumulativeEffectsManagement/Pages/default.aspx

[6] https://open.alberta.ca/dataset/133e9297-430a-4f29-b5d9-4fea3e0a30c2/resource/aa3e5504-22c8-472d-8ab5-35b99c07b74a/download/masterschedstandardsconditions-dec18-2018.pdf

- The cumulative effects model identifies water quality (phosphorous and sediment inputs), mortality (poaching and incidentally from catch and release angling) and barriers to fish passage associated with road crossings as the most common, key threats limiting bull trout populations. These predictions are viewed as hypotheses to be tested during recovery implementation as part of an adaptive management approach to recovery. The model can also be used to explore the cumulative effect of all threats on a population.
- Structuring bull trout recovery around an adaptive management framework will help us learn how to most efficiently recover bull trout populations by testing model outcomes. New data will be used to update the model and improve the confidence in model predictions.

The lack of recovery in many bull trout populations is thought to be a consequence of the increasing cumulative impacts of industrial and recreational activities, as well as, competition from introduced fish species (see section 3.3) (ASRD 2012). The legacy of past conservation actions has likely helped to maintain many bull trout populations, albeit at suppressed levels, and slowed the rate of decline (ASRD 2012).

Specific factors, or threats, limiting bull trout in Alberta were identified by the GoA and previous status assessments (Figure 7; ASRD and ACA 2009). In the past, this list of threats was assessed using expert opinion and scientific literature in the recovery planning process before developing recommendations for actions. Often the assessment of the relative importance of a specific threat was quite basic. The consequence was plans that lacked overarching, coordinated and efficient strategies to implement actions expected to yield population-level results. It is now recognized that this approach does not address the complexities of cumulative effects, nor the uncertainty around which threats are most limiting. This past approach could lead to a waste of resources if projects focus on addressing factors that are not significantly limiting populations.

FIGURE 7. Threats known to be important considerations for bull trout recovery.
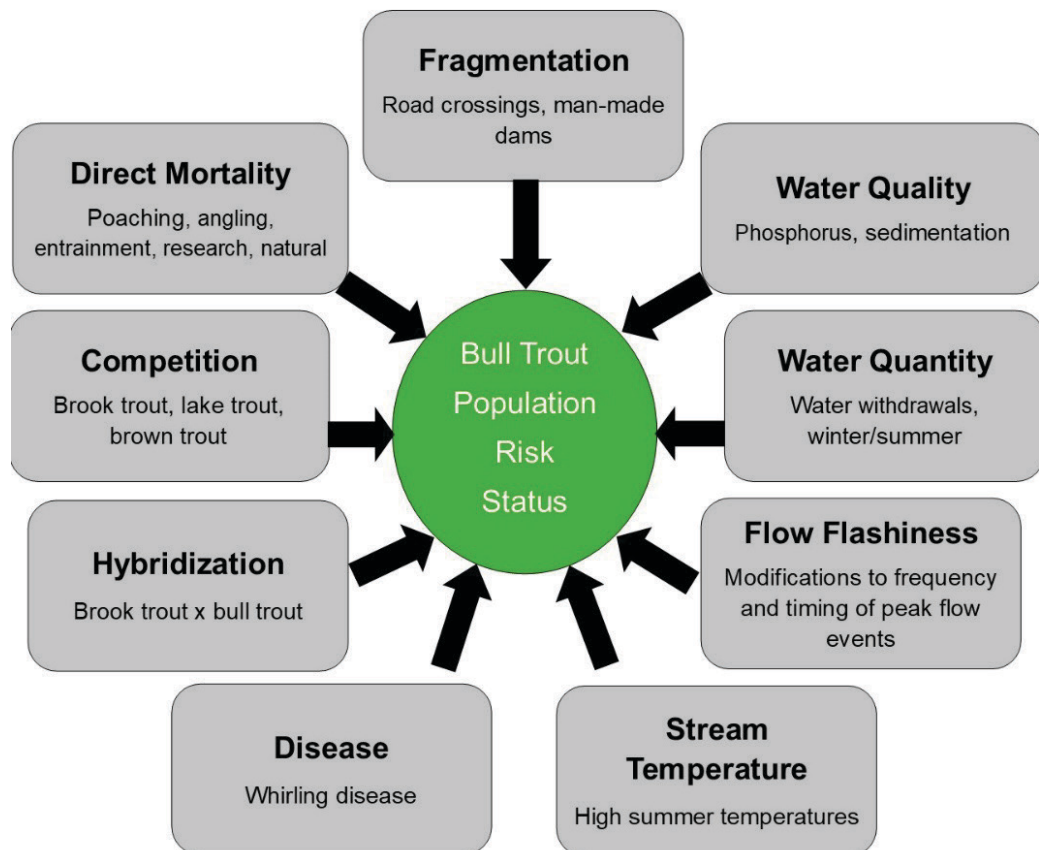
It became clear to GoA staff that a new tool was needed to develop clear hypotheses on: 1) the relative importance of threats; 2) where the key knowledge gaps are; and, 3) where it will be feasible to recover bull trout and to what extent. To meet these needs, the GoA developed the bull trout cumulative effects model. Models, both conceptual and analytical, are commonly used to explore complex natural resource management problems and better reconcile which factors are likely most important in the system. They can help identify intervention points or recovery actions that have the highest probability of increasing the population. The Alberta model is similar to those developed in other jurisdictions to prioritize fish populations for conservation and recovery (Al-Chokhachy et al. 2018).

3.4.1 Identifying the Most Probable and Widespread Threats

Alberta's cumulative effects model is composed of dose-response curves that describe the relationship between bull trout adult density (FSI score) and each specific threat (Figure 7). All dose-response curves are based on the best available data and expert opinion. For example, there is a well-documented relationship between water temperature and bull trout abundance (Figure 8). Bull trout are rarely found in streams where the mean August temperature exceeds approximately 15°C (ASRD 2012). To assess the relative importance of water temperature as a threat in a particular stream, the population response, as represented by FSI score, was plotted against estimated average August temperature (Figure 8). Dose-response curves and estimates of the current magnitude of each threat for all the HUC 8 watersheds were developed (see GoA in press). Not all of the threats are as well characterized as water temperature, so the model descriptions include an assessment of the confidence in the data used to develop both the dose-response curve and the estimate of the magnitude of the threat in each HUC 8. If we had perfect knowledge, then it would be possible to have a high degree of certainty in what the important threat(s) are in each HUC 8. Since this is not the case, the model was used as a screening tool to identify the threats that are likely important. In a review of the model, the DFO Science Sector describes this tool as a semi-quantitative static modelling approach that can be used to prioritize among multiple threats at hierarchical levels and focus on potential threat analyses and recovery actions (DFO 2019). This information can be used to develop likely hypotheses that can be tested during recovery implementation using an adaptive management framework (see section 3.4.3).

FIGURE 8. Predicted bull trout Fish Sustainability Index score at different water temperatures.

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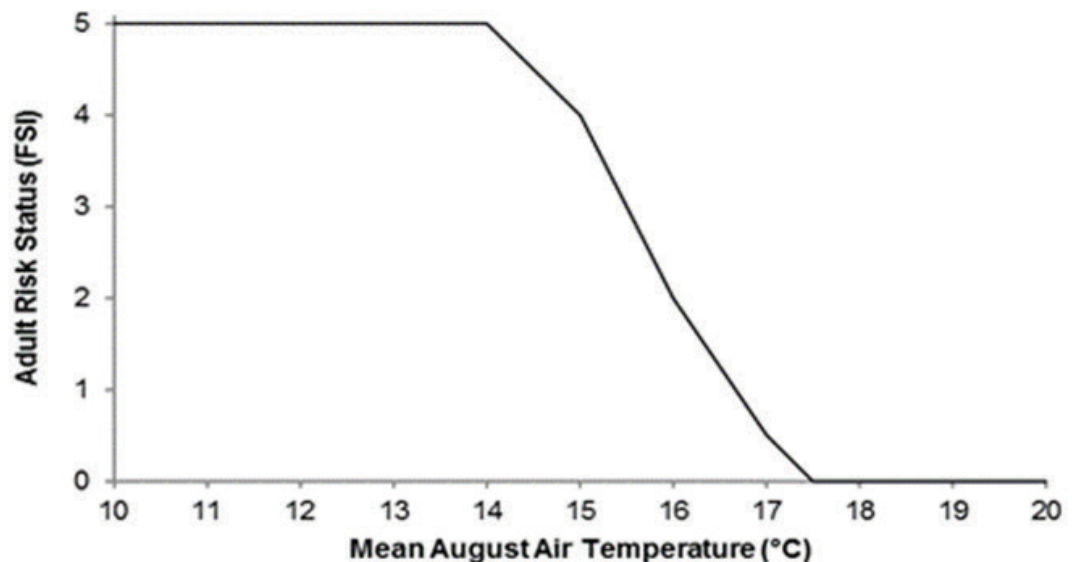
The results on the importance of each threat in each HUC 8 were summarized for the province using box and whisker plots to show the relative magnitude and prevalence of each threat (Figure 9). Figure 10 explains how to interpret a box and whisker plot. Water quality (sediment and phosphorous inputs), mortality (poaching and incidental from catch and release angling) and fragmentation from road crossings were identified as the most likely, common key threats to bull trout (Table 2). The model outcome is used to prioritize which threats (i.e., sediment, angling mortality and fragmentation) likely require the most pressing provincial-level improvements. In contrast, some threats, like competition from non-native fish, are only predicted to have significant impacts in a few watersheds. Mitigation of these threats may feature prominently in watershed-level recovery action plans, but are of lower priority when it comes to setting up provincial-level programs and strategies.

FIGURE 9. The range of predicted impacts of various potential limiting factors on adult bull trout density in Alberta. The predicted impact of each factor was calculated for all HUC 8 watersheds that historically or currently contain bull trout (n=88).
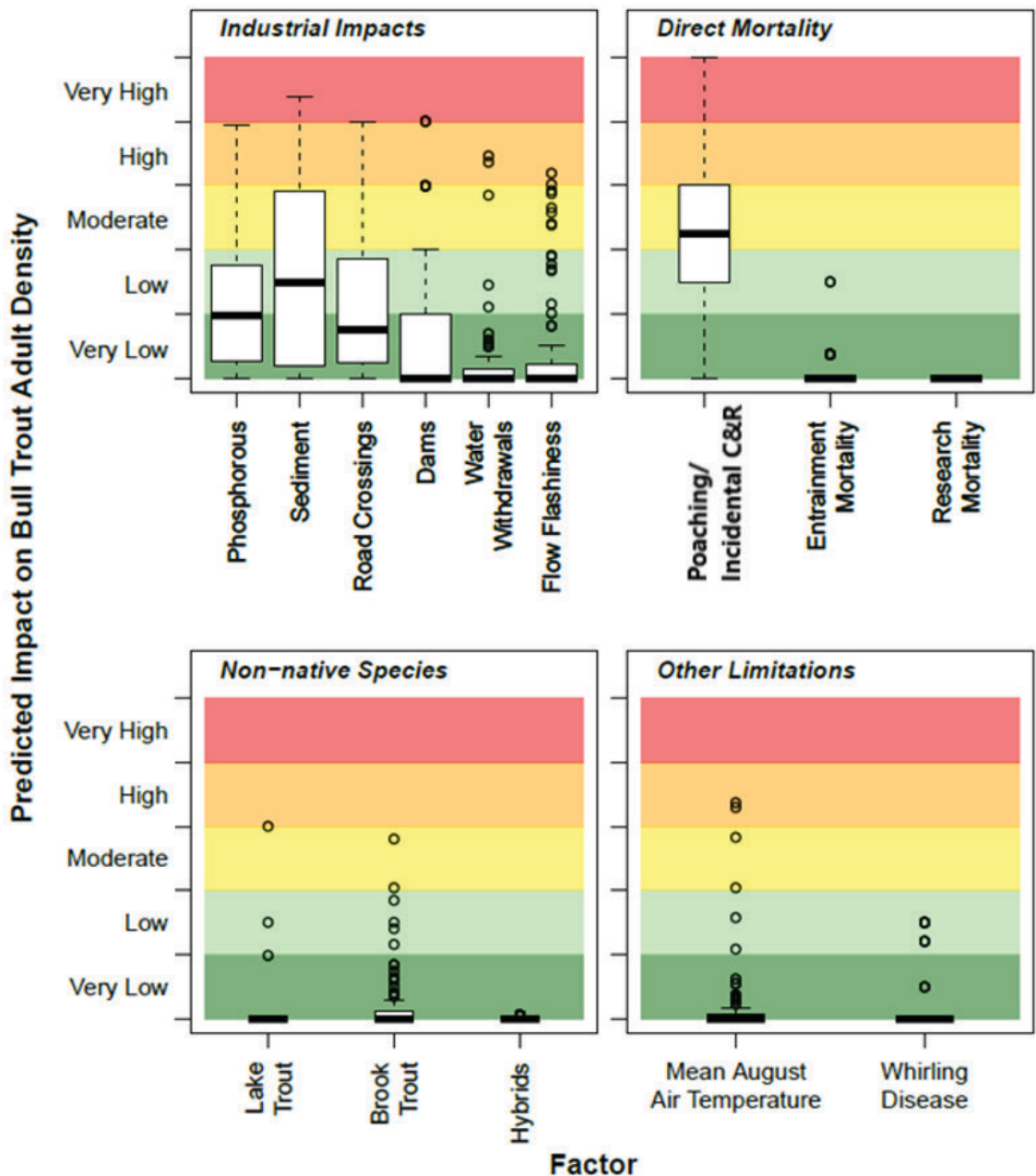
FIGURE 10. Explanation of how to interpret a box and whisker plot.
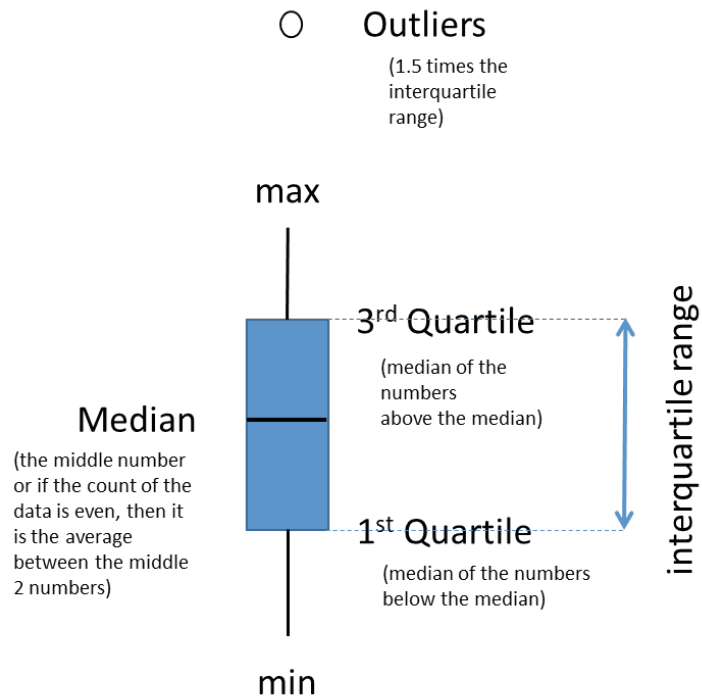
TABLE 2. Summary of the predicted impacts of various human-caused changes in the reaches of the major river basins that contain bull trout. A "X" indicates that the cumulative effects model predicts that at least 50% of the HUC 8 watersheds are affected by a score of at least 1.0.

Threat or Limiting Factor	Peace	Athabasca	North Saskatchewan	Red Deer	Bow	Oldman
Industrial Impacts						
Phosphorus				X		X
Sediment	X	X	X*	X	X	X
Dams					X	X
Road Crossings				X	X	X
Water Withdrawals						
Flow Flashiness						
Direct Mortality						
Poaching/Incidental Catch and Release	X	X	X	X	X	X
Entrainment						
Research						
Non-native Fish						
Lake Trout						
Brook Trout						
Hybrids						
Other						
Mean Aug Air Temp						X
Whirling Disease					X	

* Slightly under 50% but notable

3.4.2 Assessing Cumulative Effects and Potential Recovery Targets

Another important benefit of the model is that it can be used to describe the cumulative effects of all threats on a bull trout population and to identify potential recovery scenarios. To do this, the outputs from all dose-response curves were combined to generate a single output variable—the overall predicted adult risk status. To illustrate how this worked, Reilly and Johnston (pers. comm.) generated a hypothetical example where bull trout are limited by only three threats (Figure 11). In line A of Figure 11, if temperature results in an adult density score of 4.2/5, fragmentation results in a score of 1/5, and angler mortality results in a score of 1/5 using the dose-response curves, the overall score is a 0.2/5, suggesting that this population is at very high risk and that fragmentation from road crossings and poaching/incidental mortality are the key limiting factors. A recovery program would need to address fragmentation and poaching/incidental mortality, but not temperature, to improve this bull trout population, as illustrated in lines B and C in Figure 11.

FIGURE 11. Example of how threats interact cumulatively and how the model can be used to generate potential recovery scenarios.
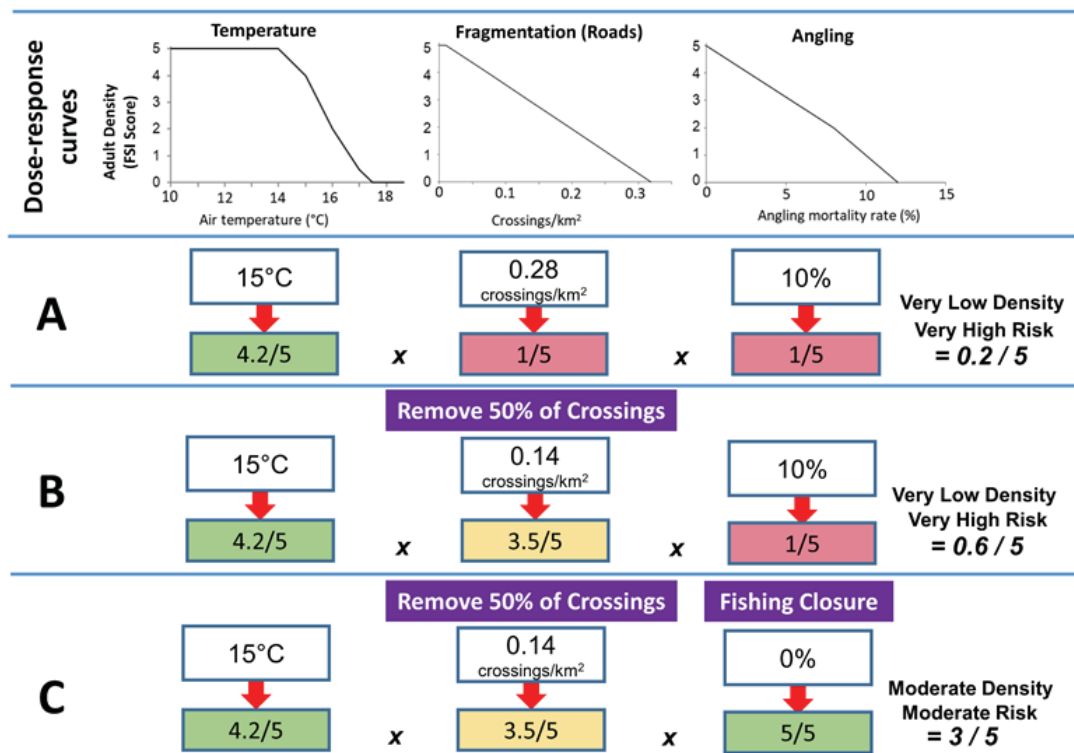
Note that in this analysis, all of the cumulative effects are assumed to be additive, i.e. we are assuming that they are all acting independently of each other. It is possible that some interactions between effects may increase or decrease the sum of the effects; however, currently there are insufficient data to assess this. The appropriate way to calculate additive effects was a controversial point in the Roche et al. (2019) report and has been further clarified in MacPherson et al. 2020.

3.4.3 Models, Uncertainty and Adaptive Management

Managing cumulative effects is often hampered by variability in site conditions and management effects, inability to predict secondary or indirect effects, lack of data on recovery rates, difficulty of validating predictive models, variability in the temporal and spatial scales, and uncertainty of future events (MacDonald 2000; Scherer 2011). All of these considerations apply to bull trout. Some of this complexity and associated uncertainty can be reduced over time by taking an adaptive management approach (MacDonald 2000); a model is used to generate hypotheses, recovery actions are implemented to test the hypotheses, populations are appropriately monitored, and learnings are used to decrease key uncertainties in the model to then inform the next cycle of management action (Walters and Holling 1990). Structuring bull trout recovery around an adaptive management framework will help us learn how to most efficiently recover bull trout populations, and allow us to move forward with recovery actions in the face of uncertainty.

Currently, the cumulative effects model has been run at the HUC 8 watershed scale. This is useful for providing strategic guidance to identify which threats are likely most important, which populations are likely to respond well to recovery actions, and to evaluate the potential effectiveness of different recovery options. Next steps should include running the model at smaller spatial scales (i.e., HUC 10 watersheds) where necessary and then pairing this information with finer scale, datasets and local knowledge to develop localized action plans. For example, the model results may indicate that fragmentation is a key threat and, if addressed, the bull trout population may improve from a high-risk to a low-risk state. Fine scale information is then required to determine where exactly fragmentation or point source sedimentation is occurring, detailed construction/remediation plans to address specific road-crossing structures, budgets, timelines and potential partnerships. Typically, these fine-scale data will need to be collected as a part of implementation in order to prioritize actions.

3.4.4 Future Potential Threats

Most of the bull trout range occurs outside of national and provincial protected areas on crown land that is managed for multiple uses. There are extensive mineral reserves, oil and gas formations and wood fiber harvesting in the east slope of Alberta[7,8]. New industrial projects like mines, dams or major oil and gas facilities would be considered in these areas and such a proposal would be assessed using the Environmental Impact Assessment (EIA) process. Potential impacts to species at risk like bull trout are given careful consideration in this process and would inform the decision of whether a major industrial project like a coal mine, hydroelectric dam or oil and gas facility, are in the public interest, considering the environmental, social and economic aspects. In addition, for any fish species listed as threatened or endangered under the federal *Species at Risk Act* require additional review and permitting through the Department of Fisheries and Oceans to perform any work or development within designated critical habitat.

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[7]   https://www.alberta.ca/interactive-energy-maps.aspx

[8]   https://www.dfo-mpo.gc.ca/species-especes/sara-lep/permits-permis/index-eng.html

4. Recovery Objectives

4.1   Recovery Area

Since the 1950s, 19 bull trout populations in HUC 8 watersheds have become functionally extirpated (Figure 4) due to the cumulative impact of reductions in habitat quality (i.e., higher water temperature, reduced water quality, changes to flow regime), loss of connectivity, historical legal harvest, and ongoing incidental mortality and poaching (see Section 3.0). At this time, it is unfeasible to try to recover bull trout in streams that:

- far exceed the species temperature tolerance,
- are fragmented by major dams that lack fish passage structures, or
- have undergone widespread changes in land use that are irreversible and/or very difficult to mitigate successfully.

The specific geographic area where the conservation actions are being applied is called the Recovery Area and it encompasses all the HUC 8s where there is recent evidence of occupancy (i.e., FSI score of at least 1; Figure 12). The excluded area is in the eastern part of the distribution where factors that fall under the bullets above have made it unrealistic to consider restoration at this time. The current distribution (Figure 4) still includes all the major river basins and is a relatively large area totalling approximately 16 % of the total area of Alberta.

Within the Recovery Area there are two historically fishless, watersheds that are a component of the aquatic ecosystem that supports bull trout. Further assessment may identify these historically fishless sites as candidate sites for establishing new populations.

FIGURE 12. Bull trout Recovery Area and the current population status in local watersheds (HUC 8). Note that the Upper Crowsnest and the Upper Ram HUC 8s were split at waterfalls to better characterize bull trout population status upstream and downstream of the waterfall. For populations status in national parks see DFO 2020a.

Classification: Public
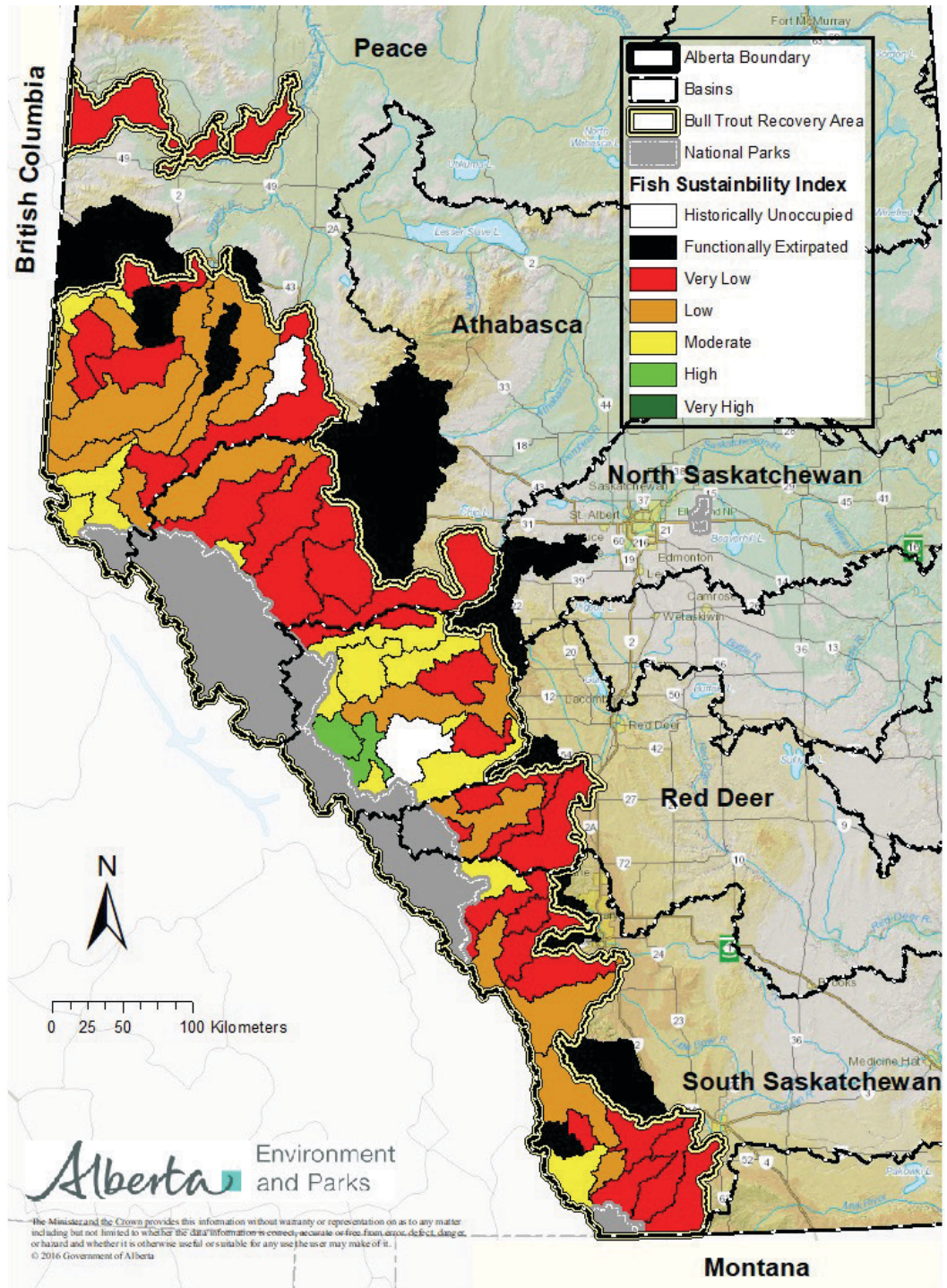
4.2   Assessing Recovery Potential and Recovery Objectives

A conventional long-term recovery goal would be to maintain or recover bull trout populations within the Recovery Area to a condition similar to historical density and age structure (Figure 4). However, there is uncertainty about the degree to which it will be feasible to reverse all the cumulative impacts needed to recover bull trout in some local watersheds within the Recovery Area. To better characterize what is technically possible, the cumulative effects model, combined with expert opinion, was used to assess recovery potential in each local watershed in the Recovery Area. This was accomplished by evaluating what the system capacity would be if the important threats such as sedimentation, poaching/incidental catch and release mortality, and human-caused barriers to fish passage were mitigated (see Appendix A for a more detailed description of the methodology). Changes that are very difficult to reverse such as hydroelectric dams, conversion to agricultural land, urban development, and water withdrawals for irrigation were not considered. Beyond excluding very difficult to reverse land-use changes, socio-economic factors (cost and public acceptance) were not considered in the scenario development. Note that the purpose of this exercise was to assess what might be technically feasible to help inform planning decisions and the scenarios used should not be interpreted as a proposal for recovery actions.

The model predictions on recovery potential were reviewed by GoA biologists and used to assign each HUC 8 to a predicted recovery potential category:

- **Core Population:** High confidence that the population in the HUC 8 watershed can be maintained or restored to a moderate to very low risk state (i.e., adult density FSI score ≥ 3).
- **Potential Core Population:** Further investigations, including pilot restoration projects, are needed to determine the degree to which these populations can be maintained or restored to a moderate to very low risk state.
- **Support Population:** Populations, based on our current understanding, are unlikely to be restored to a moderate to very low risk state (i.e., adult density FSI score ≥ 3) because it is unlikely that the cumulative effect of all the key threats (e.g., dams, diversions, industrial and urban land uses) can be fully mitigated, or there is no known historical evidence that the population has ever existed at a moderate to very low risk state. However, it is expected that bull trout occupancy can be maintained in the HUC 8 watershed, at least in part, due to dispersal from nearby populations (e.g., it provides important overwintering habitat or is a migratory corridor) or because threats are minimal or can be addressed in some of the tributary HUC 10s within the HUC 8.
- **Likely Unrecoverable:** Populations, based on our current understanding, that are at serious risk of extirpation in most of the HUC 8, even if conservation actions are applied.

The predicted recovery category for each HUC 8 in Figure 13 represents the best-case recovery scenario for bull trout conservation in Alberta based on current information. The recovery potential exercise (see Appendix A) also identified the HUC 8s that are unlikely to respond to conservation actions, making them poor candidates for investment. Based on current information, even if conservation actions are applied, 12 HUC 8s are Likely Unrecoverable and 2 are likely to become Extirpated. New information generated as part of recovery plan implementation or as it becomes available from other sources will be used to periodically revise the boundaries of the Recovery Area and the assessment of the recovery potential of individual HUC 8s. Note that HUCs labelled as likely unrecoverable are still valuable aquatic habitat for other fish species, however, it is not likely possible to restore these areas, within a reasonable timeframe and cost, to the conditions required to be suitable bull trout habitat.

Most of the opportunities for maintaining or recovering bull trout to a Core or Potential Core population are in the central and northern river basins. The results also demonstrate the need for urgent action in the Bow and Oldman river basins if bull trout populations are to be maintained in these basins. Ideally, all major basins would have at least one HUC 8 that has the potential to be recovered to a Core population status. However, it may only be possible to achieve this at the HUC 10 scale (see inset box in Figure 13) in the Bow and Oldman river basins. Restoration at the HUC 10 scale may also apply to many of the Support HUC 8s as there may only be opportunities for maintenance and/or restoration of populations at these finer scales.

The two HUC 8s along the Peace River (i.e., the two most northern watersheds containing bull trout in the province) were scored Support populations (Figure 13). Bull trout have relatively recently dispersed into this reach of the river because the water is now cooler due to the bottom draw hydroelectric dams in British Columbia. There is limited opportunity to expand the population into tributaries in this area, and the continued persistence of these populations will be dependent on how water is managed in British Columbia.

Objectives

It will take several decades to see significant recovery progress because:

- the generation time of bull trout is seven years (COSEWIC 2012),
- the area in which bull trout occur is large and there is a need to focus recovery efforts,
- additional information needs to be gathered during implementation to better understand the threats and to develop and/or refine the tools to mitigate the threats, and,
- habitat restoration, modifying land use, and gaining support from directly affected stakeholders is a long-term endeavour.

With the above in mind, specific objectives for the next 10 years were developed.

Objective 1 (10-year Objective)

The current population status is maintained or improved in the Core, Potential Core and Support populations identified in Figure 13.

Rationale: Maintaining populations in the HUC 8s in predicted Core, Potential Core and Support recovery categories is a high priority in order to ensure there are no further population declines and to preserve the opportunity to improve populations in the future when there is better understanding of how to recover populations.

Indicator: It will not be logistically possible to quantitatively sample the population in all 57 HUC 8s that are scored Core, Potential Core and Support populations frequently enough to determine trend in population abundance. However, there will be intensive monitoring on a subset of these HUCs as part of the recovery implementation in addition to other sources of population information such as sampling for whirling disease, creel surveys, redd counts, and information on age structure and distribution. This information will be collated every five years (more frequently if possible) to evaluate the extent to which this objective is being achieved. The target is for no further declines in the monitored HUCs.

Objective 2 (5-year Objective)

Improve the adult and immature FSI score for bull trout, by a minimum of one FSI score level, in at least one watershed (HUC 8 or HUC 10) within the Core, Potential Core, or Support populations within each of the Peace, Athabasca, North Saskatchewan, Red Deer, Bow and Oldman river basins.

Indicator: Six restoration projects (i.e. one project per basin) completed by the end of year five. These watershed-level recovery projects will be part of an adaptive management experiment (strategy 6.2) designed to achieve the objective. Monitoring population abundance will be an integral component of these projects. Restoration projects refer to all the conservation actions needed to address the important threats within a watershed (HUC 8 or 10). Restoration projects will be selected in watersheds where the model outputs identify specific threats that if addressed, would have a biologically significant effect (i.e., increase of one FSI score).

Objective 3 (10-year Objective)

At least two more new restoration projects (HUC 10 or HUC 8) started in each major river basin (i.e., six basins). Improve the adult and immature FSI score for bull trout, by a minimum of one FSI score level, in at least two additional Core, Potential Core, or Support watersheds (HUC 8 or HUC 10) within the Core or Potential Core watersheds within each of the Peace, Athabasca, North Saskatchewan, Red Deer, Bow and Oldman river basins (12 new restoration projects by the end of year 10).

Indicator: The number of new projects that have been planned and initiated, with the target of starting the new projects by year five of recovery plan implementation.

As more information is collected during recovery plan implementation, it is expected that recovery objectives for each local watershed within the Recovery Area will be refined and become more prescriptive in future iterations of this recovery plan.

FIGURE 13. Representation of recovery potential based on current understanding of the factors affecting bull trout populations within the Recovery Area. The future state of each HUC 8 was based on model predictions of how system capacity can be improved based on a hypothetical threat mitigation scenario (see Appendix A). Note that the Upper Crowsnest and the Upper Ram HUC 8s were split at waterfalls to better characterize bull trout population recovery categories upstream and downstream of the waterfall. Inset map shows HUC 10s within a HUC 8 watershed. For recovery potential in national parks see DFO 2020a.

Predicted Recovery Category	HUC 8 Count
Core	18
Potential Core	12
Support	28
Likely Unrecoverable	11
Extirpated	2
Total =	71

Legend

- Alberta Boundary
- Bull Trout Recovery Area
- National Parks
- Historically Unoccupied

Predicted Recovery Category

- Core
- Potential Core
- Support
- Likely Unrecoverable
- Extirpated

Base Data provided by Spatial Data Warehouse Ltd.
Alberta Road Network data provided by GeoBase®
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5. Habitat Needed to Support Recovery

The habitat that contributes directly or indirectly to maintaining the biophysical attributes needed to support bull trout populations occurs within the Recovery Area (Section 4.1), and more specifically the HUC 8s identified as Core, Potential Core and Support (Figure 12). The specific aquatic habitats include lakes, streams and rivers, all of which provide elements required to meet seasonal life-stage requirements, both for upstream waters and occupied habitat. The biophysical features of the aquatic environment needed to support the different life stages of bull trout are summarized in Table 3. Streams are very dynamic; therefore, the specific location of the habitat for these different life stages will change over time.

Many of the identified biophysical features (Table 3) interact with processes that are occurring outside of aquatic habitat. Specifically, streamside vegetation and hydrologically connected areas such as intermittent/ephemeral streams and wet areas help maintain quality aquatic habitat by influencing water temperature, nutrient load, sediment load, streamflow and stream size. Consequently, some part of the adjacent terrestrial environment should be considered as important habitat for freshwater fish (Richardson et al. 2010). For further description of the features, functions, and attributes of riparian habitat see DFO (2020b).

DFO establishes legal protection for SAR species habitat under SARA as Critical Habitat. Critical Habitat is defined as habitat necessary for survival or recovery and spawning grounds and nursery, rearing, food supply, migration and any other areas aquatic species depend on to carry out their life processes (DFO 2020a). Bull trout Critical Habitat was preliminarily identified by DFO in the federal recovery strategy for bull trout (DFO 2020a) based on science advice from a committee on which AEP participated (DFO 2020c).

TABLE 3. Summary of the habitat requirements or each life stage of bull trout. Reprinted with some modifications from Sawatzky (2016) with permission.

Life Stage	Function	Feature(s)	Attributes (Observed)	For Identification of Critical Habitat (Inferred)
Spawning/ Incubation	Reproduction	• Interstices of bottom substrate in small tributary streams; redds are often constructed in areas with perennial groundwater upwellings	• High gradient streams • Spawning depth range: 0.07 – 0.93 m • Incubation depth range: 0.1 – 0.2 m • Substrate: gravel/cobble-dominated substrate • Substrate size: 0 – 200 mm • Cover: overhanging vegetation, undercut banks, large woody debris, root wads, but overhead cover is not a prerequisite for spawning; redds are often constructed along river margins • Run-type reaches; low gradient and flood plain sections • Velocity: 2 – 99 cm/s • Turbidity: 0.1 – 1.0 NTU • Oxygen: Intergravel 8 – 12 mg/L, mean 9 mg/L; instream 10 – 11.5 mg/L, mean 10 mg/L • Water temperature: Spawning 5 – 9°C; perennial groundwater upwellings are important in maintaining temperature • Fluvial and adfluvial bull trout migrate to spawning habitat, thus unobstructed access is required	• Unimpeded access to spawning areas • Gravel/cobble-dominated substrate associated with perennial groundwater upwellings • Areas with minimal disturbances and low levels of fine sediment • Areas with appropriate water temperatures

Life Stage	Function	Feature(s)	Attributes (Observed)	For Identification of Critical Habitat (Inferred)
Young-of-Year	Nursery Cover Feeding Overwintering	• Shallow shorelines, pools and riffles of side channels; deeper pools; interstices of bottom substrate; often overwinter in areas associated with perennial groundwater upwellings	• Depth range: 0.07 – 0.93 m • Substrate: cobble and boulder, silt • Cover: overhanging vegetation, undercut banks, large woody debris, gravel substrate, boulders, small wood, cobble, velocity breaks • Velocity: low-velocity backwaters and side channels • Nose velocity: 0 – 0.1 m/s; upper limit: 0.23 m/s • Water temperature: 2 – 20°C; ultimate upper incipient lethal temperature (UUILT) 20.9°C (60 days), 23.5°C (7 days) • Pool and run habitats are preferred • Connectivity between spawning sites and rearing locations	• Low-velocity backwaters and site channels; pool and run habitats • Adequate cover (intact riparian zone) • Seasonal and perennial groundwater upwellings • Connectivity between spawning sites and rearing locations • Areas with appropriate water temperatures
Juvenile and Adult	Feeding Cover Overwintering	• Higher gradient habitats, often in shallow pools and riffles; interstices of bottom substrates; often overwinter in isolated pools maintained by perennial groundwater upwellings • Pools, riffles, runs, lakes (adfluvial)	• Gradient: 1.0 – 15.6% • Depth: deeper water during the day and shallower water (littoral zone, runs, channel margins, backwaters) at night; pools associated with groundwater input for overwintering • Substrate: cobble, boulder, silt (juveniles), rubble, sand (night use) • Cover: overhanging vegetation, undercut banks, large woody debris, substrate, boulders, root wads (juveniles), velocity breaks (juveniles), may also use deep-water habitat; diel shifts to habitats without cover at night are common • Oxygen: acute limit= >2 mg/L; likely the same for juveniles and adults • Water temperature: below 12°C; UUILT slightly lower than for young-of-year; maximum daily-maximum temperature 12°C, maximum weekly-maximum temperature 11°C; average maximum summer temperature 17°C • Fluvial bull trout migrate to feeding and overwintering areas and therefore require well-connected habitat • Velocity (juvenile) nose velocity: 0.05 – 0.25 m/s, upper limit: 0.48 m/s; bottom velocity: 0.20 – 0.28 m/s, upper limit: 0.31 m/s, mean column velocity: 0.0 – 0.20 m/s, upper limit: 0.8 m/s	• Unimpeded access to overwintering areas • Adequate cover (intact riparian zone) • Pools and riffles • Seasonal and perennial groundwater upwellings • Areas with appropriate water temperatures

6. Recovery Strategies and Actions

This section describes the strategies and actions needed to mitigate the key threats and other barriers to recovery (identified in Section 3.0) to achieve the recovery goal and objectives (Section 4.0). Additional details on implementation are discussed in Section 7.0.

6.1 Increase the Prominence of Native Trout Conservation

Section 3.3 identified the need to increase the priority given to the conservation and recovery of bull trout and other native trout in regional plans and in other government policies related to the management of native cold-water fish populations, extraction of natural resources and recreation management. Part of the problem is that Albertans' awareness of the many conservation issues facing native trout is low, and historically trout have been managed primarily for their recreational value as a sportfish (section 3.3). The intent of this strategy is to increase the profile of the issues facing native trout and other native fish such as Arctic grayling and mountain whitefish, to build support for change, and to help secure the long-term societal commitment that will be necessary to recover native trout such as bull trout and achieve the recovery objectives (section 4). This includes building awareness and support with staff in departments and agencies responsible for the management of public land, natural resource utilization and infrastructure development.

There is the need to highlight the fact that bull trout is Alberta's provincial fish[9], which could be done through the development of a wholesome education campaign, such as "Clean Drain Dry". This could be done through partnerships with non-government organizations with an interest in native trout, similar to what has been done in other jurisdictions for example, Eastern Brook Trout Joint Venture[10] and The Western Native Trout Initiative[11]. There are benefits to aligning with other programs that concentrate on ecosystem services such as well-functioning headwaters (e.g., Watershed Planning and Advisory Councils) or land stewardship (e.g., Cows and Fish). Liebich et al. (2018) noted that awareness of fish and fish conservation issues was declining in Maine residents but the general public did value waterbodies and that framing the issue around the importance of place might be more successful. There may be opportunities to link fish and watershed conservation with national/international initiatives like the Aichi conservation targets[12]. However, it is important when working with partners that there is a clear profile and focus given to the conservation of native trout by highlighting that self-sustaining native trout populations are good indicators of well-functioning ecosystems, and the restoration of native trout populations will contribute to high-quality sportfishing opportunities as well as a suite of other ecological and societal benefits. For example, healthy and connected habitat that supports native trout are also associated with good water quality, flood and drought resilience, habitat for a variety of other plant and animal species, and diversity of other recreation opportunities.

Desired Outcome

1. The GoA has increased the priority given to the conservation of native trout in the Eastern Slopes and foothills of Alberta.

2. Albertans are aware, supportive and engaged in recovery efforts for native trout and the habitats that support them in the Eastern Slopes of Alberta.

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[9] https://www.canada.ca/en/canadian-heritage/services/provincial-territorial-symbols-canada/alberta.html

[10] https://easternbrooktrout.org/

[11] https://westernnativetrout.org/

[12] http://biodivcanada.ca/default.asp?lang=En&n=9B5793F6-1&offset=1

Recovery Actions

1. Ensure that native trout conservation issues are identified and appropriately prioritized in regional and subregional plans for all the regions that intersect with the bull trout Recovery Area.

2. Ensure that linkages between environmental management framework (e.g., biodiversity management frameworks) indicators and native trout conservation are clearly identified.

3. Develop and implement a native fish education program that is provincially coordinated and co-delivered with partners. The focus would be on native trout in the Eastern Slopes, but could include other species and be linked with other aquatic programs.

4. Target audiences will be identified, focusing on those who live, work and play in the Eastern Slopes and have the greatest impact on bull trout and their habitat. Another target audience that will need to be included is GOA staff and partner agencies that regulate land and water use in areas important for native trout recovery.

5. Develop and implement regulatory guidance, such as Information Letters, for how bull trout recovery should influence regulatory decisions associated with water allocation and land use.

Progress Measures

1. The proportion of the Land Use Framework regional plans and sub-regional plans within the bull trout Recovery Area that identify the recovery of native trout as a management priority and link to recovery strategies and actions.

2. The extent to which a provincial education program has long-term funding, has been delivered to active stakeholders, and is supported.

3. The percentage of the target audiences that have been reached by the education program.

6.2 Strategies to Address the Wide-Ranging Potential Threats to Bull Trout

Strategy 6.2 proposes addressing threats using intensive experimental restoration pilot projects in an adaptive management framework. In contrast, the three strategies in section 6.3 address the wide-ranging potential threats by finding refinements to existing regulatory and resource management processes at the scale of the entire Recovery Area with a focus on the Core, Potential Core and Support HUC 8s. The intention of this strategy is to maintain or improve current bull trout populations in Alberta (recovery objective 1) by working with existing accountable agencies and programs to take a more precautionary approach until there is the required knowledge and resources to implement active restoration projects in all 58 HUC 8s that were scored as Core, Potential Core or Support.

The cumulative effects model identified water quality (sedimentation and phosphorus), barriers to fish passage from road-stream crossings (fragmentation), and poaching/catch and release angling mortality as being the most important wide-ranging threats affecting bull trout (Table 2). Each is addressed in a separate strategy; however, it is expected that there will be opportunities to co-implement many of the actions.

6.2.1 Reduction of Sediment and Phosphorus

Phosphorus is stored in sediment and excess sediment-laden runoff can flow into streams and accumulate. Human-caused sediment was identified as being a widespread potential threat in every basin in the bull trout Recovery Area, whereas phosphorus was only a widespread threat in the Red Deer and Oldman basins. Higher phosphorus levels are consistent with intensive agricultural activities such as annual cropping that become more widespread moving from Core to Likely Unrecoverable watersheds (Table 5). These activities were most prevalent in the southern basins that have a much higher proportion of White Area where agriculture is the dominant land use. Consequently, in the Core and Potential Core areas human-caused sediment and, to a lesser degree, phosphorus levels will be driven by run-off from

land uses that disturb terrestrial vegetation and the mitigation measures to limit flow paths to the stream channel fail. Of particular importance are unpaved resource extraction roads and the increased rates of erosion associated with roads/trails crossings (Al-Chokhachy et al. 2016; Croke and Hairsine 2006; Maitland et al. 2016; Marion and Wimpey 2017; Reid and Dunne 1984; Rice and Lewis 1986). As such, strategies that reduce erosion should be equally effective for reducing sedimentation and phosphorus in these areas. Agricultural sources of phosphorus run-off from cultivated fields and intensive livestock operations will be more important to manage in areas with more agricultural land use. The regulation and management of activities that contribute to erosion is distributed amongst the government departments and agencies that regulate and permit specific activities. In addition to regulatory and management, education and engagement of land users that disturb vegetation can help with voluntary practices that reduce sediment and phosphorus.

Ensure Best Practice: The management of sediment is an evolving science, and rigorous application of best management practices has been shown to reduce sediment from logging and road construction disturbances (Cristan et al. 2016). Consequently, it is important to periodically review current sediment management practices to ensure that the highest standards are being used in regulations, conditions and guidelines. Compliance monitoring is critical to ensuring these standards are applied on the ground. There is a variety of information sources, such as compliance databases, new research, and information from pilot recovery projects that should be analyzed to identify opportunities to improve the standard of practice in the bull trout Recovery Area.

There are new spatial analysis tools that can be used to identify areas with the potential for erosion (Benda et al. 2007). Propensity for erosion could be used as an important consideration for locating future human footprint within the bull trout Recovery Area. Coordination amongst industry partners using innovative planning approaches for road development has the potential to result in fewer redundant roads being built[13].

TABLE 4. The amount of agricultural land in each recovery potential category for each basin within the bull trout Recovery Area. The national parks were not included in this analysis. Agricultural land was calculated from the Alberta Biodiversity Monitoring Institute (ABMI) Wall to Wall 2010 Landcover layer (AMBI 2010) and includes tilled land in annual crops or pastures seeded to perennial forbs and grasses.

| Basin | %Green Area | %White Area | Amount of Agricultural Land | | | | | | | |
| | | | Core | | Potential Core | | Support | | Likely Unrecoverable | |
			km²	(%)	km²	(%)	km²	(%)	km²	(%)
Peace River	79.2	20.8	0	0	0	0	2902.1	16.1	0	0.0
Athabasca River	97.8	2.2	0	0	7.2	0.1	0	0	100.5	2.9
North Saskatchewan River	95.2	4.8	134.7	3.3	0	0	170.4	3.1	7.1	0.5
Red Deer River	51.3	48.7	7.9	3.4	173.8	9.5	295.7	16.6	1284.9	49.9
Bow River	56.2	43.8	0	0	0	0	960.0	15.6	197.6	6.8
Oldman River	28.5	71.5	0	0	110.9	9.1	848.7	22.3	2170.4	40.1

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[13] https://friresearch.ca/sites/default/files/null/Final%20RAD%20Plan%20Manual%20May%2001%2012.pdf

Identify and Remediate Legacy Infrastructure: Unpaved roads and stream crossings from linear features like roads are a main source of sediment in high-relief areas like the bull trout Recovery Area, and a relatively small number of sites can be responsible for most of the erosion (Rice and Lewis 1986). In a recent assessment of sediment contribution by different road and crossing types in northwestern Montana, 4% of the point sources accounted for 100% of the sediment (Cissel et al. 2014).

More detailed analysis is required to identify where in each watershed the sediment inputs are occurring. There are applications being developed that identify likely problem areas associated with roads and trails (Benda et al. 2007). Analytical tools/platforms such as NETMAP[14] have been used by the Foothills Research Institute (fRI) on Todd Creek in the Oldman River watershed as a case study to demonstrate a two-level Cumulative Effects Assessment (CEA) process (McCleary 2013). The first level is a desktop Geographical Information Systems (GIS) exercise that uses terrain modelling combined with other sources of GIS information such as soil erodibility to identify regions or infrastructure that are at high risk of being an important source of sediment. This was recently applied to every watershed in the in the Eastern Slopes (TerrainWorks and fRI Research 2018a, 2018b, 2019). The second level is a follow-up field assessment to confirm model predictions and to prioritize remediation actions which is ongoing.

Field assessments of problem infrastructure for the entire Recovery Area would help to prioritize areas where management actions could be taken. This work should be done with partners and linked to Strategy 6.2 whenever feasible.

Livestock: Extensive cattle grazing is a common activity in many watersheds within the Recovery Area. Alteration of riparian vegetation by grazing and trampling can decrease bank stability and contribute to erosion, although the magnitude of the issue has not been well-characterized (Trimble and Mendel 1995). Additional sampling to assess the effects of grazing on riparian vegetation and its contribution to erosion is required to better define the extent to which cattle grazing is contributing to sedimentation. Cows and Fish: Alberta Habitat Management Society has developed riparian assessment tools and has been conducting riparian assessments in the Bow and Oldman river headwaters for years and has an extensive education and outreach program[15]. Of particular importance for sediment management is the ability to efficiently identify and mitigate point-source grazing impacts; the Cows and Fish Program will be an important partner in conducting assessments and engaging allotment holders to mitigate any issues.

Off Highway Vehicle Stream Crossings: An additional source of sedimentation is erosion at or near stream crossings for Off Highway Vehicles (OHV; see Farr et al. 2017 for a recent review). It can be particularly severe where the trail crosses a stream with steep erodible banks (Fitzsimmons and Fontana 2004). Most OHV trails are unplanned and unregulated so they often cross streams at suboptimal sites and at multiple locations (Fitzsimmons and Fontana 2004). It is legal to drive off road on vacant public land in Alberta unless there is a Public Land Use Zone (PLUZ) that designates trail systems. While it is illegal to drive across the bed and shores of waterbodies, it often occurs. When a PLUZ has been designated and a trail system identified, supporting infrastructure like bridges, signs and culverts can be built to keep OHVs out of waterbodies and lessen environmental impacts. There is also the opportunity to close or reroute trails where sedimentation or other issues occur.

All of the Core, Potential Core, and Support habitat should have a designation such as a protected area or PLUZ that would provide regulatory authority for the management of motorized vehicles. Currently, 28 % of the bull trout Recovery Area is part of a federal or provincial protected area and a further 9.8 % is contained within a PLUZ. The primary way that new PLUZs are determined is through the regional planning process; the only approved regional plan in the bull trout Recovery Area is the South Saskatchewan Regional Plan. However, if there are areas with conflicting land uses or acute problems, subregional or issue-specific (i.e., land footprint management plan) planning or establishment of protected areas or PLUZs can be made in advance of regional plans. An assessment of watersheds that have acute recreational management problems contributing to sedimentation would help prioritize where new regulatory authorities are most needed to facilitate recovery actions. Where a PLUZ is created and OHV trails designated, risk of erosion should be an important consideration in trail locations. Addressing the issue may require rerouting some legacy trails and decommissioning others.

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[14]   http://www.terrainworks.com/watershed-analysis-basin-assessments

[15]   http://cowsandfish.org/index.html

Desired Outcomes

1. The GoA aligns in its policies, land and water management, monitoring and compliance practices for sediment management effectively mitigating human-caused increases to sediment yields over and above natural sediment regimes.

Recovery Actions

1. Work with regulators to develop a multi-departmental process to review all of the regulations, planning, guidelines and compliance monitoring used to manage human-caused erosion and sediment input, to identify opportunities to improve outcomes in sensitive fish habitat such as the bull trout Recovery Area. This includes having programs in place for monitoring, compliance and reporting of failure rates and, where permits have been issued with exemptions to regulations, standards or guidelines for the management of sediment.

2. Advance and incorporate new tools such as those that predict high-risk areas for erosion and wet areas for more widespread application (Kuglerová et al. 2014).

3. Work with relevant regulators, affected industries, recreational planners and key stakeholders to develop a commonly agreed on methodology for conducting watershed assessments for sediment. Assess the extent to which important sources of sediment will be resolved as part of the Watercourse Crossing Program (described in 6.3.2 below). Apply agreed on methodology as part of implementation projects.

4. Conduct watershed assessments and develop sediment remediation plans for all HUC 8 (or HUC 10, where appropriate) watersheds within the bull trout Recovery Area, with priority given to HUC 8s that are identified as Core, Potential Core and Support (Figure 13) watersheds and where sediment has been identified as an important threat.

5. Establish PLUZs throughout the Recovery Area where additional management of recreational sources of sediment is required.

6. Provide support to education and compliance campaigns to encourage individuals engaged in recreational activities within these PLUZs to minimize erosion and to report violations like washing and bogging vehicles in streams to the Report a Poacher hotline.

Progress Measures

1. The percentage of HUC 8s within the Core, Potential Core and Support watersheds that have had a watershed assessment (or equivalent) for sediment completed.

2. The number of high-priority sediment remediation projects identified in watershed assessments that have been completed.

3. Report on the trend in road density and OHV trails within the bull trout Recovery Area.

4. The percentage of the Core and Potential Core and Support areas that have access management planning that has the objective of minimizing effects on fish habitat.

5. The number of improvements to regulations, standards, guidelines, and compliance rate for the management of sediment that have been implemented for all new developments and for ongoing management of recreation, agricultural and industrial activities in the Recovery Area.

6. The number of occurrence reports of OHVs being used in a way that will result in sediment in flowing water in the bull trout Recovery Area (e.g., using unapproved stream crossings, washing vehicle instream, purposefully bogging), particularly during low flow periods when the impact on spawning gravels is most severe.

6.2.2 Eliminate Human-caused Barriers to Bull Trout Movement

Barriers to the movement of bull trout was also a high ranking threat with population-level effects being predicted in three of the six river basins (Table 2). While the magnitude of the threat is based on a model prediction that requires further validation, we do know that road crossings frequently fail, particularly hanging culverts that become undercut by erosion and become a barrier to fish passage. Some culverts may be too small in diameter and the water velocity exceeds the swimming ability of local fish.

A crossing that is a barrier to fish passage is regulated by the federal *Fisheries Act* and the provincial *Water Act*, but compliance monitoring has been under resourced and there is a large backlog of crossings that need to be inspected. To address this backlog, the government has implemented the Watercourse Crossing Program (WCP)[16]. In new protected areas like the Castle Provincial and Wildland parks, remediation projects on important native trout streams has been a priority and significant progress has been made.

The Foothills Stream Crossing Partnership (FSCP) is a multi-industry partnership that works with the WCP for the purpose of improving the condition and performance of stream crossings. The FSCP has been operating since 2005. However, not all crossing owners within the bull trout Recovery Area are participating in the FSCP. For all crossing owners not a part of the FSCP the GoA has released the Watercourse Crossing Management Directive which describes the responsibility of crossing owners to monitor and maintain all crossing and provide remediation plans focusing on any crossing identified in high risk watersheds[17]. Additional strategies, such as adding conditions for remediating legacy problems to permit renewals or new approvals might be required to ensure that all crossing owners address their responsibilities to ensure fish passage. Infrastructure that becomes a barrier for fish passage is often also a source of sediment, and there will likely be opportunities to address the source of both threats within a single project.

More permanent infrastructure (e.g. dams) that block fish passage have a significant financial costs associated with remediation, and therefore, do not happen often. However, whenever infrastructure renewals, upgrades or decommissioning come up they should highly consider bull trout implications and recovery opportunities. The GoA continues to increase protective measures through policy improvements and regulatory conditioning to better ensure infrastructure projects align with bull trout recovery requirements.

Desired Outcome

1. All stream crossing owners in the White and Green areas use the Roadway Watercourse Crossing Inspection Manual.

2. All stream crossings on permanent and temporary roads in the White and Green areas within the bull trout Recovery Area have been inspected as per the Roadway Watercourse Crossing Inspection Manual.

3. Temporary and permanent stream crossings in the bull trout Recovery Area that impair or completely block fish passage have been removed or remediated.

Recovery Actions

1. Watershed assessments (Strategy 6.3.1) are coordinated with other WCPs and, to the extent possible, are using equivalent methodologies to assess the threats to sedimentation and barriers to fish passage.

2. Work with the WCP to expand participation to all of the industry groups and government agencies responsible for crossings, recognizing that the listing of native fish as species at risk will increase the priority in the Recovery Area for ensuring that existing crossings are compliant with current laws and regulations.

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[16] https://www.alberta.ca/watercourse-crossing-program.aspx

[17] https://open.alberta.ca/dataset/114f4057-36ef-4d0a-a496-858030559c1c/resource/a8611278-1e50-4d15-817a-014ee5e3189d/download/aep-watercourse-crossings-management-directive.pdf

3. Follow up with non-participating industry groups and government agencies to ensure that there is a common understanding of the priority associated with addressing fish passage issues for fish species at risk and to ensure that there is a plan of action to resolve fish passage issues within the bull trout Recovery Area.

4. Develop and administer an outreach and education program for all crossing owners and responsible regulators to encourage the adoption of Roadway Watercourse Crossing Inspection Manual.

5. Work with regulators to develop a multi-departmental process to review all of the regulations, planning, guidelines and compliance monitoring used to manage fish passage at road crossings. Adding wording to address barriers to fish passage to the regulations, planning, guidelines and compliance monitoring review for sediment should be considered (Action 1, section 6.3.1).

Progress Measures

1. Records on stream crossing inspections and are available for the reporting of the current state and progress towards resolving stream crossing issues.

2. Increase in the percentage of existing crossings within the bull trout Recovery Area that have been inspected using the Roadway Watercourse Crossing Inspection Manual[18].

3. Increase in the percentage of bull trout movement barriers that have been assessed, removed, or remediated.

4. Increase in the amount of connected habitat within each basin as a proportion of the natural condition.

6.2.3 Reduce Incidental Angling Mortality and Poaching

Incidental angling mortality and poaching has the potential to be a major contributing factor to the decline of bull trout, and is an ongoing conservation challenge in all six major watershed basins occupied by this species (Table 2). The concern is that incidental angling mortality combined with poaching may lead to fishing mortality rates for bull trout that are not sustainable, particularly when angling effort is sufficiently high (Johnston et al. 2015) and fish densities are low. Post et al. (2003) concluded that the combination of life history and fishery traits such as slow growth, late age at maturity, low fecundity, longevity and high catchability render bull trout particularly susceptible to overfishing, even with relatively low angler effort. This strategy proposes provincial approaches to reduce angler impacts on bull trout as a precautionary measure while further assessment occurs in some watersheds (section 6.2).

Improving Education and Training: To date, conservation messaging by the GoA focuses on how to identify bull trout, under the banner line "No black, put it back". This is distributed online and in the Sportfishing Regulations Guide. Other jurisdictions provide more specific direction. Montana has a cold-water fishery similar to Alberta's, and bull trout there have been federally listed as Threatened under the *Endangered Species Act*. Montana has made it illegal to intentionally fish for bull trout in most bull trout holding water, although they do provide limited fishing opportunities in specified waters (Montana Fish, Wildlife and Parks 2019 Bull Trout Regulations[19]). They also provide an online tutorial and voluntary testing material that provides information on identification, life history, how to avoid catching bull trout, and best practices for releasing fish.

The research on how to minimize incidental mortality and harm from catch-and-release angling is ongoing (Cook et al. 2015; Brownscombe et al. 2017). Education and outreach messaging and programming needs to be updated to promote a high standard of practice for catch-and-release fishing, particularly for species of conservation concern such as bull trout. Ensuring that anglers have the necessary fish identification skills to distinguish bull trout would contribute to better fishing practices (Schmetterling and Long 1999; Stelfox et al. 2001). Training on fish identification and how to handle and release a bull trout and other

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18 https://open.alberta.ca/dataset/a832eee1-53b4-45f7-a46c-8e81b498080f/resource/d338eb1d-5609-4a3a-bc96-e876442df0c4/download/6799953-2015-roadway-watercourse-crossing-inspection-manual-version-5.2.2.-2015-03-13.pdf

19 http://fwp.mt.gov/fish/regulations/default.html

native trout, particularly for new anglers, would also be beneficial. Increasing public awareness of the conservation needs of bull trout and other cold-water stream fish would also help promote best practices (see Strategy 6.1). Consideration should be given to collaborating with angler-related industries (Danylchuk 2017) and non-government organizations (Sims and Danylchuk 2017) in developing and delivering messaging and training on best practices. There are already examples of web sites (www.keepemwet.org and www.fishsmart.org) developed by anglers in partnership with scientists that have been established to promote best practices for handling catch-and-release fish.

Engaging Recreational Anglers: Cowx et al. (2010) point out that getting anglers to buy in to conservation objectives is more difficult when management scales are large, anglers are responsible for degrading fish stock, ecological awareness of the need to act is low and there is a lack of recognition that changing personal behaviour is important to achieve conservation outcomes. To overcome this, strong leadership and networks among various participants, appropriate legislation, and constructive and long-lasting communication with anglers is needed to bring about change and action (Cowx et al. 2010). Effective engagement, perhaps with more integrative approaches between anglers and citizen science programs, will be critical in order to identify socially acceptable approaches (Arlinghaus et al 2013; Bower et al. 2017; Mannheim et al. 2018). Conservation surcharges on fishing licenses is a common way of raising money for conservation projects and can be very effective in improving engagement, particularly if anglers are able to influence the projects selected.

Regulating and Enlisting the Support of the Commercial Fishing Industry: Alberta does not regulate professional guides and outfitters for fishing, unlike neighboring jurisdictions like Montana or British Columbia. This makes it difficult to understand the extent of commercial use of bull trout fisheries and challenging to engage with guides to get their input and assistance in shifting fishing pressure away from sensitive bull trout populations.

Deterring Poaching: In addition to accidental harvest (i.e. being misidentified as a harvestable species), bull trout are sometimes purposefully illegally harvested for food. The motivations of poachers can be complex and include pleasure/entertainment in defying the law, fundamental disagreement with the rules, or they may come from a community or family of origin where there is a culture of breaking wildlife laws (Long 1997; Filteau 2012). Conventional deterrence theory indicates that enforcement action needs to be swift, certain and have severe penalties (Paternoster 2010) to effectively deter poachers. The provincial *Fisheries Act* does provide for fines up to $100,000; however, fines are usually well short of the maximum.

There are lessons to be learned from past attempts to reduce poaching. In the early 1990s, the illegal harvest of bull trout was identified as an issue for the Muskeg River. Local staff formulated an education and compliance plan that included: youth education, signage at known bull trout pools, and targeted patrols (Ramstead 1997). The conclusion of participating staff was that most of the non-compliance was because the perpetrators were unaware of the conservation issues and regulations and that a coordinated program of education and compliance was working before it was discontinued due to government funding cutbacks (S. Ramstead, pers. comm.).

Another challenge is that poaching has a low probability of being detected because bull trout occur over a large area, much of it difficult to access, and there are relatively few enforcement officers available. Increasing the number of patrols and coordination between enforcement agencies would likely help. In lake fisheries, the deterrence effect of additional officers began to limit poaching once 3% of the fishermen encountered an officer on patrol (Walker et al. 2007). Targeting enforcement at known problem areas and using new technologies like hidden cameras would also likely increase detection and contribute to deterrence. Another approach to compliance would be to use education/outreach and social science to change social norms in order to both reduce the number of people willing to poach and increase the number of people able/willing to detect and report a poaching event (Cialdini and Trost 1998; St John Freya et al. 2010; Steinmetz et al. 2014). Fish and Wildlife Enforcement Branch has kept records on occurrence reports since 1999 and has created a Report a Poacher hotline that provides rewards for citizens to call in potential fish and wildlife offences. From 1999 until May 2018, there were 239 investigative files involving bull trout. Only 38 of those files were eligible for a Report a Poacher reward, suggesting there are opportunities for improvement (B. Voogd, Fish and Wildlife Enforcement Branch, pers. comm.).

Planning Angler Access: Development of new roads and linear features can increase human access to bull trout streams. Increasing road density has been linked to declines in bull trout, increased erosion and barriers to fish passage (Ripley et al. 2005). Given our hypothesis of the potential vulnerability of bull trout populations to catch-and-release fishing and poaching, road placement effects on sportfishing access need to be given greater consideration in access management. Currently, it is not directly considered in guidance for new road development (Forestry Planning Operating Ground Rules, Alberta Transportation standards, or the Master Schedule of Standards and Conditions), where the focus is on minimizing the effects on fish passage and fish habitat. For example, an important consideration would be ensuring that new roads are not placed parallel and in close proximity to bull trout-occupied streams. Closing industrial roads to public access is also an option that could benefit bull trout in some situations and, if pursued, should include a signage and a compliance assurance plan.

Fishing Regulations: There are regulations for some stream reaches that restrict the use of bait, invoke seasonal closures during seasons in which bull trout are particularly susceptible to angling, and complete closures of some reaches to protect known key spawning areas. However, the application of these regulations is inconsistent amongst different river basins and the regulations should be reviewed for consistency and for opportunities to improve outcomes for bull trout.

Integrating with other Fisheries Management Initiatives: The current direction for fisheries management in Alberta is to use science-based stock assessments combined with consultations with stakeholders to develop fish management objectives for ecosystem conservation, habitat conservation, and Indigenous and recreational fisheries. It will be important to ensure that these objectives align with bull trout recovery priorities.

Desired Outcomes

1. Anglers have the information they need to form their own ethical response to targeting bull trout when angling.

2. Commercial guides and anglers do not intentionally try to catch bull trout in watersheds where populations are at very high to high risk.

3. Captured bull trout are released using best practices.

4. Regulations for sportfishing minimize the impact of legal angling on local bull trout populations.

5. Albertans are aware that it is illegal to kill bull trout and report poaching-related activities they observe to the Report a Poacher hotline.

6. Poachers are effectively deterred from illegally harvesting bull trout.

Recovery Actions

1. Develop recreational fisheries management objectives that align with recovery priorities for all watersheds containing bull trout.

2. Develop and implement an online training program that includes: bull trout conservation issues, why it is sometimes important not to target them when angling, how to avoid catching them, responsibilities as an angler, best practices for safe handling and release, and how to distinguish bull trout from other trout and char species.

3. Engage sportfishing groups and other leaders in the sportfishing community to garner support for recovery actions and look for opportunities to collaborate. Consideration should be given to linking this to developing a special fishing license endorsement than includes a surcharge to help support the recovery efforts of bull trout and/or other native fish. Representatives from Alberta's sportfishing community should have a role in determining funding priorities and selecting recovery projects.

4. Conduct a review of sportfishing regulations in Alberta and other jurisdictions to identify effective strategies that reduce the impact of legal angling. This review should consider options such as bait bans, seasonal closures, sanctuaries or reach-specific closures, spatial closures, gear restrictions (such as single barbless hooks) and managing fishing effort by managing access. Some jurisdictions have made angling for bull trout illegal and an evaluation of the effectiveness of this approach should be included in this review.

5. Develop and implement a compliance and education strategy to prevent poaching of bull trout. This should be a priority action in suspected problem areas. Considerations for elements of the plan should include increasing enforcement presence, targeted signage and education, and use of new technologies such as cameras and helicopter flyovers.

6. License commercial fishing guides/outfitters and engage them in shifting fishing pressure away from sensitive bull trout streams.

7. Continue efforts to inform prosecutors and the judiciary on the conservation issues facing native trout conservation.

8. Include Report a Poacher messaging in outreach and education messaging (reference strategy 6.1)

9. Develop and include criteria for road placement and public access management in regional and subregional plans, Forestry Operating Ground Rules and Master Schedule of Standards and Conditions.

Progress Measures

1. Proportion of watersheds within the bull trout Recovery Area that have recreational fisheries management objectives that support bull trout recovery.

2. Sportfishing regulations have been reviewed and revised accordingly.

3. A new education/training program has been developed that is linked to sportfishing licensing.

4. A system is in place to regulate commercial sportfishing guides.

5. Annual trends in Report a Poacher calls related to bull trout poaching.

6. Ratio of known bull trout poaching events to successful prosecutions.

7. Trend in the size of fines and jail sentences for successful prosecutions.

8. Trend in the number of poaching events relative to enforcement effort.

6.3 Learning by Doing: Watershed-Specific Restoration Projects

The use of a cumulative effects model (Section 3.4) to identify the major threats to bull trout is the first step for recovery. It is not completely understood how populations will respond since there is a level of uncertainty associated with the dose-response curves, the understanding of the current state of the ecosystem, and if, and how quickly we can expect the population to respond. This is particularly problematic for bull trout because they occur in a very large area (the area of the Core, Potential Core and Support populations is 13.9% of Alberta) and the cost to recover populations in even one local watershed could be significant. This is why an adaptive management approach is suggested in which the watersheds (HUC 8 or HUC 10) for initial pilot projects are selected based on their potential to generate learning opportunities to better define the cause-effect relationships between each threat and local population response. This approach requires a thoughtful study design and more intensive monitoring, which should result in more efficient and targeted recovery of bull trout populations in the future. A more current analysis of trends in bull trout population structure, abundance and distribution across the province, including an assessment of limitations in the data would benefit the development of this study design.

Native trout recovery will require engagement with stakeholders affected by recovery projects and conservation and angling groups that have the resources to assist in program delivery. There is considerable variation between river basins in conservation issues and social context, so it is likely that each basin will require a customized engagement process. A third-party review of the NCNT program has suggested that the GoA explore alternative models of recreational fisheries management with an emphasis on how the public can be meaningfully engaged to enhance stewardship and move forward with a genuine commitment to transparency and openness (Roche et al. 2019). Reconciling stakeholder concerns with the continuing conservation needs of a species that is both federally and provincially listed as a Threatened species will be an ongoing challenge.

Desired Outcome

Every Core, Potential Core and Support watershed within the bull trout Recovery Area has an operational plan that is being implemented.

Recovery Actions

1. Develop and implement a stakeholder engagement plan/approach for each river basin.

2. Using cumulative effects modelling, empirical and local datasets and stakeholder input, develop an operational plan for all the Core, Potential Core and Support watersheds within the Recovery Area with initial recovery projects developed and implemented within an adaptive management framework according to timelines set out in the objectives.

    a. To the extent possible, integrate bull trout restoration projects with other cold-water species recovery programs that have overlapping areas of occupancy.

3. Continue the analysis of assessment information gathered by the GoA and stakeholders, with the assistance of modern analytical tools and external expertise, to further refine and identify trends in bull trout population structure, abundance and distribution across the province, in order to better quantify the impact of specific recovery actions.

4. Prioritize for implementation and work with relevant stewardship partners to fund and implement plans.

5. Periodically (at least every five years), analyse results from implementation projects to assess what has been learned about key threats and changes to bull trout population status and use the results to update the cumulative effects model.

Progress Measures

1. Percentage of Core, Potential Core and Support watersheds that have a completed operational plan.

2. Percentage of high-priority operational plans that have been implemented.

6.4 Continue to Develop and Implement Science-Supported Land-use Thresholds for Key Threats

Alberta has been working to improve its system for managing for cumulative effects[20] for over 45 years, beginning with the development of integrated resource management and planning (Kennett 2002) and progressing to the more recent (2009) *Alberta Land Stewardship Act* which supports the Land-use Framework and established the legal basis for the development of regional plans and associated environmental management frameworks (EMFs). As more detailed planning occurs (e.g., sub-regional plans), there is the opportunity to include thresholds (including limits, targets and triggers) for specific aspects of human development (e.g., road density). Strong science support will assist in influencing the thresholds used in EMFs and sub-regional plans including water management plans.

Water management planning is a process that addresses multiple issues and produces resource management recommendations, including thresholds that can be used by any resource decision-maker when their decision could impact water quantity, quality, and habitat of species. For areas of the province where these plans do not yet exist, the Surface Water Allocation Directive (2019) provides scientifically defensible water allocation decision guidance to address the cumulative effects of water diversions within a watershed. The Directive includes the principle of maintaining natural hydrologic variability and enables the push for water use activity to larger, more resilient watercourses and away from the more sensitive headwaters. This Directive supports outcomes and goals identified in the Water for Life strategy, the Fish Conservation Management Strategy for Alberta, and Land-use Framework. The Directive approach may be incorporated into regional planning processes where applicable.

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[20] https://landuse.alberta.ca/CumulativeEffects/CumulativeEffectsManagement/Pages/default.aspx

An approach to managing some human impacts (e.g., tree harvest rates) on habitat is to imitate how natural disturbances affect habitat. However, applicability of this approach for aquatic systems is still in the research phase (Moore and Richardson 2012; Sibley et al. 2012), and a key consideration when applying this approach would be a better understanding of the threshold where the cumulative effect of human disturbances on several key habitat parameters exceeds the range of natural variability.

This strategy identifies the actions needed to refine our understanding of the key threats affecting bull trout, to provide the scientific foundation that can be used as an input to the land management system in Alberta.

Desired Outcome

1. Science-supported thresholds for development/human activities that are:

   • reflective of cold-water fish management recovery objectives;

   • used to inform land use planning and management decisions for all activity in the bull trout Recovery Area that are limiting bull trout population recovery; and,

   • communicated to affected stakeholders.

Recovery Actions

1. Ensure that recovery activities include sampling designs and monitoring that will improve the confidence in the dose-response curves predictions (see section 3.4 and 6.2).

2. Publish key findings in peer-reviewed journals and participate in science reviews.

3. Incorporate findings in communication products (section 6.1).

4. Use results to develop predictive relationships, identify thresholds, and develop implementation tools that synthesize results and make it easy to utilize results when making land use and fisheries management decisions.

Progress Measures

1. The number of sub-regional plans or equivalent within the bull trout Recovery Area that use development thresholds or other strategies to address the conservation requirements of bull trout and other native trout.

2. Number of publications with results that indicate science-supported thresholds for development.

6.5   Emerging Issues and Knowledge Gaps

Climate change, hybridization, and invasive species such as whirling disease are all threats that have been identified but not fully characterized due to uncertainty and in some cases a lack of data. Climate change and whirling disease are two emerging issues that have not been significant drivers of population declines in the past, but may affect recovery and recovery activities in the future. Hybridization of bull trout with non-native brook trout (*Salvelinus fontinalis*) is occurring to some extent throughout the bull trout range but is currently not well understood.

The main way that climate change would affect cold water fish like bull trout is by increasing water temperature and reducing stream flows, which will shift suitable habitat closer towards headwaters, reducing population abundance and distribution (Santiago et al. 2017; Young et al. 2018). This could constrain where recovery activities can be undertaken. Other jurisdictions have done finer scale analysis based on water temperature to identify areas that are likely to persist as thermal refugia for cold water fish populations (Isaak et al. 2015, 2016). This type of information can be used to inform land-use planning by identifying priority areas for ensuring the long-term persistence of cold-water fish. To undertake this type of analysis requires more direct measurement of water temperatures in streams targeted for bull trout recovery. A related activity would be to identify areas with hyporheic exchange and extensive upwelling zones since these types of areas will also contribute to thermal refugia and are an important feature of bull trout spawning areas (Baxter and Hauer 2000).

Climate change is also predicted to increase the frequency, intensity and size of wildfires (Hagmann et al 2021). While native trout like bull trout have co-evolved with the effects of wildfire (Hessburg 2017), the larger more frequent wildfires predicted to be associated with climate change are expected to exacerbate the stress from stream temperature increases (Koontz et al. 2018). There is ongoing discussion and analysis on how best to adapt forest management strategies and emergency responses to the increased threat from wildfires (Prichard et al. 2021; Silins et al. 2014; Tymstra et al. 2020). An emerging issue is to ensure that the needs of sensitive species like bull trout are considered within these public policy discussions (Falke et al. 2015; Newman 2019).

Whirling disease is an infectious parasite of trout, char and whitefish that can cause direct mortality and reduce fitness (Sarker et al. 2015). The parasite (Myxobolus cerebralis) alternates between two freshwater hosts, a worm (*Tubifex tubifex*) and a salmonid fish host (Bartholomew et al. 2003). Three months after the T. tubifex worm feeds on the parasite it will begin to release up to millions of spores that will attach to the skin of fish and migrate to areas of cartilage resulting in extensive damage especially to young (i.e., 3-6 weeks) salmonids. The parasite can also damage to the nervous system causing 'whirling' behaviour which leads to decreased ability to escape predators. Bull trout are susceptible to infections of the parasite but rarely expresses clinical signs of the disease (Sarker et al. 2015).

Currently, GoA staff are sampling fish, worms and sediments to better understand the current distribution of the parasite throughout Alberta. The life cycle in the worm host is temperature dependent and hundreds of temperature data loggers have been deployed throughout the Eastern Slopes and this information will be used to develop a new model for a stream temperature network for the Eastern Slopes (Isaak 2004). This information will be used to identify and predict areas of high risk of whirling disease outbreaks under current and changing climate conditions.

Impacts from climate change and whirling disease are likely to be more severe where stream and lake habitats are degraded or fragmented, and less severe where habitats are robust and interconnected (Rieman and Isaak 2010). For example, the T. tubifex host does better where erosion has resulted in sedimentation. Rieman and Isaak (2010) identify four key activity areas to conserve resistant and resilient populations: 1) reduce non-climate stresses, 2) conserve and expand critical habitat, 3) reconnect streams and habitat, and 4) conserve genetic and phenotypic diversity. Fortunately, all of the recovery activities that address non-climate change primary threats (Strategies 6.2 and 6.3) contribute to population resilience which in turn will assist with climate change and whirling disease adaptation.

The extent to which bull trout are affected by hybridization with non-native brook trout is currently not well understood (Popowich et al. 2011). Hybridization between brook trout and bull trout has been documented in both the United States (DeHaan et al. 2010) and Canada (Costello et al. 2003; Popowich et al. 2011). Within Alberta, hybrids between brook trout and bull trout have been documented in 18 HUC 8s (J. Reilly, pers. comm.). Hybrids can be difficult to identify based on visual characteristics and, to better understand the extent of hybridization (distribution and viability of hybrids), genetic surveys should be developed and conducted.

There has been work on genetic structuring of bull trout populations in Alberta (Warnock et al. 2010; Carrol 2017) which will help inform future conservation actions should it become necessary to undertake conservation translocations or establish hatchery populations for conservation stocking. Tissue samples collected for other purposes, such as assessment of hybridization, should be archived and made available to future genetic investigations.

Prussian carp (*Carassius gibelio*) and Goldfish (*Carassius auratus*) are invasive fish species found in Alberta. Both have been detected in Alberta waters and are set to expand their range within Alberta and further through connected waters. These species have several invasive traits which make them likely to be a high competitor for bull trout (wide tolerance of environmental conditions, habitat generalist, feeding generalist, high reproductive rates and potential for reproductive interference). Carp is considered one of the most detrimental aquatic invasive species in Europe and it is anticipated that it will have similar impacts in the Canadian Prairies. Currently Prussian carp and goldfish have limited overlap with bull trout range but this is an emerging issue that needs to be tracked and to support education activities to prevent further human facilitated spread of these species into bull trout or other native trout habitat.

Desired Outcome:

1. Climate change and whirling disease risk are considered when developing and prioritizing watershed restoration projects.

2. The tools to assess hybridization have been developed and used to better assess the threat of hybridization.

3. New encroachments of invasive non-native fish are prevented from establishing in bull trout range.

Recovery Activities

1. Collect multi-year water temperature data across all Strahler order streams in the Core, Potential Core and Support areas of the bull trout Recovery Area.

2. Use the data from instream dataloggers and develop a new model for a stream temperature network for the Eastern Slopes.

   a. Collect additional water temperature data where there are large gaps between data collection points and rerun the model to improve accuracy.
   b. Identify hyporheic exchange and extensive upwelling zones that are could assist in identifying new bull trout spawning habitat and thermal refugia.
   c. Develop a risk model to determine potential future impact of whirling disease.
   d. Apply climate impact models using the best available data and methodology to understand the potential short- and long-term changes to whirling disease risk and effects on the size, quality and connectivity of bull trout habitat.
   e. Incorporate climate models when investigating short- and long-term feasibility and priority of watershed-specific operational plans.
   f. Make water temperature and climate change models publically available

3. Develop genetic tools to enable the assessment of brook trout – bull trout hybridization and assess the extent of hybridization in representative populations of bull trout, or for populations where hybridization is considered a moderate to significant threat.

4. Work with the Alberta Aquatic Invasive species program to include messaging about invasive non-native fish species in the native trout education programs.

5. Support initiatives like Southern Rockies Watershed Project[21] that will provide the understanding of the climatic, hydrological, and ecological interactions needed to support the sustainable management of Alberta's Eastern Slopes watersheds in the face of a rapidly changing climate.

Progress Measures

1. New whirling disease risk model results have been incorporated into the cumulative effects model.

2. An updated climate impact model has been developed using the best available data and methodology that includes the bull trout Recovery Area. Results should be made available in a technical report.

3. An assessment of the extent of brook trout–bull trout hybridization within representative populations has been completed and the results are available in a technical report.

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[21] https://srwp.ualberta.ca/

7. Implementation Plan

7.1   Key Considerations

When the Alberta Species at Risk Program was first set up in 2000, most of the listed species were terrestrial and the issues associated with the few listed aquatic species were not complex. Program needs have changed dramatically with the change in conservation status of native trout. Addressing the conservation needs of native trout will require long-term investments that include increasing/reallocating GoA staff capacity and program funding and developing/expanding partnerships with not-for-profits, industry and the federal government. It is currently not possible to estimate the total cost of bull trout recovery because there are too many unknowns. Reducing the uncertainty around what will be required to recover bull trout is a key feature of this recovery plan.

Since 2015, there has been a dramatic increase in conservation programming for native trout. Significant investments have been made by the GoA in westslope cutthroat trout recovery, and native trout programs like the Native Trout Recovery Program (NTRP) and the Minister's *Fisheries Act*ion Plan. The Department of Fisheries and Oceans Canada has also increased funding.

7.2   Integrated Program Delivery

There are now three species of native trout (i.e. bull trout, westslope cutthroat trout and Athabasca rainbow trout) that are provincially and federally listed as either *Threatened* or *Endangered* (Table 1). Westslope cutthroat trout and Athabasca rainbow trout co-occur in many of the same streams as bull trout (Figure 15). Westslope cutthroat and Athabasca rainbow trout have unique threats from hybridization but share many of the same issues as bull trout.

In order to deliver a more integrated program, fisheries management in Alberta has developed the NTRP to:

- align existing native trout fishery and habitat management,
- facilitate partnerships with non-government organizations that deliver aquatic or conservation programming,
- resolve potential conflict in the rare circumstances where two co-occurring native trout species have competing conservation needs, and,
- work with DFO as part of the Rocky Mountain Eastern Slopes being a freshwater priority places[22] under the Canada Nature Fund for Aquatic Species at Risk—Priority Places and Threats program.

There is also an opportunity to expand this NTRP to include other native cold water fish, such as Arctic grayling, mountain whitefish and pygmy whitefish, as a step towards a more fully integrated approach to promoting the healthy riparian and aquatic ecosystems within Alberta's Regional Planning and Integrated Resource Management System.

[22] http://www.dfo-mpo.gc.ca/species-especes/sara-lep/cnfasar-fnceap/priority-priorite/index-eng.html

FIGURE 15. The ranges of westslope cutthroat trout and Athabasca rainbow trout relative to the range of bull trout.

	Federal Listing	Provincial Listing
Bull Trout	Threatened (2019)	Threatened (2014)
Athabasca Rainbow Trout	Endangered (2019)	Threatened (2014)
Westslope Cutthroat Trout	Threatened (2013)	Threatened (2009)

Bull Trout Range
Athabasca Rainbow Trout Range
Westslope Cutthroat Trout Range
River Basins
National Park

Alberta Environment and Parks

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The NTRP will be the primary delivery mechanism for the Bull Trout Recovery Plan. The Bull Trout Recovery Plan informs the NTRP by providing a framework for strategic priorities and progress measures for reporting on population recovery and recovery activities. Finer scale recovery actions will be communicated through NTRP workplans with Indigenous and stakeholder consultation and tailored based on socio-economic and geographic considerations.

There is also the opportunity to further integrate native trout recovery in a three-fish (westslope cutthroat trout, bull trout and Athabasca rainbow trout) recovery action plan. A three-fish plan would allow recovery habitat and recovery actions for westslope cutthroat trout and Athabasca rainbow trout to be updated using the cumulative effects model similar to what has been done for bull trout (Section 3.4). Developing the three-fish plan will be an opportunity to further involve directly affected Indigenous communities and stakeholders and will be the primary way that concerns about stakeholder involvement raised by the 3rd party science review will be addressed (Roche et al. 2019). There may also be the opportunity to have the provincial three-fish plan adopted as a federal action plan under the federal *Species at Risk Act*. It is also expected that this planning process will consider other cold-water fish that have overlapping distributions with native trout such as Arctic grayling, mountain whitefish and pygmy whitefish and that conservation actions for native trout will have widespread benefits to maintaining healthy Eastern Slope aquatic ecosystems.

7.3 Recovery Priorities

The top three priorities of bull trout recovery are summarized and listed below in order of importance:

- **Strategy 6.2:** Prioritizing implementation activities within the initial restoration watersheds is a critical next step in order to demonstrate the feasibility of recovering and maintaining local populations of bull trout in riverine systems that are part of Alberta's busy working landscape.
- **Strategy 6.3:** It is important to address the wide-ranging threats by updating and refining current land management practices in order to improve the outcomes for bull trout. The hope is that this will help stabilize populations while the recipe for to maintain and recover populations is being developed in Strategy 6.2.
- **Strategy 6.1:** Conserving species at risk in Alberta is a societal value, a recognition that there is a responsibility to recover populations that have been put at significant risk of extirpation by human activities. In the end, native trout recovery in Alberta will only succeed if Albertans are aware, supportive and engaged in recovery efforts for native trout.

7.4 Estimated Costs and Responsibility for Implementing Major Activities

Monitoring of Indicators for Recovery Objectives

Lead: GoA, Fish and Wildlife Stewardship, program delivery partners

Cost: N/A
The cost of measuring the progress measures will be covered off in other implementation activities by ensuring that population monitoring is part of the evaluation of implementation projects.

Strategy 6.1: Increase the Prominence of Native Trout Conservation

Lead: GoA, Fish and Wildlife Stewardship

Support/Collaborators: Provincial public engagement and education staff and program delivery partners.

Cost: $50,000 – $200,000/year
The higher cost range would reflect the costs associated for additional capacity.

Strategy 6.2: Strategies to Address the Wide-Ranging Potential Threats to Bull Trout

Lead: GoA, Fish and Wildlife Stewardship

Support/Collaborators: Lands Division, Ministry of Agriculture and Forestry, and industry partners

Cost: $100,000 to $250,000
Most of the actions in this strategy are internal government actions to ensure that bull trout are considered in other programs and can be accomplished for relatively little cost. There will be new costs associated with substrategy 6.3.3. The higher end costs would reflect cost of additional dedicated staff capacity and contracts for reviews.

Strategy 6.3: Learning by Doing: Watershed-Specific Recovery Projects

Lead: GoA, Fish and Wildlife Stewardship

Support/Collaborators: Program delivery partners, Lands Division, Agriculture and Forestry, and research partners.

Cost: $100,000 to several million per recovery watershed.
The cost of implementing recovery actions and assessing effectiveness in the initial recovery watersheds will vary depending on the threats within the watershed. Watersheds with significant habitat issues related to road and crossing infrastructure could cost many millions of dollars to fully remediate. Picking watersheds that are likely to have more favorable cost-benefit ratios will help mitigate the cost of the first projects and it is expected that efficiencies will be found in the future.

Strategy 6.4: Continue to Develop and Implement Science-Supported Thresholds for Key Threats

Lead: GoA, Fish and Wildlife Stewardship

Support/Collaborators: research partners and Lands Division.

Cost: $50,000 to $100,000/year
Support to involve additional expertise from academia or other research institutions.

Strategy 6.5: Emerging Issues and Knowledge Gaps

Lead: GoA, Fish and Wildlife Stewardship

Support/Collaborators: research partners.

Cost: $50,000 to 200,000/year
Many of the actions in this strategy will be covered by other programs but there will be some incremental costs to involve additional expertise from academia or other research institutions.

7.5 Progress Reporting and Plan Revision

Annual work planning and reporting will be coordinated by the Fish and Wildlife Stewardship Branch and the NTRP. A systematic review of recovery progress will be conducted every five years and an assessment of whether the plan needs to be revised will be made at those times.

8. Socio-economic Scan

The socio-economic scan provides an overview of current and past social and economic conditions in Alberta that may affect bull trout conservation and the implementation of the bull trout recovery strategies and actions. The potential impacts are scored as either positive or negative (Table 5).

TABLE 5. Potential social and economic impacts if the proposed strategies and associated actions in the Bull Trout Recovery Plan are implemented.

Strategy	Operational Changes	Potential Impacts		
		Economic (–) cost (+) benefit	Environmental (–) cost (+) benefit	Social (–) cost (+) benefit
Strategy 6.1	**Increase the Prominence of Native Trout Conservation**			
6.1 Increase the prominence of native trout conservation	Increased priority given to the conservation and recovery of bull trout and other native trout in regional and subregional plans and in other government policies	(-) increased planning and resource development costs to incorporate considerations for bull trout (+) potential future economic savings related to fish and other wildlife protection actions by minimizing current impacts in fish habitat	(+) bull trout conservation needs are better accommodated in Alberta's system of land-use planning and management (+) increased habitat quantity and quality provides a better environment for bull trout recovery as well as other species that depend on the same ecosystem	(+) improved public knowledge of Alberta's native trout and appreciation for native species (+) increased understanding on how industrial and recreational activities affect fish habitat in Alberta and opportunities to modify behaviours to minimize unnecessary disturbance on fish habitat (+) increased collaboration between government, the public, industry and recreation associations provides an opportunity to build stronger relationships that could be beneficial to future endeavours
Strategy 6.2	**Learning by Doing: Watershed-specific Restoration Projects**			
6.2 Learning by doing: Watershed-specific restoration projects	Using a model and adaptive management approach will require thoughtful study design and more intensive monitoring to evaluate	(-) cost related with more intensive monitoring of bull trout populations and complex analysis of the problem (-) cost of building operational plans, engaging with local stakeholder groups and coordinating multi-agency, multi-stakeholder projects (+) approach will lead to a more cost-effective approach to achieving recovery	(+) mitigation of threats leads to bull trout population recovery as well as other species that depend on the same ecosystem	(+) leads to greater confidence that GoA and delivery partners can successfully recover bull trout (+) Stakeholders are actively engaged in bull trout recovery (+) enhanced fishing opportunities in the future after fish populations have responded

Strategy 6.3	Wide-ranging Potential Threats			
6.3.1 Reduction of sediment and phosphorus	Improved practice for reducing sediment and phosphorus levels in areas with high levels of human disturbance	(-) costs of remediating sources of sediment and phosphorus (-) increased costs of developing and implementing best management practices.	(+) reduce impacts of human disturbance on the ecosystems that bull trout and other wildlife rely on to survive (+) improve water quality (+) improvements to sustainability of bull trout populations	(+) social licence to develop resources (+) increased awareness and implementation of best management practices for agriculture, industry and recreational activities (+) increased collaboration between government, the public, industry and recreation associations provides an opportunity for stronger relationships (+) potential in the future to have enhanced fishing opportunities when populations respond positively
6.3.2 Eliminate human-caused barriers to bull trout movement	Improve condition and performance of stream crossings through the Watercourse Crossing Program (WCP)	(-) costs of identifying and rehabilitating watercourse crossings (+) potential future economic savings related to fish and other wildlife protection actions by minimizing current impacts to fish habitat	(+) increased gene pool mixing in bull trout populations (+) improved sustainability of bull trout populations	(+) social licence to develop resources (+) improved public trust in government (regulatory and resource management) (+) potential in the future to have enhanced fishing opportunities when populations respond positively
6.3.3 Reduce incidental angling mortality and poaching	Provide education and training for anglers, increased enforcement targeting poachers, and better management of fisheries to reduce impacts on vulnerable bull trout populations	(-) financial cost of developing and delivering education (-) may reduce numbers of anglers at some locations and associated economic benefit (+) potential to have additional funding support for native trout recovery through licencing fees	(+) improved sustainability of bull trout populations (+) discouraging poaching in general provides additional protection to other fish species in the same habitat as bull trout (-) other fish and wildlife may receive less enforcement if resources have to redirected	(-) fishing pressure might need to be reduced in some areas resulting in a short-term reduction in fishing opportunity (+) the quality of the fishery should improve in the long term (+) stakeholders are actively engaged in bull trout recovery through the licencing system

Strategy 6.4	Science-supported Land-use Thresholds			
6.4 Continue to develop and implement science-supported land-use thresholds for key threats	Scientific results used to inform Alberta's system of land use management	(-) increased cost of resources (time and human) used for conducting the science (-) once thresholds are identified and implemented, they could require phasing of development activities to allow for habitat restoration before there are new developments (+) potential future economic savings related to fish and other wildlife protection actions by minimizing current impacts to fish habitat (+) if standardized thresholds are developed and inserted into decision-making, it would improve certainty for industry and smooth application processes	(+) improved sustainability of bull trout populations and other species that rely on the same habitats to survive (+) knowledge of more accurate thresholds will allow the design of better policies	(+) Alberta would be a leader in the sustainable management of cold-water ecosystems (+) science informed policies are a desirable societal practice
Strategy 6.5	Emerging Issues and Knowledge Gaps			
6.5 Emerging issues and knowledge gaps	Incorporation of emerging issues such as climate change and whirling disease into future recovery actions	(-) costs of resources (time and human resources) used studying emerging issues (+) knowledge impacts of emerging issues will allow the design of better policies that are able to minimize the costs and maximize benefits of the implementation	(+) improved sustainability of bull trout populations and other species that rely on the same habitats to survive	(+) increased understanding on how emerging issues such as climate change and whirling disease affect bull trout populations and other wildlife in Alberta will create new knowledge that better shapes environmental policies in Alberta

9. Literature Cited

Al-Chokhachy, R., B.B. Shepard, J.C. Burckhardt, D. Garren, S. Opitz, T.M. Koel, L. Nelson and R.E. Gresswell. 2018. A portfolio framework for prioritizing conservation efforts for Yellowstone cutthroat trout populations. Fisheries 43(10): 485–496.

Al-Chokhachy R, T.A. Black, C. Thomas, C.H. Luce, B. Rieman, R. Cissel, A. Carlson, S. Hendrickson, E.K. Archer and J.L. Kershner. 2016. Linkages between unpaved forest roads and streambed sediment: why context matters in directing road restoration. Restor. Ecol.

Alberta Biodiversity Monitoring Institute. Wall-to-wall Land Cover Map. 2010. Version 2.1. Available: https://abmi.ca/home/data-analytics/da-top/da-product-overview/Data-Archive/Land-Cover.html

Alberta Environment and Parks. 2018a. Livingstone-Porcupine Hills recreation management plan. Government of Alberta. 80 pp.

Alberta Environment and Parks. 2018b. Livingstone-Porcupine Hills land footprint management plan. Government of Alberta. 43 pp.

Alberta Environment and Sustainable Resource Development (AESRD). 2014. Fish Conservation and Management Strategy for Alberta. AESRD, Edmonton, AB. 56 pp.

Alberta Sustainable Resource Development (ASRD). 2012. Bull trout conservation management plan 2012–17. Alberta Sustainable Resource Development, Species at Risk Conservation Management Plan No. 8. Edmonton, AB. 90 pp.

Alberta Sustainable Resource Development (ASRD) and Alberta Conservation Association (ACA). 2009. Status of the bull trout (*Salvelinus confluentus*) in Alberta: update 2009. Alberta Sustainable Resource Development. Wildlife Status Report No. 39 (Update 2009), Edmonton, AB. 48 pp.

Arlinghaus, R., S. Cooke and W.M. Potts. 2013. Towards resilient recreational fisheries on a global scale through improved understanding of fish and fisher behaviour. Fisheries Management and Ecology 20: 91–98.

Bartholomew, J.L., H.V. Lorz, S.A. Sollid and D.G. Stevens. 2003. Susceptibility of juvenile and yearling bull trout to Myxobolus cerebralis and effects of sustained parasite challenges. Journal of Aquatic Animal Health 15(3): 248–255.

Benda, L.E., D.J. Miller, K. Andras, P.E. Bigelow, G.H. Reeves and D. Michael. 2007. NetMap: a new tool in support of watershed science and resource management. Forest Science 53(2): 206–219.

Behnke, R.J. 2002. Trout and Salmon of North America. Illustrated by J.R. Tomelleri. Introduction by T. McGuane. The Free Press, A Division of Simon & Schuster Inc. New York, NY.

Berry, D.K. 1994. Alberta's bull trout management and recovery plan. Alberta Environmental Protection, Fish and Wildlife Services, Fisheries Management Division, Edmonton, Alberta. 22 pp.

Bower, S.D., A.J. Danylchuk, R. Raghavan, S.C. Danylchuk, A.C. Pinder, A.M. Alter and S.J. Cooke. 2017. Involving recreational fisheries stakeholders in development of research and conservation priorities for mahseer (Tor spp.) of India through collaborative workshops. Fisheries Research 186(3): 665–671.

Brewin, M.K. 1997. The bull trout task force (Alberta). Pp 1–14 in Mackay, W.C., M.K. Brewin and M. Monita (editors). Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, AB. 14 pp.

Brownscombe, J.W., A.J. Danylchuk, J.M. Chapman, L.F.G. Gutowsky and S.J. Cooke. 2017. Best practices for catch-and-release recreational fisheries — angling tools and tactics. Fisheries Research 186: 693–705.

Bryski, M. 1999. Arctic grayling historical review — grayling fisheries of the McLeod River sub-basin in Fisheries Management Area 4. Alberta Conservation Association, Edson, Alberta. 83 pp.

Burrows, J., T. Euchner and N. Baccante. 2001. Bull trout movement patterns: Halfway River and Peace River progress. Pp 153–157 in Brewin, M.K., A.J. Paul and M. Monita (editors). Bull Trout II Conference Proceedings. Trout Unlimited Canada, Calgary, AB. 4 pp.

Cialdini, R.B., and M.R. Trost. 1998. Social influence: social norms, conformity, and compliance. Pp 151–192 in Gilbert, D.T., S.T. Fiske and G. Lindzey (editors). The handbook of social psychology (4th ed., Vol. 2). Boston: McGraw-Hill. 1984 pp.

Cissel, R., T. Black, N. Nelson and C. Luce. 2014. Southwest Crown of the Continent GRAIP roads assessment: Center Horse and Morrell/Trail Project Area, Poorman Creek, and Cold Creek, Lolo, Helena, and Flathead national forests Montana. US Forest Service Rocky Mountain Research Station, Report to Southwest Crown Collaborative. Available: http://www.swcrown.org/wp-content/uploads/2014/11/Lolo-Helena-Flathead-NFs-SWCC-Watersheds-2014-Final-Report.pdf.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012. COSEWIC assessment and status report on the bull trout *Salvelinus confluentus* in Canada. COSEWIC. Ottawa, ON. iv + 103 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Cook, K.V., R.J. Lennox, S.G. Hinch and S.J. Cooke. 2015. Fish out of water: how much air is too much? Fisheries 40(9): 452–461.

Costello, A.B., T.E. Down, S.M. Pollard, C.J. Paca and E.B. Taylor. 2003. The influence of history and contemporary stream hydrology on the evolution of genetic diversity within species: an examination of microsatellite DNA variation in bull trout, *Salvelinus confluentus* (Pisces: Salmonidae) Evolution 57(2): 328–344.

Cowx, I.G., R. Arlinghaus and S.J. Cooke. 2010. Harmonizing recreational fisheries and conservation objectives for aquatic biodiversity in inland waters. Journal of Fish Biology 76: 2194–2215.

Cristan, R., W.M. Aust, M.C. Bolding, S.M. Barrett, J.F. Munsell and E. Schilling. 2016. Effectiveness of forestry best management practices in the United States: literature review. Forest Ecology and Management 360: 133–151.

Croke, J.C., and P.B. Hairsine, P. B. (2006). Sediment delivery in managed forests: a review. Environmental Reviews, 14(1), 59–87.

Danylchuk, A.J. 2017. Perceptions of recreational fisheries conservation within the fishing industry: knowledge gaps and learning opportunities identified at east coast trade shows in the United States. Fisheries Research 186: 681–687.

Davidson, D.J., and N.A. MacKendrick. 2004. All dressed up with nowhere to go: the discourse of ecological modernization in Alberta, Canada. The Canadian Review of Sociology and Anthropology 41(1): 47–65.

DeHaan, P.W., L.T. Schwabe and W.R. Ardren. 2010. Spatial patterns of hybridization between bull trout, *Salvelinus confluentus*, and brook trout, Salvelinus fontinalis in an Oregon stream network. Conservation Genetics 11:935–949.

Department of Fisheries and Oceans (DFO). 2017. Recovery potential assessment of bull trout, *Salvelinus confluentus* (Saskatchewan–Nelson rivers populations). DFO Canadian Science Advisory Secretariat Science Advisory Report 2016(50): 30 pp.

Classification: Public

Department of Fisheries and Oceans (DFO). 2019. Review of Alberta Environment and Parks Cumulative Effects Assessment Joe Model. Canadian Science Advisory Secretariat Science Advisory Report 2019(045): 14 pp.

Department of Fisheries and Oceans (DFO). 2020a. Recovery Strategy for the Bull Trout (*Salvelinus confluentus*), Saskatchewan-Nelson Rivers populations, in Canada [Final]. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. viii + 130 pp.

Department of Fisheries and Oceans (DFO). 2020b. Guidance on the identification of Critical Habitat in the riparian zone for freshwater species at risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/040.

Department of Fisheries and Oceans (DFO). 2020c. Information for identification of candidate critical habitat of Bull Trout (*Salvelinus confluentus*) (Saskatchewan-Nelson rivers populations). DFO Canadian Science Advisory Sector Science Response. 2020(044): 57 pp.

Falke, J., R. Flitcroft, J. Dunham, K. Mcnyset, P. Hessburg, G. Reeves. 2015. Climate change and vulnerability of bull trout (*Salvelinus confluentus*) in a fire-prone landscape. Canadian Journal of Fisheries and Aquatic Sciences. 72. 1-15. 10.1139/cjfas-2014-0098.

Farr, D., A. Braid, A. Janz, B. Sarchuk, S. Slater, A. Sztaba, D. Barrett, G. Stenhouse, A. Morehouse and M. Wheatley. 2017. Ecological response to human activities in southwestern Alberta: scientific assessment and synthesis. Alberta Environment and Parks, Government of Alberta. 88 pp.

Filteau, M.R. 2012. Deterring defiance: 'Don't give a poacher a reason to poach'. International Journal of Rural Criminology 1:236–255.

Fitch, L.A. 1997. Bull trout in southwestern Alberta: notes on historical and current distribution. Pp. 147–160 in Mackay, W.C., M.K. Brewin and M. Monita (editors). Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, AB. 455 pp.

Fitzsimmons, K., and M. Fontana. 2004. Upper Bow River watershed off-highway vehicle stream crossing inventory and assessment program 2003 / 2004 activity report and catalogue of sample sites in the Waiparous Creek drainage. Alberta Conservation Association, Cochrane, AB. 321 pp.

Fredenberg, W., J. Chan and J. Young. 2005. Bull trout core area conservation status assessment. U.S. Fish and Wildlife Service, Portland, Oregon. 94 pp + App.

Government of Alberta (GoA). 1984. A policy for resource management of the Eastern Slopes, revised 1984. Edmonton, AB. ENR Number T/38. vi + 23 pp.

Government of Alberta (GoA). 2014. South Saskatchewan regional plan 2014–2024. An Alberta land-use framework integrated plan. Revised May 2018. Edmonton, AB. 20 pp.

Government of Alberta (GoA). In press. Rocky Creek Bull Trout Cumulative Effects Model and Threat Summary. Species at Risk Series. 30 pp.

Hagmann, R. K., et al. 2021. Evidence for widespread changes in the structure, composition, and fire regimes of western North American forests. Ecological Applications e02431.

Hessburg, Paul. 2017. Adaptation to wildfire: A fish story. Science Finding. 198. 1-6.

Homel, K., P. Budy, M.E. Pfrender, T.A. Whitesel and K. Mock. 2008. Evaluating genetic structure among resident and migratory forms of bull trout (*Salvelinus confluentus*) in northeast Oregon. Ecology of Freshwater Fish 17: 465–474.

Hughson, W., and M.G. Sullivan. 2015. Assessment of the keystone species mountain whitefish, and the fish community of the mainstem Athabasca River in Jasper National Park. Unpublished Report. 46 pp.

Isaak, D.J., M.K. Young, D.E. Nagel, D.L. Horan and M.C. Groce. 2015. The cold-water climate shield: delineating refugia for preserving salmonid fishes through the 21st century. Global Change Biology 21: 2540–2553.

Isaak, D.J, M.K. Young, C.H. Luce, S.W. Hostetler, S.J. Wnger, E.E. Peterson, J.M. Ver Hoef, M.C. Groce, D.L. Horan and D.E. Nagel. 2016. Slow climate velocities of mountain streams portend their role as refugia for cold-water biodiversity. Proceedings National Academy of Science 113(16): 4374–4379.

Johnston, F.D., J.R. Post, C.J. Mushens, J.D. Stelfox, A.J. Paul and B. Lajeunesse. 2007. The demography of recovery of an overexploited bull trout, *Salvelinus confluentus*, population. Canadian Journal of Fisheries and Aquatic Sciences 64: 113–126.

Johnston, F.D., R. Arlinghaus, J. Stelfox and J.R. Post. 2011. Decline in angler use despite increased catch rates: anglers' response to the implementation of a total catch-and-release regulation. Fisheries Research 110: 189–197.

Johnston, F.D., B. Beardmore and R. Arlinghaus. 2015. Optimal management of recreational fisheries in the presence of hooking mortality and noncompliance—predictions from a bioeconomic model incorporating a mechanistic model of angler behavior. Canadian Journal of Fisheries and Aquatic Sciences 72: 37–53.

Kennett, S.A. 2002. Integrated resource management in Alberta: past, present and benchmarks for the future. Canadian Institute of Resources Law Occasional Paper # 11. 29 pp.

Koontz, E.D., E.A. Steel, and J.D. Olden. 2018. Stream thermal responses to wildfire in the Pacific Northwest. Freshwater Science 2018 37:4, 731-746.

Kuglerová, L., A. Ågren, R. Jansson and H. Laudon. 2014. Towards optimizing riparian buffer zones: ecological and biogeochemical implications for forest management. Forest Ecology and Management 334: 74–84.

Liebich, K.B., J.F. Kocik and W.W. Tayler. 2018. Reclaiming a space for diadromous fish in the public psyche and sense of place. Fisheries 43: 231–240.

Long, M.H. 1997. Sociological implications of bull trout management in northwest Montana: illegal harvest and game warden efforts to deter poaching. Pp 71–73 in Mackay, W.C., M.K. Brewin and M. Monita. (editors). Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, AB. 455 pp.

Maitland, B.M., M. Poesch, A.E. Anderson, and S.N. Pandit. 2016. Industrial road crossings drive changes in community structure and instream habitat for freshwater fishes in the boreal forest. Freshwater Biology 61:1–18

MacDonald, L.H. 2000. Evaluating and managing cumulative effects: process and constraints. Environmental Management 26(3): 299–315.

Macdonald, L.H. and D.B.R. Coe. 2008).Road sediment production and delivery: process and management. pp 381–384. Proceedings of the First World Landslide Forum. United Nations University, Tokyo, Japan.

MacPherson, L., M. Coombs, J. Reilly, M.G. Sullivan and D.J. Park. 2014. A generic rule set for applying the Alberta Fish Sustainability Index, second edition. Environment and Sustainable Resource Development, Edmonton, AB. 51 pp.

MacPherson, L., M. Sullivan, J. Reilly and A. Paul. 2020. Alberta's fisheries sustainability assessment: a guide to assessing population status, and quantifying cumulative effects using the Joe modelling technique. DFO Canadian Science Advisory Secretariat Science Advisory Document. 2019/058

Mannheim, S.L., A.-R. Childs, E.C. Butler, A.C. Winkler, M.S. Parkinson, M.W. Farthing, T. Zweig, M. McCord, N. Drobniewska and W.M. Potts. 2018. Working with, not against recreational anglers: evaluating a pro-environmental behavioural strategy for improving catch-and-release behaviour. Fisheries Research 206: 44–56.

Marion, J. L., and Wimpey, J. 2017. Assessing the influence of sustainable trail design and maintenance on soil loss. Journal of Environmental Management, 189, 46–57.

Masterman, B.A., and J.D. Stelfox. 2010. Looking back: an historical report of angler experiences along the Eastern Slopes of south-western Alberta. Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, AB. 47 pp.

Marczyk, J.S. 1985. Integrated resource planning in Alberta. Impact Assessment 4(1-2): 39–62.

McCleary, R. 2013. A cumulative watershed effects assessment template for the Eastern Slopes: the geomorphic and riparian components with a case study of Todd Creek watershed. Unpublished report. Prepared for the Foothills Research Institute. i + 65 pp.

Moore, R.D., and J.S. Richardson. 2012. Natural disturbance and forest management in riparian zones: comparison of effects at reach, catchment, and landscape scales. Freshwater Science 31(1): 239–247.

Newman, E. A. 2019. Disturbance ecology in the Anthropocene. Frontiers in Ecology and Evolution 7:147.

Park, D., M. Sullivan, E. Bayne and G. Scrimgeour. 2008. Landscape-level stream fragmentation caused by hanging culverts along roads in Alberta's boreal forest. Canadian Journal of Forest Research 38: 566–575.

Parker, B.R., D.W. Schindler, F.M. Wilhelm and D.B. Donald. 2007. Bull trout population responses to reductions in angler effort and retention limits. North American Journal of Fisheries Management 27: 848–859.

Paternoster, R. 2010. How much do we really know about criminal deterrence? Journal of Criminal Law and Criminology 100(3): 765–824.

Popowich R.C., P.A. Venturelli, J.D. Stelfox and E.B. Taylor. 2011. Validation of morphological characteristics used for field identification of bull trout × brook trout hybrids. North American Journal of Fisheries Management 31(3): 548–553.

Post, J.R. and F.D. Johnston. 2002. Status of the bull Trout (*Salvelinus confluentus*) in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 39, Edmonton, AB 40pp.

Post, J.R., C. Mushens, A.J. Paul and M. Sullivan. 2003. Assessment of alternative management strategies for sustaining recreational fisheries: model development and application to bull trout, *Salvelinus confluentus*. North American Journal of Fisheries Management 23: 22–34.

Prichard, S. J., et al. 2021. Adapting western North American forests to climate change and wildfires: 10 common questions. Ecological Applications 31(8):e02433. 10.1002/eap.2433.

Ramstead, S. 1997. Managing bull trout with enforcement and education. Pp 72–82 in Mackay, W.C., M.K. Brewin and M. Monita. (editors). Friends of the Bull Trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, AB. 455 pp.

Reid L.M. and T. Dunne. 1984. Sediment production from forest road surfaces. Water Resources Research 20:1753–1761.

Rice, R.M., and J. Lewis. 1986. Identifying unstable sites on logging roads. Pp. 239–247 in Proceedings, Division I. 18th IUFRO World Congress. Volume I. International Union of Forestry Research Organizations, Vienna, Austria.

Richardson J.S., E. Taylor, D. Schluter, M. Pearson and T. Hatfield. 2010. Do riparian zones qualify as critical habitat for endangered freshwater fishes? Canadian Journal of Fisheries and Aquatic Sciences 67: 1197–1204.

Rieman, B.E., and D.J. Isaak. 2010. Climate change, aquatic ecosystems, and fishes in the Rocky Mountain west: implications and alternatives for management. General Technical Report RMRS-GTR-250. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 46 pp.

Ripley, T., G. Scrimgeour and M.C. Boyce. 2005. Bull trout (*Salvelinus confluentus*) occurrence and abundance influenced by cumulative industrial developments in a Canadian boreal forest watershed. Canadian Journal of Fisheries and Aquatic Sciences 62: 2431–2442.

Roche, D.G., J.R. Bennett, E. Martins and S.J. Cooke. 2019. A third party scientific review of Alberta Environment and Park's North Central Native Trout Recovery Program. Government of Alberta, Ministry of Environment and Parks. 65 pp.

Santiago, J.M., R. Muñoz-Mas, J. Solana-Gutiérrez, D. García de Jalón, C. Alonso, F. Martínez-Capel, J. Pórtoles, R. Monjo and J. Ribalaygua. 2017. Waning habitats due to climate change: the effects of changes in streamflow and temperature at the rear edge of the distribution of a cold-water fish. Hydrology and Earth System Sciences 21: 4073–4101.

Sarker, S., D. Kallert, R.P. Hedrick, and M. El-Matbouli. 2015. Whirling disease revisited: Pathogenesis, parasite biology and disease intervention. Diseases of Aquatic Organisms. 114:155-175.

Sawatzky, C.D. 2016. Information in support of recovery potential assessment of Bull Trout (*Salvelinus confluentus*) (Saskatchewan-Nelson rivers populations) in Alberta. DFO Canadian Science Advisory Sector Document 2016(113): v + 190 pp.

Scherer, R. 2011. Cumulative effects: a primer for watershed managers. Streamline Watershed Management Bulletin 14(2): 14–20.

Schmetterling, D.A., and M.H. Long 1999. Montana anglers' inability to identify bull trout and other salmonids. Fisheries Magazine 24(7): 24–27.

Sibley, P.K., D.P. Krutzweiser, B.J. Naylor, J.S., Richardson and A.M. Gordon. 2012. Emulation of natural disturbance (END) for riparian forest management: synthesis and recommendations. Freshwater Science 31(1): 258–264.

Silins, U., K.D. Bladon, E.N. Kelly, E. Esch, J.R. Spence, M. Stone, M.B. Emelko, S. Boon, M.J. Wagner, C.H.S. Williams and I. Tichkowsky. 2014. Five-year legacy of wildfire and salvage logging impacts on nutrient runoff and aquatic plant, invertebrate, and fish productivity. Ecohydrol. 7, 1508–1523. Sims, B., and A.J. Danylchuk. 2017. Characterizing information on best practice guidelines for catch-and-release in websites of angling-based non-government organizations in the United States. Fisheries Research 186(3): 688–692.

St John Freya, A.V., G. Edwards-Jones and J.P.G. Jones. 2010. Conservation and human behaviour: lessons from social psychology. Wildlife Research 37: 658–667.

Steinmetz, R., S. Srirattanaporn, J. Mor-Tip and N. Seuaturien. 2014. Can community outreach alleviate poaching pressure and recover wildlife in South-East Asian protected areas? Journal of Applied Ecology 51: 1469–1478.

Stelfox, J.D., D.M. Baayens, A.J. Paul and G.E. Shumaker. 2001. Quirk Creek brook trout suppression project. Pp. 37–46 in Brewin, M.K., A.J. Paul and M. Monita (editors). Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, AB. 9 pp.

Sullivan, M. 2009. The bull trout of Jacques Lake, Jasper National Park: a population in recovery. Published February 2009. Addendum June 2014. Alberta Cooperative Conservation Research Unit. 16 pp.

TerrainWorks Inc. and Foothills Research Institute (fRI). 2018a. Identifying unpaved road sediment delivery to critical fish habitats for strategic prioritization of mitigation actions in Alberta. Project area #1: Oldman River and Bow River watersheds. 77 pp.

Classification: Public

TerrainWorks Inc. and Foothills Research Institute (fRI). 2018b. Identifying unpaved road sediment delivery to critical fish habitats for strategic prioritization of mitigation actions in Alberta. Project area #2: Upper Saskatchewan and Red Deer watersheds. 77 pp.

TerrainWorks Inc. and Foothills Research Institute (fRI). 2019. Identifying unpaved road sediment delivery to critical fish habitats for strategic prioritization of mitigation actions in Alberta. Project area #3: Athabasca and Peace rivers. 80 pp.

Trimble, S.W., and A.C. Mendel. 1995. The cow as a geomorphic agent — a critical review. Geomorphology, 13(1–4): 233-253.

Tymstra, C., B.J. Stocks, X. Cai, M.D. Flannigan, 2020. Wildfire management in Canada: Review, challenges and opportunities. Prog. Disaster Sci. 5, 100045

U.S. Fish and Wildlife Service (USFWS). 2014. Revised draft recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). Portland, Oregon. xiii + 151 pp.

Walters, C.J., and C.S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology: 71(6): 2060–2068.

Walker, J.R., L. Foote and M.G. Sullivan. 2007. Effectiveness of enforcement to deter illegal angling harvest of northern pike in Alberta. North American Journal of Fisheries Management 27(4): 1369–1377.

Warnock, W.G. 2008. Molecular tools reveal hierarchical structure and patterns of migration and gene flow in bull trout (*Salvelinus confluentus*) populations of south-western Alberta. M.Sc. Thesis, University of Lethbridge, Lethbridge, AB. 174 pp.

Williams, J.E., A.L. Haak, N.G. Gillespie and W.T. Colyer. 2007. The Conservation Success Index: synthesizing and communicating salmonid condition and management needs. Fisheries 32: 477–493.

Young, M.K., D.J. Isaak, S. Spaulding, C.A. Thomas, S.A. Barndt, M.C. Groce, D. Horan and D.E. Nagel. 2018. Effects of climate change on cold-water fish in the northern Rockies. In: Halofsky J., and D. Peterson (editors). Climate change and Rocky Mountain ecosystems. Advances in global change research, vol 63. Springer. 236 pp.

Appendix A

Assessing Recovery Potential

The cumulative effects model and expert opinion were used to assess the recovery potential of populations at a HUC 8 watershed scale in the Recovery Area. This recovery scenario was used to inform the recovery goal (Section 4 Alberta Bull Trout Recovery Plan). This appendix describes the methodology used to develop the recovery scenario.

The first step used the cumulative effects model to develop a hypothetical scenario to demonstrate what potential improvements in system capacity could be achieved if threat mitigation actions were applied. The scenario chosen was designed to be an ambitious application of technically feasible threat mitigations. Social acceptability was not considered for this stage and economics were only considered for very difficult to reverse land use changes (e.g., major dam removal, agricultural cultivation). Water withdrawals for irrigation were not considered. The scenario was developed by adjusting each mitigatable threat in each watershed to the levels described in Table A.1 and calculating the predicted system capacity improvement (the metric is the FSI score). This was used to assess where there is potential to improve bull trout population status if restoration activities are applied. Note that this exercise was not about determining the optimal restoration approach for a population; actual restoration will be customized for each population based on local information about the threats (see Strategy 7.2). In addition to identifying the populations at a HUC 8 watershed scale that have the potential for recovery, the exercise was also used to identify those that are unlikely to respond to restoration making them poor candidates for investment in restoration.

The second step required GoA fisheries management staff to use the modelled scenario results, empirical data on current population status, and their local knowledge to assign the population in a watershed into one of the following predicted recovery categories:

- **Core Population:** High confidence that the population in the HUC 8 watershed can be maintained or restored to a moderate to very low risk state (i.e., adult density FSI score ≥ 3).
- **Potential Core Population:** Further investigations, including pilot restoration projects, are needed to determine the degree to which these populations can be maintained or restored to a moderate to very low risk state.
- **Support Population:** Populations, based on our current understanding, are unlikely to be restored to a moderate to very low risk state (i.e., adult density FSI score ≥ 3) because it is unlikely that the cumulative effect of all the key threats (e.g., dams, diversions, industrial and urban land uses) can be fully mitigated, or there is no known historical evidence that the population has ever existed at a moderate to very low risk state. However, it is expected that bull trout occupancy can be maintained in the HUC 8 watershed, at least in part, due to dispersal from nearby populations (e.g., it provides important overwintering habitat or is a migratory corridor) or because threats are minimal or can be addressed in some of the tributary HUC 10s within the HUC 8.
- **Likely Unrecoverable:** Populations, based on our current understanding, that are at serious risk of extirpation in most of the HUC 8, even if conservation actions are applied.

The results were used to inform the provincial recovery goals and objectives (Section 4.0 Alberta Bull Trout Recovery Plan). Refer to Figure 13 in the Alberta Bull Trout Recovery Plan for a map of HUC 8 recovery categories.

TABLE A.1. Description of the factors used in the cumulative effects model that were used to assess recovery potential of local watersheds. For proposed recovery activities or approaches refer to section 6.0.

Scenario	Description	Activities Required to Achieve	Additional Explanation
Improve Water Quality	30% reduction in sediment and phosphorus	Limits on new development. Decommissioning unnecessary roads or roads prone to land sliding. Improving road drainage, mulching or rock riprap on cut banks and fill slopes. Rock armoring drainage outlets. Repairing OHV damage. Remediating point source grazing impacts.	Limit sediment transport potential and reduce hydrologically connected soils and disturbed areas.
Removing Human-caused Barriers to Fish Passage	Remove 1/2 the barriers	Replacing culverts with properly sized culverts or bridges	The long-term desired outcome would be to get all crossings into compliance with existing laws. The chosen scenario just reflects the magnitude of the task and how long it will take to address all the problematic infrastructure.
Minimize Angling-related Mortality	Angling mortality reduced to 2% unless already lower	Conservation closures, reduce road access to anglers, targeted compliance and education	
Reduce Footprint Effect on Run-off	Reduce footprint to 50% unless already lower	Cessation of logging and other land clearing activities or changing harvest sequence	This threat relates to predicted changes in the frequency and severity of run-off events and assumes impacts to fish populations are likely to become severe when disturbances like clear-cuts occupy over 50% of the area of the watershed.
Remove Non-native Fish	All non-native fish that compete with bull trout are removed	Remove non-native fish	Remove competition for resources