Species at Risk Act
Recovery Strategy Series
Incorporation under
Section 44 of SARA

Recovery Strategy and Action Plan for the Westslope Cutthroat Trout *(Oncorhynchus clarkii lewisi*) Alberta Population (also known as Saskatchewan-Nelson River Populations) in Canada

Westslope Cutthroat Trout

2019

Canada

Recommended citation:

Fisheries and Oceans Canada. 2019. Recovery Strategy and Action Plan for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta population (also known as Saskatchewan-Nelson River populations) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 61 pp + Part 2

For copies of the recovery strategy, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the SAR Public Registry.

Cover illustration: Shane Petry

Également disponible en français sous le titre
Programme de rétablissement et plan d'action pour la truite fardée versant de l'ouest (*Oncorhynchus clarkii lewisi*) population de l'Alberta (également connue sous le nom populations de la rivière Saskatchewan et du fleuve Nelson) au Canada.

ISBN 978-0-660-33345-8
Catalogue no. En3-4/182-2019E-PDF

Recovery Strategy and Action Plan for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta population (also known as Saskatchewan-Nelson River Populations) in Canada 2019

The Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada was posted on the Species at Risk Public Registry in March 2014.

Under Sections 45 of the *Species at Risk Act (*SARA), the competent ministers may amend a recovery strategy at any time. This 2019 Recovery Strategy and Action Plan for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta population (also known as Saskatchewan-Nelson River populations) in Canada (hereafter, "recovery strategy-action plan") is for the purposes of:

- Amending the critical habitat in Section 5 of the Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada (Fisheries and Oceans Canada 2014), based on updated information;

- Including recovery measures and the evaluation of socio-economic costs and benefits (to meet section 49(1) of SARA).

In some cases, additional changes have been made to the previous recovery strategy to align the document with current guidelines and templates for recovery documents.

Since the 2014 recovery strategy was finalized, some critical habitat studies outlined in the schedule of studies have been completed, resulting in the identification of additional critical habitat.

This recovery strategy - action plan was posted on the Species at Risk (SAR) Public Registry for a 60-day comment period on May 14, 2019. At the time of final posting, this recovery strategy-action plan will replace the 2014 recovery strategy.

Incorporation – federal and provincial cooperation

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for protection of species at risk throughout Canada.

In the spirit of cooperation under the Accord, the Government of Alberta has provided the "Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017" (the Alberta recovery plan) that was completed by a joint Alberta-Canada recovery team in 2013. The federal Minister of Fisheries and Oceans and the Minister responsible for the Parks Canada Agency as the competent ministers under the *SARA* (SARA) incorporate the Alberta recovery plan as part of the federal Recovery Strategy and Action Plan for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta population (also known as Saskatchewan-Nelson River populations) in Canada.

The finalized recovery strategy-action plan, once included in the SAR Public Registry, will be the SARA recovery strategy and action plan for this species.

The recovery strategy - action plan for the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) consists of two parts:

1. The federal text which completes the recovery strategy - action plan in terms of meeting the requirements of SARA s. 41(1) and s. 49(1). This text includes additions, exceptions or modifications to the document being incorporated,
2. The Alberta recovery plan.[1]

[1] Alberta Environment and Parks, Fish and Wildlife reviewed this recovery strategy-action plan and acknowledge, and accept that aspects of the recovery strategy-action plan conflict with some content in the Alberta recovery plan. The Government of Alberta is working to update the Alberta recovery plan to reflect a new state of knowledge and management intent. The new Alberta recovery plan will be adopted and will replace the 2012-2017 Alberta recovery plan once it is finalized.

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for protection of species at risk throughout Canada. Under the *SARA* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy and action plan for species listed as extirpated, endangered, or threatened and are required to report on the implementation of the recovery strategy-action plan and the progress towards meeting its objective within five years after the publication of the final document on the Species At Risk (SAR) Public Registry and in every subsequent five-year period, until its objectives have been achieved or the species' recovery is no longer feasible.

This document has been prepared to meet the requirements under SARA of both a recovery strategy and action plan. As such, it provides both the strategic direction for the recovery of the species, including the population and distribution objectives for the species, as well as the more detailed recovery measures to support this strategic direction, outlining what is required to achieve the objectives. SARA requires that an action plan also include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation. It is important to note that the setting of population and distribution objectives and the identification of critical habitat are science-based exercises and socio-economic factors were not considered in their development. The socio-economic evaluation only applies to the more detailed recovery measures. This recovery strategy - action plan is considered one in a series of documents that are linked and should be taken into consideration together. These include the COSEWIC status report and the DFO 2009 recovery potential assessment.

The Minister of Fisheries and Oceans and the Minister responsible for the Parks Canada Agency are the competent ministers under SARA for the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) and have prepared this recovery strategy - action plan, as per section 37 and 47 of SARA. In preparing this recovery strategy - action plan, the competent ministers have considered, as per Section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. Alberta Environment and Parks, Alberta Agriculture and Forestry, Environmental Non-Governmental Organization Coalition, Spray Lake Sawmills, Trout Unlimited Canada and the University of Calgary provided input into the development of the recovery strategy-action plan as per section 39(1) and 48(1) of SARA . Appendix B, lists organizations and individuals that have contributed to the 2014 recovery strategy and the 2019 recovery strategy-action plan.

As stated in the preamble of SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in

implementing the directions set out in this recovery strategy - action plan and will not be achieved by Fisheries and Oceans Canada and the Parks Canada Agency, or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this recovery strategy - action plan for the benefit of the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) and Canadian society as a whole.

The recovery measures in this document provide the detailed recovery planning that supports the strategic direction set out in the recovery strategy section of the document and outlines recovery measures to be taken by Fisheries and Oceans Canada, other jurisdictions, and/or organizations to help achieve the population and distribution objectives. The Multi-species Action Plan for Banff National Park of Canada; and, the Multi-species Action Plan for Waterton Lakes National Park of Canada and Bar U Ranch National Historic Site of Canada identify the recovery measures for Westslope Cutthroat Trout that will be implemented in these protected heritage places. Implementation of this recovery strategy - action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

Fisheries and Oceans Canada extends its sincere appreciation to numerous organizations that contributed to the development of this recovery strategy - action plan and to the recovery team who contributed their knowledge and hard work into the development of this document. A detailed list of the recovery team membership, including individuals and organizations that reviewed and/or contributed to the 2014 Recovery Strategy and the recovery strategy - action plan is provided in the Record of Cooperation and Consultation (Appendix B).

Fisheries and Oceans Canada would like to especially thank the late Matt Holder and Charlie Pacas, who provided invaluable information and insight. They will be greatly missed.

Executive summary

Based on COSEWIC's assessment and status report of November 2016, the designatable unit (DU) name for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) changed from Alberta population to Saskatchewan-Nelson River populations. This final amended recovery strategy and action plan has been updated from the proposed version and uses both the name that currently appears in Schedule 1 of SARA and the new DU name assigned by COSEWIC in Part 1: Federal addition to the Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017).

Cutthroat Trout are widely distributed throughout much of western North America. Westslope Cutthroat Trout are the only subspecies native to Alberta. Historically, the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) inhabited most streams in south-western Alberta from the alpine to the prairies. Currently, genetically pure Cutthroat Trout occupy only a small fraction of the original Westslope Cutthroat Trout distribution and occur as small, disconnected populations.

In 2009, the Westslope Cutthroat Trout was listed as Threatened under Alberta's *Wildlife Act* and in 2013, listed as Threatened under the federal *SARA*. This designation was due to the subspecies' small distribution and continuing decline in extent of occurrence, the severely fragmented nature of populations, continuing decline in quality of habitat, and the presence of barriers to dispersal making migration between populations difficult.

In 2009, a joint federal/provincial recovery team was established for the Westslope Cutthroat Trout to produce a recovery strategy (federal) and recovery plan (provincial) that would meet the needs both federally and provincially. In 2013 a provincial Recovery Plan for the Westslope Cutthroat Trout was developed and in 2014 the federal Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada was published. This recovery strategy - action plan updates and replaces the 2014 Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada (and includes updates to critical habitat within Section 5).

The population and distribution objectives are:

"Protect and maintain the existing distribution of ≥ 0.99 genetically pure populations of Westslope Cutthroat Trout, and re-establish genetically pure populations to self-sustaining levels, within the Saskatchewan – Nelson rivers watershed in Alberta."

To help achieve the population and distribution objectives, four broad strategies are proposed: 1) research, 2) monitoring, 3) management and regulation, and 4) education and outreach. Within each of these, a number of approaches are outlined with the aim to protect and manage the species, and to reduce or eliminate threats to its survival.

Key approaches are to:

- identify, maintain, and improve the distribution of genetically pure populations;
- improve knowledge of population genetics, size, distribution, and trends;
- identify opportunities to recover populations within recovery areas;
- increase prominence of native fish conservation, in recreation planning and land-use management to reduce the impact of human footprint;
- improve awareness of the species for their conservation and;
- re-establish genetically pure populations in sites within the original Westslope Cutthroat Trout distribution.

The action plan portion of this document outlines measures that provide the best chance of achieving the population and distribution objectives for the species, including the measures to be taken to address the threats and monitor the recovery of the species, under the strategies and approaches outlined in the recovery strategy. An evaluation of the socio-economic costs and benefits to be derived from the implementation of recovery measures is provided in Section 5.

Critical habitat for the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) is only partially identified at this point in time. Further studies are required to identify additional critical habitat to support the population and distribution objectives, to refine knowledge of the biophysical functions, features, and attributes and to determine recoverable areas. Additional critical habitat will be identified as information becomes available. This recovery strategy - action plan identifies critical habitat to the extent possible and lists the examples of activities likely to result in the destruction of critical habitat.

Table of contents

Part 1: Federal addition to the Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017

Species at Risk Act requirements, modifications and exclusions to the recovery strategy and action plan

Once a species is placed on Schedule 1 of SARA, the competent ministers must determine whether the recovery of the species is technically and biologically feasible, and if feasible, must address the threats to survival of the species identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The following (summarized from sections 41(1) and 49(1) of SARA) must also be addressed in the recovery strategy - action plan:

1. a description of the species and its needs that is consistent with information provided by COSEWIC
2. an identification of the threats to the survival of the species and threats to its habitat that is consistent with information provided by COSEWIC and a description of the broad strategy to be taken to address those threats
3. an identification of the species' critical habitat, to the extent possible, based on the best available information, including the information provided by COSEWIC, and examples of activities that are likely to result in its destruction
4. a schedule of studies to identify critical habitat, where available information is inadequate
5. a statement of measures that are proposed to be taken to protect the species' critical habitat and an identification of any portions of the species' critical habitat that have not been protected
6. a statement of the population and distribution objectives that will assist the recovery and survival of the species, and a general description of the research and management activities needed to meet those objectives
7. a statement about whether additional information is required about the species
8. a statement of the measures that are to be taken to implement the recovery strategy, including those that address the threats to the species and those that help to achieve the population and distribution objectives, as well as an indication as to when these measures are to take place
9. the methods to be used to monitor the recovery of the species and its long-term viability
10. an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation
11. any other matters that are prescribed by the regulations

In addition to the above, and if applicable, the competent ministers also consider whether the species has a residence as defined by SARA and lastly they may consider whether certain activities could be exempted from the SARA prohibitions.

It should be noted that in Alberta, a species at risk recovery document is referred to as a "recovery plan"; federally the same type of document is referred to as a "recovery strategy". This terminology is used when making reference to either document. Throughout the federal recovery strategy - action plan, the term "original Westslope Cutthroat Trout distribution" is used; it should be noted that the terms "historic range",

"historical range" and "native range" are used in the Alberta recovery plan and should be interpreted synonymously with the term "original Westslope Cutthroat Trout distribution". In addition, "actions" used in the Alberta recovery plan should be considered synonymous with "recovery measures" as described in the federal recovery strategy - action plan. Also, what is referred to as "genetically pure" in the federal document is referred to synonymously as "pure", "genetically-pure", or "genetically pure-strain" in the Alberta provincial plan.

Part 1 of the Recovery Strategy-Action Plan highlights only those requirements under SARA that are not fully discussed in the Alberta Recovery Plan[2].

This recovery strategy - action plan will be updated when any new critical habitat is identified and when the Alberta recovery plan is updated. Reporting on the implementation of the recovery strategy - action plan, and the progress towards meeting its objectives will occur within five years after it is included in the public registry and in every subsequent five-year period, until its objectives have been achieved or the species' recovery is no longer feasible.

1. Residence of the Westslope Cutthroat Trout

1.1 Location of the species' residence

SARA states that "No person shall damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada." [s.33]

Also, SARA defines "residence" as: "a dwelling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating".

The following (the residence statement) is a description of the residence for Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations).

1.2 Structure, form and investment

In Alberta, Westslope Cutthroat Trout generally spawn in small gravel-bottomed streams where the female prepares a redd in the gravel by thrashing her tail to displace gravel until a depression about 30 cm wide and 12 cm deep is dug. Eggs are deposited into the redd and a male fertilizes the eggs. The redd containing the eggs is covered

[2] The Government of Alberta is working to update the provincial recovery plan to reflect a new state of knowledge and management intent. The new provincial recovery plan will be adopted and will replace the 2012-2017 plan once it is finalized.

with gravel by the female dislodging gravels just upstream of the redd (Scott and Crossman 1973; Nelson and Paetz 1992).

Redds created and used by Westslope Cutthroat Trout for spawning demonstrate there is significant investment in the creation and to some extent, in the protection of the residence (filling with gravel) by Westslope Cutthroat Trout. Thus, a redd is considered to be the residence of this fish. The residence is limited to the redd itself and the spawning and incubation time period during which eggs and alevins are present in the redd structure.

Genetically pure populations of Westslope Cutthroat Trout inhabit only a small portion of the original Westslope Cutthroat Trout distribution. Residence for this species only occurs within the population of genetically pure Westslope Cutthroat Trout and is restricted to areas designated as critical habitat.

1.3 Occupancy and life-cycle function

Spawning takes place between May and July depending on location, and usually occurs when water temperatures reach 10˚C (Nelson and Paetz 1992) (6˚C in high elevation populations; S. Humphries pers. comm.). Incubation is also temperature dependent and generally lasts six to seven weeks. Once the eggs hatch, alevins will remain in the redd for another one to two weeks (Nelson and Paetz 1992; Scott and Crossman 1973). Following emergence, fry migrate to low energy habitats, with low water velocity and appropriate cover.

2. Population and distribution objectives

The population and distribution objectives for this recovery strategy - action plan are to:

Protect and maintain the existing distribution of ≥ 0.99 genetically pure populations of Westslope Cutthroat Trout, and re-establish genetically pure populations to self-sustaining levels, within the species' original distribution in the Saskatchewan – Nelson rivers watershed in Alberta.

A number of objectives are proposed to meet the population and distribution objectives and address threats to the survival of the species. The recovery objectives are as follows:

- Identify and protect critical habitat for remaining genetically pure populations
- Improve knowledge of populations genetics[3], size, distribution, and trends
- Identify opportunities to help recover genetically pure and near genetically pure strains of Westslope Cutthroat Trout, partly by restoring habitat and eliminating or suppressing populations of non-native fish that are having negative impacts on Westslope Cutthroat Trout

[3] Including adopting novel analyses and tools as they become available and appropriate.

- Increase education and awareness of Westslope Cutthroat Trout for their conservation
- Re-establish genetically pure populations of Westslope Cutthroat Trout at sites within their historical range that recognize the diversity of their life history strategies in Alberta

3. Broad strategies and recovery actions

Strategies proposed to address the identified threats, and to guide appropriate research and management activities to meet the recovery goal and objectives, are discussed in Section 7 of the recovery plan, under the broader approaches of:

- Research
- Monitoring
- Management and regulation
- Education and outreach

Each strategy and/or approach is designed to assess, mitigate, or eliminate specific threats to the species; to address information deficiencies that might otherwise inhibit species recovery; or to contribute to the species' recovery in general.

Whirling disease has been detected in a number of waterbodies in four major watersheds in central and southern Alberta, including watersheds occupied by Westslope Cutthroat Trout. The potential effect that whirling disease is having, or may have, on Westslope Cutthroat Trout populations in Alberta is an important factor to consider in the cumulative effects facing this species. See Part 2, Section 3.2.1.2 for more information related to whirling disease.

3.1 Strategic direction for recovery and implementation schedule

Success in the recovery of this species is dependent on the actions of many different jurisdictions; it requires the commitment and cooperation of the constituencies that will be involved in implementing the directions and measures set out in this recovery strategy - action plan.

This recovery strategy - action plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for Westslope Cutthroat Trout, including measures to be taken to address threats to the species and monitor its recovery, to guide not only activities to be undertaken by Fisheries and Oceans Canada (DFO) but those for which other jurisdictions, organizations and individuals have a role to play. As new information becomes available, these measures and the priority of these measures may change. DFO strongly encourages all Canadians to participate in the conservation of the Westslope Cutthroat Trout through undertaking measures outlined in this action plan. DFO recognizes the important role of the partners and stakeholders for the Westslope Cutthroat Trout and its member organizations and agencies in the implementation of measures for this species.

The Multi-species Action Plan for Banff National Park of Canada; and,the Multi-species Action Plan for Waterton Lakes National Park of Canada and Bar U Ranch National Historic Site of Canada identify the recovery measures for Westslope Cutthroat Trout that will be implemented and reported on in these protected heritage places.

The recovery measures described in Table 1 are the priority measures that will be undertaken by DFO and its partners to protect and restore populations of Westslope Cutthroat Trout in Alberta. These recovery measures are based on actions described in the Alberta recovery plan, but have been modified from the original text to reflect current recovery priorities. Implementation of the recovery measures is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Section 8 of the Alberta Recovery Plan, presents the actions, determined by the 2013 Alberta Westslope Cutthroat Trout Recovery Team that could be taken to achieve the recovery goals and objectives for the species. Actions identified in this section are not considered commitments in this recovery strategy and action plan, but may be implemented or modified as considered necessary during implementation of measures by DFO and its partners. The implementation schedule (Section 9 of the Alberta Recovery Plan) prioritizes the actions; links them to objectives; and, identifies a lead agency for each action. Note that the Alberta Recovery Plan identified a timeframe for the recovery actions. The timeframe listed in the implementation table in Section 9 is provided to demonstrate costs associated with the action and does not indicate the conclusion of the recovery action. Many of the recovery actions will be ongoing throughout the recovery of the species.

Table 1. Measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners

#	Recovery measures[4]	Threats or objective addressed	Timeline (short, or long term)[5]	Partners[6]
Broad strategy: research				
Approach: improve knowledge of population genetics				
1	Using standardized sampling techniques and genetic analysis, conduct surveys to characterize the genetic structure and status of priority[7] Westslope Cutthroat Trout populations in the species' original distribution. Consideration should be applied to areas with no or incomplete information to determine whether additional populations of Westslope Cutthroat Trout exist within their original distribution.	Recovery objective 1: identify and protect critical habitat for remaining genetically pure populations Recovery objective: 2. Improve knowledge of	Long term	**Alberta Environment and Parks (AEP)** DFO

[4] See Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017, Section 8 (Action Plan) and Section 9 (Implementation Schedule) for a complete list and description of all recovery measures.
[5] Timeline: Long-term activities are likely ongoing throughout recovery of the species. Short-term indicates that activity can be completed in a short period of time.
[6] Lead partner is bolded and listed first.
[7] Priority populations are those populations identified for protection and/or recovery.

#	Recovery measures[4]	Threats or objective addressed	Timeline (short, or long term)[5]	Partners[6]
		population genetics		
Approach: conduct feasibility studies of recovering populations within recovery areas (Figure 1)				
2	Classify and prioritize existing stream and lake populations according to status of threats and determine where populations can be restored, improved or re-established. Determine how threat elimination and mitigation might contribute to an increase in genetically pure populations that are sustainable and resilient. Where appropriate, examine the feasibility of enhancing existing populations by stocking. Decisions to stock will be strongly informed by up to date genetic information. The delivery and success of potential restocking efforts, considering genetic diversity, should take into account: a. Classification and prioritization of populations, b. identify habitat/populations conducive to restocking, c. prioritize target populations for enhancement through restocking, d. identify source populations for stocking (considering integrity of genetic diversity within the distribution range;	Recovery objective: 3. Identify opportunities to help recover genetically pure and near-genetically pure strains of Westslope Cutthroat Trout, In part, by restoring habitat and by eliminating or suppressing populations of non-native fish that are having negative impacts on Westslope Cutthroat Trout. Threats: invasive species, adverse effects on habitat, consumptive use/exploitation, stocking, pollution, and climate change	Short term	**AEP** DFO
Broad strategy: monitoring				
Approach: population monitoring				
3	Conduct ongoing spatial and temporal population monitoring on priority populations. Monitoring should include population estimates, relative abundance, distribution, population structure (e.g., size-frequency distribution, life history stage), genetic status, as well as abundance and distribution of non-native species. Frequency will depend on the priority of the population and whether monitoring is related to a restoration or mitigation project.	Recovery objective: 2. Improve knowledge of population genetics, size, distribution, and trends	Long term	**AEP** DFO
Broad strategy: management and regulation				

#	Recovery measures[4]	Threats or objective addressed	Timeline (short, or long term)[5]	Partners[6]
Approach: limit the spread of non-native species				
4	Prepare a priority list of waterbodies where suppression or removal of non-native species or a genetic recovery may be feasible. Based on this list, conduct pilot projects on candidate waterbodies and evaluate effectiveness before proceeding with additional projects. A review of existing literature and consultations with other jurisdictions (i.e. Parks Canada) on similar projects should be completed when designing methods.	Recovery objective: 3. Identify opportunities to help recover genetically pure and near-genetically pure Westslope Cutthroat Trout Threats: invasive species, climate change	Short term (for the priority list) long term (to implement pilot studies and evaluate effectiveness)	**AEP** DFO
Approach: restore populations within the recovery areas				
5	Restore and recover priority populations, where feasible, to expand genetically pure populations and re-establish populations in candidate areas within the recovery areas, by protecting and/or restoring habitat, managing harvest, reducing hybridization and eliminating or suppressing populations of non-native fish that are having negative impacts on Westslope Cutthroat Trout.	Recovery objective: 3. Identify opportunities to help recover genetically pure and near-genetically pure Westslope Cutthroat Trout Recovery objective: 5. Re-establish genetically pure populations of Westslope Cutthroat Trout at sites within their historical range that recognize the diversity of their life history strategies in Alberta	Long term	**AEP** DFO ENGOs

#	Recovery measures[4]	Threats or objective addressed	Timeline (short, or long term)[5]	Partners[6]
6	Develop recovery implementation group(s) made up of Government of Canada and Government of Alberta staff, stakeholders, and Indigenous communities to assist in the development and implementation of watershed restoration projects. Considerations for participation in the implementation group would include the degree that a group is directly affected by the issues being addressed, has resources and/or capacity to assist in implementation, or has a regulatory mandate. To the extent possible, implementation should be integrated with other native trout recovery activities and be coordinated with other watershed conservation activities.	Recovery objective: 3. Identify opportunities to help recover genetically pure and near-genetically pure Westslope Cutthroat Trout. Recovery objective: 5. Re-establish genetically pure populations of Westslope Cutthroat Trout at sites within their historical range that recognize the diversity of their life history strategies in Alberta	Short term (to develop groups) long term (to implement)	**DFO** Government of Alberta, stakeholder, Indigenous groups
Approach: manage and reduce footprint of human activities				
7	Increase prominence of native fish conservation in recreation planning and land-use management. Apply cumulative effects considerations to manage effects of resource extraction, land and water use. Complete an assessment of current rule applications, implementation, and compliance, and if there are gaps or areas for improvement, development and implementation of options to address them.	Recovery objective: 4. Increase education and awareness of Westslope Cutthroat Trout for their conservation Recovery objective: 5. Re-establish genetically pure populations of Westslope Cutthroat Trout at sites within their historical range that recognize the diversity of their life history	Short term (planning) long term (to implement	**AEP** DFO

#	Recovery measures[4]	Threats or objective addressed	Timeline (short, or long term)[5]	Partners[6]
		strategies in Alberta Threats: invasive species, adverse effects on habitat, consumptive use/exploitation, stocking		
Broad strategy: education and outreach				
Approach: improve awareness of the species				
8	Identify target audiences (e.g., land owners, anglers, industry, contractors, general public) and determine how each may contribute to action plan activities and why protecting/recovering genetically pure populations of Westslope Cutthroat Trout is important (explain genetic tools, principles and why this matters). Based on this information, define key messages and outreach options (e.g. targeted social media, community meetings, signage, fact sheets, popular articles, podcasts, digital stories, information specific items in sport fishing regulations, GPS features, Bow Habitat Station) to target each group.	Recovery objective: 4. Increase education and awareness of Westslope Cutthroat Trout for their conservation Threats: invasive species, adverse effects on habitat, consumptive use/exploitation, stocking	Short term to develop outreach, long term to implement	**AEP** DFO ENGOs
9	Evaluate awareness efforts to determine success of outreach programs and materials and use adaptive management to develop alternative outreach products if deemed necessary.	Recovery objective: 4. Increase education and awareness of Westslope Cutthroat Trout for their conservation	Short- term	**AEP** DFO ENGOs

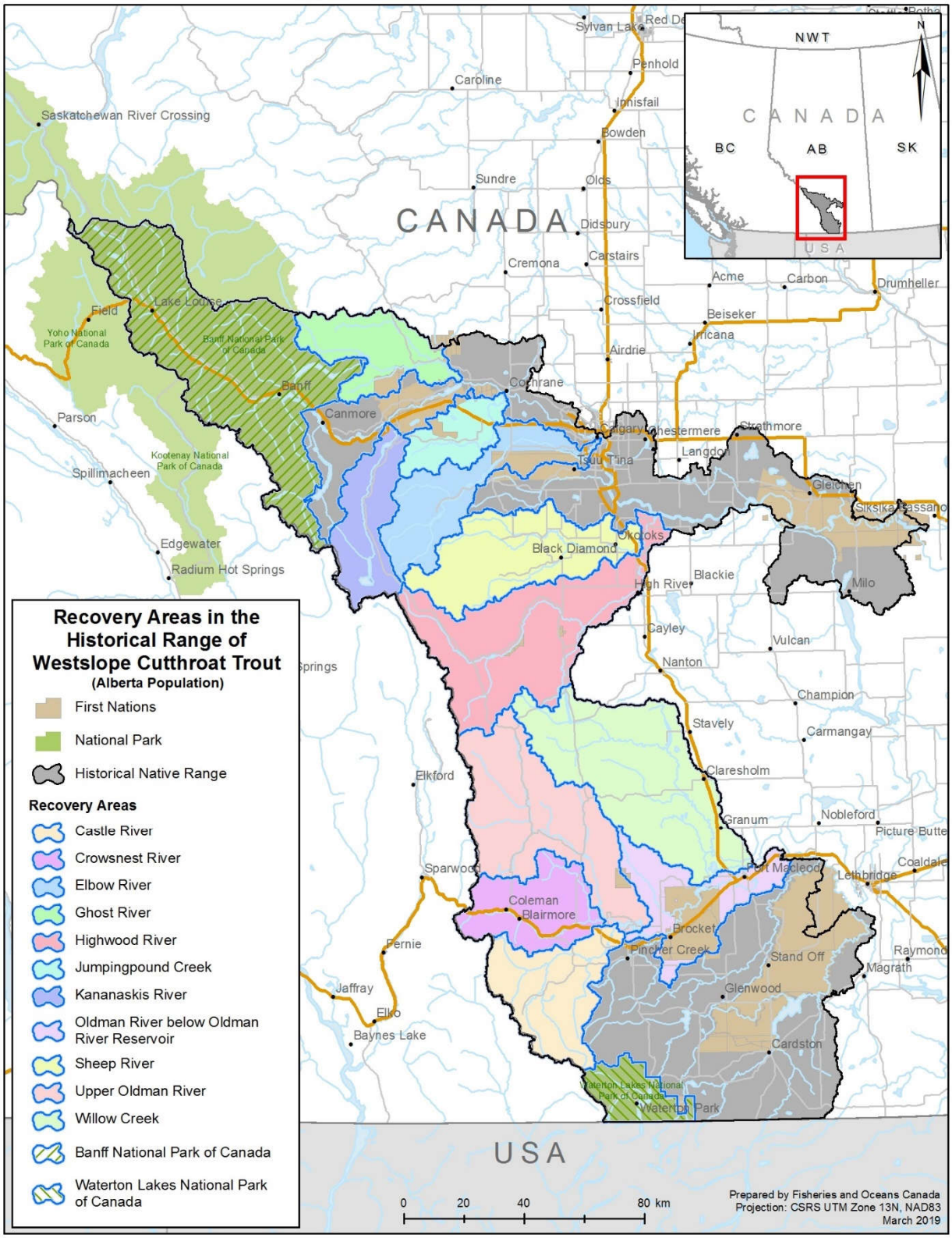

Figure 1. Recovery areas in which stream and lake populations will be prioritized according to status of threats to determine where populations can be restored, improved or re-established.

3.2 Actions already completed or underway

Refined genetic diagnostic methods of measuring hybridization and genetic diversity of Westslope Cutthroat Trout have improved the accuracy and precision of estimates of hybridization with non-native trout throughout the entire range of Westslope Cutthroat Trout. The Westslope Cutthroat Trout Genetic Delineation Project was completed which categorizes all mapped watercourses in the species range in Alberta from the headwaters (excluding national parks) downstream to the historical extent of the species on the Bow and Oldman Rivers near Calgary and Lethbridge respectively, based on known genetic status of Westslope Cutthroat Trout, where possible, and Westslope Cutthroat Trout presence/absence where no genetic results are currently available.

Recovery of existing Westslope Cutthroat Trout populations within their historical range was advanced by the removal of non-native species and/or hybridized Westslope Cutthroat Trout from Sawback Creek, Rainbow Lake, Cascade Creek, Hidden Lake and upper Corral Creek in Banff National Park. The Agency also implemented Restricted Activity Orders to prohibit water activities in gazetted critical habitat areas. Changes in angling regulations were implemented after a population assessment of Westslope Cutthroat Trout in Picklejar Lakes. A Fish Sustainability Index, Fisheries Management Objectives, and Recreational Fisheries Management Objectives for waterbodies that contain Westslope Cutthroat Trout are being developed. Riparian inventories have been completed in select areas within the historical distribution of Westslope Cutthroat Trout. Improvements have been made to riparian and instream habitat conditions by installation of OHV bridges, stream crossing modifications, weed and erosion management, and off-site livestock water site areas.

From 2015 to present, watershed-scale population assessments have been conducted by AEP and partners (including Alberta Conservation Association (ACA)) on select areas in the Bow and Oldman River watersheds. Monitoring studies included fish composition and abundance changes in Quirk Creek, after the removal of Brook Trout, in hopes of restoring native Westslope Cutthroat and Bull Trout; using new monitoring methods that more accurately assesses the population of Westslope Cutthroat Trout in Sawback Lake; and gauging Westslope Cutthroat Trout population responses to land management alterations in the Upper Oldman River.

Efforts to limit the spread of invasive and non-native aquatic species are improving through government regulations such as the Federal Invasive Species Regulation, amendments of the *Fisheries Act* of Alberta, and changes to angling regulations in Waterton National Park. There was an Alberta Invasive Species (AIS) campaign delivered by Alberta to discourage AIS introductions. Parks Canada Agency successfully implemented its decontamination protocol in all of its Rocky Mountain national parks as well as enforced boating restrictions and mandatory self-inspection of personal watercraft to limit the spread of AIS. In combating whirling disease, Parks Canada Agency has conducted studies on its distribution, and the genetic identification of the parasite’s secondary host in Banff National Park. The Agency also closed all

Westslope Cutthroat Trout critical habitat areas to the public, banned felt bottom wading boots, enforced zero possession of all sport fish in Banff National Park of Canada, Yoho National Park of Canada and Kootenay National Park of Canada, and removed diseased fish in Johnson Lake, and Little Herbert Lake in 2019.
Activities to foster Westslope Cutthroat Trout awareness include making information factsheets available to the public, and posting signage near waterways to target off-highway vehicle users, and along streams designated as critical habitat.

4. Critical habitat

4.1 Identification of the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) critical habitat

4.1.1 General description of the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) critical habitat

Critical habitat is defined in SARA as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in in the recovery strategy or in an action plan" as per s. 2(1) of SARA.

Also, SARA defines habitat for aquatic species as "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [s. 2(1)]

For the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations), critical habitat is identified to the extent possible, using the best available information, and provides the features and attributes necessary to support the species' life-cycle processes. This recovery strategy - action plan identifies critical habitat for Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations), as all areas currently occupied by naturally-occurring genetically pure populations within the original Westslope Cutthroat Trout distribution, including the areas on which Westslope Cutthroat Trout depend indirectly (e.g. riparian areas) in order to carry out their life processes and areas where genetically pure populations of the species formerly occurred and has the potential to be reintroduced. See Appendix D for maps and lists of waterbodies that have been identified as critical habitat (Figures 3-18, Tables 5-8). The areas currently identified as critical habitat in this plan is insufficient to fully achieve the population and distribution objectives. As information is collected and analyzed, any new critical habitat will be added in order to fully achieve the population and distribution objectives.

The schedule of studies (Table 3) outlines what is required to identify additional critical habitat necessary to achieve the species' population and distribution objectives.

4.1.2 Information and methods used to identify critical habitat

Defining instream critical habitat

Genetic analysis and recovery feasibility were considered in the identification of critical habitat. Microsatellite and single nucleotide polymorphisms (SNP) were used to assess hybridization in Alberta's Westslope Cutthroat Trout populations. Outside of National Parks, DFO utilized data from AEP's Genetic Delineation Product to inform the identification of critical habitat. The Parks Canada Agency used a similar approach to identify critical habitat within Banff National Park. All stream segments where Westslope Cutthroat Trout were determined to possess a genetic admixture proportion (or purity) across the population of ≥ 0.99 were considered a genetically pure population and therefore were included in the critical habitat designation, as well as areas upstream, as shown in Figures 3-18, that provide indirect habitat to the genetically pure populations. In addition, areas with near- genetically pure categories, based on high sample size SNP analysis, that are known to be connected to genetically pure populations, were included as critical habitat, as areas where the (genetically pure) species formerly occurred and has a high potential for recovery.

Appendix D provides the maps and geographical coordinates that specify the boundaries within which critical habitat for Westslope Cutthroat Trout is found. Note that unnamed tributaries within the stream segments of designated critical habitat are included as critical habitat unless otherwise stated.

Defining riparian critical habitat areas

Critical habitat for Westslope Cutthroat Trout in Alberta, includes riparian cover and in-stream structure, which contributes to aquatic complexity, creation of refugia, stabilizes the bank of waterbodies, reduces predation, maintains colder water temperatures by reducing insolation and provides a significant food source of terrestrial insects (COSEWIC 2016). The identification of riparian critical habitat was informed by DFO 2009 and scientific information related to riparian buffers. Critical habitat includes all riparian areas on both stream banks for the entire length of the stream segments and all banks of waterbodies identified as critical habitat.

The width of the riparian area required to protect the attributes of critical habitat for Westslope Cutthroat Trout has not been quantified, however the riparian area must be sufficient to maintain clean, cold water, sediment and silt free substrates, and provide inputs of food (invertebrates) and woody debris into the aquatic environment. In order to determine the width of the riparian area DFO, PCA, AEP, and Alberta Agriculture and Forestry (AAF) used benchmarks of the terrestrial components that effectively protect key biophysical features that influence water temperature, water flow, sediment, cover and food supply in the waterbody. In the absence of quantitative data specifically identified for Westslope Cutthroat Trout, this seems to be a reasonable approach, until definitive standards are known. The width of the riparian area (Appendix C. Figure 2) within the areas designated as critical habitat are continuous and extend horizontally

from the high water mark to a width of 30 metres on both banks of the waterbody for the entire geospatial area.

Defining excluded areas

Existing anthropogenic structures such as bridges, culverts (regardless of size), roads, pipelines, water intakes, etc., that are within the areas delineated as critical habitat, are excluded and not considered to be critical habitat for the Westslope Cutthroat Trout. Because activities occurring outside of an area identified as critical habitat can destroy critical habitat, activities including installation, maintenance, repair or replacement of any anthropogenic structures, located within critical habitat, must be reviewed by Fisheries and Oceans Canada or the Parks Canada Agency to determine whether a *SARA* permit, *Fisheries Act* and/or other authorizations are required and can be issued. Some existing structures contribute to an anthropogenic barrier and its consequences for Westslope Cutthroat Trout recovery needs to be an important consideration when upgrading and maintaining existing infrastructure.

4.1.3 Identification of critical habitat

Biophysical functions, features and attributes

Table 2 summarizes the best available knowledge of the functions, features and attributes for each life stage of the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations). Note that not all attributes in Table 2 must be present in order for a feature to be identified as critical habitat. If the features as described in Table 2 are present and capable of supporting the associated functions, the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

Table 2. General summary of the biophysical functions, features, attributes and location of critical habitat necessary for survival or recovery of Westslope Cutthroat Trout in Alberta

Life stage (if more than one)	Function[8]	Feature[9]s	Attributes[10]
Spawn through alevins (resident, fluvial, adfluvial)	• spawning • incubation	• riffles (pool or shallow runs and tail outs) • riparian habitat	• clean water • water depth 0.10 – 0.75 m • water velocity 0.25 – 0.8 m/s • sediment/silt free gravel substrate • water temperature 6 – 10 ºC • riparian vegetation
Fry to Parr (to age 1)	• nursery cover • feeding	• riffles • backwaters • riparian habitat	• clean water • water depth 0.05 m - > 1.5 m • water velocity 0.01 – 0.4 m/s • sediment/silt free gravel substrate • water temperature 4 – 15 ºC • invertebrate production • large woody debris, bedrock boulders, riparian vegetation
Juvenile (age 1 to sexual maturity; males age 2 and females age 4)	• over-wintering • cover • feeding • movement (includes migration, feeding, etc.)	• riffles • pools • backwaters • lakes • food availability • riparian habitat	• clean water • water depth 0.05 m - > 1.5 m • water velocity 0.01 – 0.8 m/s • sediment/silt free gravel substrate • water temperature 4 – 15 ºC (0-6 ºC for overwintering) • large woody debris, bedrock boulders, riparian vegetation • invertebrate production • undercut bank • groundwater influx
Adult	• over-wintering • cover • feeding • movement (includes migration, feeding, etc.)	• riffles • runs • pools • lakes • food availability • riparian habitat	• clean water • water depth 0.05 m - > 1.5 m • water velocity 0.01 – >1.0 m/s • sediment/silt free gravel substrate • water temperature 4 – 15 ºC (0-6 ºC for overwintering) • large woody debris, bedrock boulders, riparian vegetation • invertebrate production • undercut bank • barrier free movement to complete life cycle • groundwater influx

[8] Function: A life-cycle process of the listed species taking place in critical habitat (e.g., spawning, nursery, rearing, feeding and migration). The function informs the rationale for its protection. The identification of critical habitat must describe how the functions support a life process necessary for the survival or recovery of species at risk

[9] Feature: Every function is the result of single or multiple features which are the structural components of the Critical Habitat. Features describe how the habitat is critical and they are the essential structural component that provides the requisite functions to meet the species' needs. Features may change over time and are usually comprised of more than one part, or attribute. A change or disruption to the feature or any of its attributes may affect the function and its ability to meet the biological needs of the species.

[10] Attribute: Attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species' life processes. Together, the attributes allow the feature to support the function. In essence, attributes provide the greatest level of information about a feature, the quality of the feature and how the feature is able to support the life-cycle requirements of the species.

Critical habitat geographic information

Critical habitat, for the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations), has been identified in the waterbodies shown in Figures 3-18 (Appendix D).

The critical habitat's functions, features and attributes have been identified using the bounding box approach. This means that critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical feature and function it supports occur, as described in Table 2. Note that this approach differs from the approach described in Part 2, section 4.0, which states that an area of occupancy approach was used to identify critical habitat. Critical habitat identified in Part 1 of this plan is based on the current genetic information and critical habitat identification approaches that have been updated since the provincial recovery plan was developed.

Summary of critical habitat relative to population and distribution objectives

The areas identified as critical habitat are areas that, based on best available information, the Minister of Fisheries and Oceans and the Minister responsible for the Parks Canada Agency, consider necessary to partially achieve the species' population and distribution objectives required for the survival and recovery of the species. Maintaining current reaches of genetically pure westslope cutthroat trout will likely be insufficient to ensure viable populations in the long-term. There is ongoing work to identify potential recovery watersheds and to develop the methodologies, expertise, and stakeholder support needed to expand the distribution of genetically pure WSCT. The goal will be to identify additional critical habitat in future amendments as per work identified in the schedule of studies.

4.2 Schedule of studies to identify critical habitat

Further research is required to identify additional habitat, refine the boundaries of the currently identified critical habitat, and refine knowledge of the biophysical functions, features and attributes of the currently identified critical habitat necessary to support the species' population and distribution objectives and protect the critical habitat from destruction. This additional work includes the following studies:

Table 3. Schedule of studies to refine critical habitat

Description of Study	Rationale	Timeline
Studies to identify and describe life history, movement and habitat use by life-stage (includes quality of habitats)	It is assumed that the habitats containing genetically pure fish also contain all of the necessary habitat types to complete their life-cycle but little work has been completed to map and confirm habitat use by life stage, quality or whether there are sufficient amounts of habitats available to	2019-2023

Description of Study	Rationale	Timeline
	grow populations. Identifying these habitats for further protection will assist in meeting population and distribution objectives and achieving survival and recovery	
Studies to identify suitable habitats and identify areas where genetic recovery of genetically pure Westslope Cutthroat Trout is feasible(outside current areas occupied by genetically pure populations)	The current amount of critical habitat is insufficient for recovery of this species. This work will help identify additional candidate sites for re-establishment of genetically pure fish and add critical habitat where considered necessary.	2019-2023
Studies to determine the width of riparian critical habitat.	Studies to obtain quantitative data specific to Westslope Cutthroat Trout in Alberta and/or the development of guidance materials will refine riparian critical habitat standards.	2019-2023
Studies to better understand the thresholds of tolerance to disturbance from human activities	Knowledge of critical habitat's thresholds of tolerance to disturbance from human activities is lacking and should be improved to inform management and regulatory decision making in regards to critical habitat protection.	2019-2023

4.3 Activities likely to result in the destruction of critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a final recovery strategy or action plan. Critical habitat was identified in the 2014 recovery strategy and is protected by the prohibition in subsection 58(1) of SARA against the destruction of any part of the critical habitat of the Westslope Cutthroat Trout, which was triggered by the Critical Habitat of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta Population Order. This Order will apply to the modifications to the critical habitat identified in this recovery strategy - action plan.

For those areas of critical habitat located within Banff National Park of Canada, a description of the critical habitat that was identified in the 2014 recovery strategy was published in the *Canada Gazette* pursuant to subsection 58(2) of SARA. The subsection 58(1) prohibition against destroying any part of the critical habitat of the species applied ninety days following publication of the description in the Canada Gazette.

The following examples of activities likely to result in the destruction[11] of critical habitat (Table 4) are based on known human activities that are likely to occur in and around critical habitat and would likely result in the destruction of critical habitat if unmitigated.

[11] Destruction occurs when there is a temporary or permanent loss of function of critical habitat at a time when it is required by the species.

The list of activities is neither exhaustive nor exclusive and has been guided by the threats discussion in the Alberta recovery plan. Only those threats resulting in an overall threat significance of high, as described in section 3.0 of the Alberta recovery plan, for the species were considered as activities likely to result in the destruction of critical habitat. The absence of a specific human activity from this table does not preclude or restrict the federal government's ability to regulate it pursuant to the SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition, and does not mean the activity will inevitably result in destruction of critical habitat. Every proposed activity must be assessed on a case-by-case basis and site-specific mitigation will be applied where it is reliable and available. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision making. However, in many cases the knowledge of a species and its critical habitat's thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

Table 4. Activities likely to destroy (ALTD) critical habitat

	Activity	Affect-Pathway	Function Affected	Feature Affected	Attribute Affected
Changes in Flow	Dam/ reservoir operation	Reduction in available habitats	•spawning •nursery •overwintering •movement (includes migration, feeding, etc.) •cover	•riffles •pools •runs •backwaters •riparian habitat	•water velocity •sediment/silt-free substrates •water depth •water temperature •woody debris, bedrock, boulders, riparian vegetation •invertebrate production •undercut banks •groundwater influx
	Mechanical forest removal and loss due to high intensity-fire	Reduction in available habitats	•spawning •nursery •overwintering •feeding •cover	•riffles •pools •runs •backwaters •riparian habitat	•water velocity •sediment/silt-free substrates •water depth •water temperature •woody debris, bedrock, boulders, riparian vegetation •invertebrate production •undercut banks •groundwater influx
	Water extraction	Reduction in available habitats	•spawning •nursery •overwintering •feeding •cover	•riffles •pools •runs •backwaters •riparian habitat	•water velocity •sediment/silt-free substrates •water depth •water temperature •woody debris, bedrock, boulders, riparian vegetation •invertebrate production •undercut banks groundwater influx

	Activity	Affect-Pathway	Function Affected	Feature Affected	Attribute Affected
Sedimentation	Forest removal, linear disturbance (road or trail construction and maintenance or lack of maintenance etc.), urbanization, mining, grazing, high intensity or frequent off-highway vehicle use, recreational access, instream construction	Reduction in available habitats	•spawning •nursery •overwintering •feeding •cover	•riffles •pools •runs •backwaters •food availability •riparian habitat	• sediment/silt-free substrates •water depths •water temperature •invertebrate production •undercut banks •riparian vegetation •groundwater influx
Habitat loss, fragmentation and or alteration	Dam or reservoir creation	Large scale change from riverine to reservoir habitat	• spawning • nursery • overwintering • feeding • cover	• riffles • pools • runs • backwaters • food availability • riparian habitat	• water velocity • sediment/silt-free substrates • water depth • water temperature • woody debris, bedrock, boulders, riparian vegetation • invertebrate production • undercut banks • groundwater influx
	Dams (include weirs) or culvert structures	Loss of access to habitats	• movement	• movement routes in	• barrier-free movement to complete life cycle

	Activity	Affect-Pathway	Function Affected	Feature Affected	Attribute Affected
				water-bodies	
	Linear disturbance (construction and maintenance or lack of maintenance of roads, pipelines, railway, mining, recreational trails)	Reduction in available habitats	• spawning • nursery • overwintering • feeding • cover	• riffles • pools • runs • backwaters • food availability • movement	• sediment/silt-free substrates • water temperature • large woody debris, bedrock, boulders, riparian vegetation • invertebrate production • undercut banks • groundwater influx

5. Evaluation of socio-economic costs and of benefits

The *SARA* requires that an action plan include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1)(e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. Its intent is to inform the public and to guide decision making on implementation of the action plan by partners. Activities which have already been completed or are ongoing related to conservation and recovery of Westslope Cutthroat Trout are discussed in Section 3.2 of this recovery strategy - action plan. This evaluation does not address past recovery efforts as they are not considered incremental costs.

The protection and recovery of species at risk can result in both benefits and costs. The Act recognizes that “wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons” (SARA 2003). Self-sustaining and healthy ecosystems with their various elements in place, including species at risk, contribute positively to the livelihoods and the quality of life of all Canadians. A review of the literature confirms that Canadians value the preservation and conservation of species in and of themselves. Actions taken to preserve a species, such as habitat protection and restoration, are also valued. In addition, the more an action contributes to the recovery of a species, the higher the value the public places on such actions (Loomis and White, 1996; Fisheries and Oceans Canada, 2008). Furthermore, the conservation of species at risk is an important component of the Government of Canada’s commitment to conserving biological diversity under the International Convention on Biological Diversity. The Government of Canada has also made a commitment to protect and recover species at risk through the Accord for the Protection of Species at Risk. The specific costs and benefits associated with this action plan are described below.

This evaluation does not address the socio-economic impacts of protecting critical habitat for the Westslope Cutthroat Trout. For those areas of critical habitat located within national parks, a description of the critical habitat was published in the Canada Gazette pursuant to subsection 58(2) and for all other locations, the critical habitat of this species is protected by the Critical Habitat of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta Population Order. An analysis of the potential incremental impacts of the Order was completed as part of the Regulatory Impact Analysis Statement for this Order. As a consequence, no additional analysis of the critical habitat protection has been undertaken. The Multi-species Action Plan for Banff National Park of Canada and the Multi-species Action Plan for Waterton Lakes National Park of Canada and Bar U Ranch National Historic Site of Canada both include an evaluation of the socio-economic costs of the action plans and the benefits to be

derived from their implementation, including considerations for Westslope Cutthroat Trout.

5.1 Policy baseline

Existing federal regulatory mechanisms that apply to the habitat of the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) include the *Species at Risk Act* , the *Fisheries Act* , the *National Energy Board Act* , the *Canada National Parks Act* and the *Canadian Environmental Assessment Act, 2012* . Existing provincial regulatory mechanisms that apply to the habitat of the Westslope Cutthroat Trout Alberta population (also known as Saskatchewan-Nelson River populations) include Alberta's *Environmental Protection and Enhancement Act* and *Water Act* .

5.2 Socio-economic profile

The lead agencies for the actions identified in this plan are Alberta Environment and Parks, and Fisheries and Oceans Canada. Partners for specific actions could also include project proponents, environmental non-governmental organizations and industry.

5.3 Socio-economic costs of implementing the recovery actions

The recovery measures in this plan are grouped under four broad approaches: research, monitoring, management and regulation actions, and education and outreach. Costs would be incurred by the lead agencies to implement the measures listed in the recovery strategy - action plan, and by partners who participate in the recovery measures. Some measures are ongoing, whereas others occur once or twice. The present value of the costs of implementing the recovery measures in this plan are anticipated to be less than $370K[12] over a 5 year period. Implementation of the actions is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

The Alberta recovery plan[13] identifies other potential costs that could result from similar actions:

"It is likely that these actions will result in some modifications to land use practices and possibly restrictions on some human activities. It is anticipated that some restrictions will result in higher costs to industry. These may be associated (for example) with increased planning costs and the inability to utilize resources in some instances. Restrictions on human activities may also result from limited access to some types of recreational

[12] The present value of the total incremental costs of the action plan was estimated with a discount rate of 7% over the five year period.
[13] The Government of Alberta is working to update the provincial recovery plan to reflect a new state of knowledge and management intent. The new provincial recovery plan will be adopted and will replace the 2012-2017 plan once it is finalized.

activities such as off-trail motorized recreation" (The Alberta Westslope Cutthroat Recovery Team 2013).

5.4 Benefits of implementing the recovery actions

Recovery measures in this plan contribute to protecting and maintaining existing ≥ 0.99 genetically pure populations at self-sustaining levels and re-establishing additional genetically pure populations to self-sustaining levels, within the species' original distribution in Alberta.

Some non-market benefits could be experienced by the Canadian public as a result of recovery actions related to habitat restoration contained in the action plan. Previous research (Hailu *et al.* 2000) found that Alberta households had positive and significant willingness to pay values for environmental programs aimed at preserving mountain stream ecosystems identified as trout habitat. In addition to these non-market benefits, the recovery measures may provide further benefits. The Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017 identifies benefits associated with recreational angling for this species:

"The trout angling community is economically valuable and this activity is sustainable if properly managed. Angling for true native trout has a premium value to many anglers (Smith 1984; Trotter 1987)."

Research activities that contribute to the knowledge of the species and its habitat could assist in protecting and recovering the species and would also contribute to the body of knowledge on all species in the ecosystem. Increased knowledge of the species and its habitat – particularly studies which refine critical habitat identification – could be used to further identify and legally protect critical habitat. Research outcomes could contribute to recovery if that knowledge is applied in future decision making and actions.

Public education and outreach would develop interest in species at risk and may lead to increased public participation in recovery measures.

5.5 Distributional impacts

Federal and provincial governments will incur the majority of costs of implementing the recovery strategy - action plan. Partners who choose to participate in recovery measures will also incur costs. Industry may experience higher costs as a result of some restrictions; for example, there may be increased planning costs and the inability to utilize resources in some instances. Canadians may experience some costs from limited access to some types of recreational activities.

The Canadian public will benefit from the implementation of the recovery strategy - action plan through the protection and maintenance of Westslope Cutthroat Trout populations and through the protection and restoration of the ecosystem.

6. Measuring progress

The competent ministers must report on the implementation of the recovery strategy-action plan, and the progress towards meeting its objectives, within five years after it is included in the public registry and in every subsequent five-year period, until its objectives have been achieved or the species' recovery is no longer feasible [SARA, S. 46]. Reporting on the ecological and socio-economic impacts of the recovery strategy - action plan (under S. 55 of SARA) will be done by assessing the results of monitoring the recovery of the species and its long term viability, and by assessing the implementation of the recovery strategy - action plan.

7. Activities permitted by the recovery strategy-action plan

Subsection 83(4) of SARA provides that "Subsections 32(1) and (2), section 33 and subsections 36(1), 58(1), 60(1) and 61(1) do not apply to a person who is engaging in activities that are permitted by a recovery strategy, an action plan or a management plan and who is also authorized under an Act of Parliament to engage in that activity, including a regulation made under section 53, 59 or 71."

The COSEWIC status assessment for Alberta Westslope Cutthroat Trout only considered genetically pure populations within its original distribution in Alberta; therefore, the SARA prohibitions relating to individuals only apply to genetically pure populations within the original Westslope Cutthroat Trout distribution. Angling does not need to be authorized for Westslope Cutthroat Trout that are stocked by the Province of Alberta for the purposes of angling, as they are not considered part of the listed population.

As described in the COSEWIC assessment and status report (2016), the primary causes of Westslope Cutthroat Trout decline are understood (hybridization, habitat loss, exploitation) and ongoing. The Alberta recovery plan provides additional detail on threats to the survival and recovery of Westslope Cutthroat Trout including invasive species (hybridization, loss of Westslope Cutthroat Trout genetic material with Rainbow Trout and other cutthroat trout species and competition with other species such as Brook Trout), adverse effects on habitat, stocking, pollution, climate change and consumptive use/exploitation.

The management of Westslope Cutthroat Trout sport fishing activities considers the origin of the population (i.e., whether it is native to a water body or stocked for sport fishing purposes), the population trends (i.e., whether it is self-sustaining) and genetic purity. Knowledge of the impacts of recreational fisheries on populations from field research, published literature (Sullivan 2007; Cleator *et al.* 2009) as well as the expert opinion of resource managers are also considered. Westslope Cutthroat Trout harvest regulations have changed from a legal harvest throughout portions of the eastern slopes, to a zero harvest (catch-and-release) regulation from 2009 to 2016 . It is recognized however, that incidental mortality from catch and release angling may be a threat to survival and recovery of populations in some watersheds (COSEWIC 2016), as

mortality can occur from the stress of being angled, and physical damage to the fish from hooking or improper handling. In addition, the level of illegal harvest, as a result of misidentification or intentional harvest, is unknown but must be also be considered. Mortality from catch-and-release angling may be a threat to the successful recovery of Westslope Cutthroat Trout populations in areas with high angling effort. Numerous streams are not easily accessible, are very small, densely treed and most have a limited angling season (2-3 months), therefore decreasing angling opportunity and effort. In addition, many individual Westslope Cutthroat Trout within these populations do not grow to a very large size (less than 30 cm) which also makes them less attractive to anglers. A cumulative effects assessment approach is being employed by AEP to identify specific threats by watershed, which will include angling and other threats such as hybridization, competition with non-native species or degradation of habitat quality. Both mortality from catch-and-release fishing and the results of cumulative effects modelling are considered in the development and implementation of fishing regulations, therefore the exemption to the SARA prohibitions will not jeopardize survival or recovery of Westslope Cutthroat Trout in Alberta.

The following activities, authorized under the *Alberta Fishery Regulations, 1998*, SOR/98-246 and the *National Parks of Canada Fishing Regulations*, C.R.C., c.1120 are permitted by this recovery strategy - action plan:

Catch-and-release angling

In considering whether to permit catch-and-release angling throughout the range of Alberta Westslope Cutthroat Trout, options for the management of the fisheries included complete closures of angling as well as partial closures or specific stream closures depending on what impacts were thought to be occurring as a result of angling pressure. It was determined that complete closures of recreational fisheries in these areas was unnecessary; however, some stream closures and angling restrictions are already in place and will continue to be evaluated to ensure recovery can occur for genetically pure populations of Westslope Cutthroat Trout. The catch-and-release fishery will continue to be monitored to ensure the survival and recovery of Alberta Westslope Cutthroat Trout.

Authorization for Catch-and-release angling

In accordance with subsection 83(4) of SARA, this recovery strategy - action plan authorizes catch-and-release angling of Westslope Cutthroat Trout in all areas of Alberta. This includes areas managed by the Province of Alberta and those managed by Parks Canada Agency.

This exemption is subject to the following conditions:

(a) in areas outside of national parks, angling is carried out:

(i) in accordance with the *Alberta Fishery Regulations, 1998*, SOR/98-246,

(ii) in accordance with a licence issued to an Indian under the authority of s.13(3) of the *Alberta Fishery Regulations, 1998*, SOR/98-246 to engage in fishing solely for the purpose of catching fish for food for their personal use or for the use of their immediate family, or

(iii) by an Indian engaged in sportfishing under s.13(2) of the *Alberta Fishery Regulations, 1998*, SOR/98-246;

(b) for areas in national parks, angling is carried out in accordance with a license issued under the *National Parks of Canada Fishing Regulations*, C.R.C., c.1120; and

(c) Individuals of Westslope Cutthroat Trout captured within critical habitat shall be released without delay to the waters from which they were caught in a manner that causes the least harm to the fish.

The competent ministers will monitor the activities authorized by this recovery strategy-action plan. Exemptions under s. 83(4) may be discontinued or altered if and when the competent ministers discover that any activity may be jeopardizing survival or recovery of this species.

For activities not listed above that are likely to interact with Westslope Cutthroat Trout (Saskatchewan-Nelson Rivers populations) in a manner prohibited by SARA, section 73 and section 74 permits may be sought by contacting the Parks Canada Agency for activities proposed within national parks and the regional DFO office for all other activities. Note that sport fishing licenses issued under the *Alberta Fishery Regulations* or the *National Parks of Canada Fishing Regulations* cannot be used to conduct activities such as scientific sampling for Westslope Cutthroat Trout. A SARA, section 73 permit must be obtained prior to these activities being conducted.

8. References

Alberta Government. 2013. Alberta Energy Regulator, Integrated Standards and Guidelines, Enhanced Approval Process. x+94 p.

Alberta Environment and Parks. 2018. Livingstone-Porcupine Hills Land Footprint Management Plan. Government of Alberta. ISBN No. 978-1-4601-3965-3.

Alberta Environment and Parks. 2018. Livingstone-Porcupine Hills Recreation Management Plan. Government of Alberta. ISBN No. 978-1-4601-3967-7.

Cleator, H., J. E. Earle, L. Fitch, S. Humphries, M. Koops, K.E. Martin, D. Mayhood, S Petry, C. J. Pacas, J. D. Stelfox, and D. Wig. 2009. Information relevant to a recovery potential assessment of pure native Westslope Cutthroat Trout, Alberta population. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Research Document 2009036, iv+24 p.

COSEWIC. 2016. COSEWIC assessment and status report on Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*., Saskatchewan-Nelson populations and Pacific populations, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi+83 pp.

DFO. 2009. Recovery potential assessment of pure native Westslope Cutthroat Trout, Alberta population. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/050.

Fisheries and Oceans Canada, Policy and Economics Branch (Quebec Region), 2008. Estimation of the Economic Benefits of Marine Mammal Recovery in the St. Lawrence Estuary.

Hailu, A., W.L. Adamowicz, and P.C. Boxall. 2000. Complements, Substitutes, Budget Constraints and Valuation: Application of a Multi-Program Environmental Valuation Method. Environmental and Resource Economics 16:51-68

Loomis, J.B., White D.S., 1996. Economic Benefits of Rare and Endangered Species: Summary and Meta-analysis. Ecological Economics.

Nelson, J. S. and M. J. Paetz. 1992. The fishes of Alberta. Second edition. University of Alberta Press, Edmonton, and University of Calgary Press, Calgary, AB, xxvi + 437 p.

Parks Canada Agency. 2017. Multi-species Action Plan for Banff National Park of Canada. Species at Risk Act Action Plan Series. Parks Canada Agency, Ottawa. iv + 27 pp.

Parks Canada Agency. 2017. Multi-species Action Plan for Waterton Lakes National Park of Canada and Bar U Ranch National Historic Site of Canada. Species at Risk Act Action Plan Series. Parks Canada Agency, Ottawa. iv + 31 pp.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pp.

Smith, R. H. 1984. Native trout of North America. Frank Amato Publications, Portland, OR 97202. 144 p.

Sullivan, M. 2007. Modelling potential effects of angling on recovery of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Alberta. Unpublished report, Fish and Wildlife Division, Alberta Environment and Parks, Edmonton

Trotter, P. C. 1987. Cutthroat: native trout of the west. Colorado Associated University Press, 617 Boulder, CO. 219 p.

Appendix A: effects on the environment and other species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's (FSDS) goals and targets.

This recovery strategy - action plan will contribute to the FSDS goal and key priority (Healthy wildlife populations) that ensures all species have healthy and viable populations. Work under this goal will support progress towards the 2020 Biodiversity Goals and Targets for Canada and the global conservation objectives of the United Nations Convention on Biological Diversity – in particular, by ensuring that needed recovery strategies and management plans are in place and by helping to prevent impacts from invasive alien species. The recovery strategy - action plan will contribute to meeting the short term milestones in the FSDS, specifically that species at risk are exhibiting stabilizing or improved trends since their listing. The four broad strategies, research, monitoring, management and regulatory actions, and education and outreach, proposed to achieve the population and distribution objectives help to fulfill contributing actions in the FSDS, including using legislations and regulations to protect species at risk, using legislations and regulations to control invasive alien species, working with partners to protect species and their habitats and building capacity and promoting education.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy - action plan will clearly benefit the environment by promoting the recovery of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi)*. Other native fish species such as Bull Trout (*Salvelinus confluentus*) and Mountain Whitefish (*Prosopium williamsoni*) will also likely benefit from recovery activities associated with this strategy. The potential for the strategy to inadvertently lead to adverse effects on other species was considered and this strategy will not result in any significant adverse effects to the physical environment. However, recovery efforts have and will continue to result in impacts (mortality) to other non-native fish species such as Rainbow Trout and Brook Trout. Careful consideration will be given to potential effects to other species before implementing any actions should they be proposed (e.g. barrier placement to prevent hybridization).

Appendix B: record of cooperation and consultation

Recovery strategies and action plans are to be prepared in cooperation and consultation with other jurisdictions, organizations, affected parties and others as outlined in SARA section 39. DFO has utilized a recovery team to seek input to the development of the 2014 Recovery Strategy and the initial drafts of the recovery strategy - action plan. Information on participation is included below (note that list below includes team members who participated on the recovery team from 2009 and onward).

Alberta-Canada Westslope Cutthroat Trout Recovery Team

Ashley Gillespie	(Co-chair) Species at Risk Biologist, Fisheries and Oceans Canada
Ed Kulcsar	Forestry Manager, Spray Lake Sawmills
Glenn Isaac	Manager Environment, Health and Safety, TransAlta Corporation
Michael Wagner	Forest Hydrologist, Alberta Agriculture and Forestry
Jennifer Earle	(Co-chair) Fisheries Biologist, Fish and Wildlife Division, AEP
Lesley Peterson	Alberta Biologist, Trout Unlimited Canada
Linda Winkel	(Secretariat), Fisheries Biologist, Fish and Wildlife Division, AEP
Lorne Fitch	Environmental Non-Governmental Organization Coalition
Mark Taylor	Aquatics Ecologist, Banff Field Unit, Parks Canada Agency
Melanie Percy	Senior Park Ecologist, AEP
Mike Bryski	Senior Fisheries Biologist, Fish and Wildlife Division, AEP
Mike Taje	Land Management Specialist, AEP
Rob Staniland	Consultant, Canadian Association of Petroleum Producers
Sean Rogers	Assistant Professor, Department of Biological Sciences, University of Calgary
Shelley Humphries	Aquatics Specialist, Banff, Yoho and Kootenay, Parks Canada Agency

Additional contributors:

Alberta Conservation Association	
Angela Braun	Resource Information Unit, AEP
Brian Meagher	Fisheries Biologist, Fish and Wildlife Division, AEP
Charlie Pacas	Previous recovery team member, Aquatics Specialist, Banff National Park, Parks Canada
Chris Carli	Aquatic Biologist, Banff Field Unit, Parks Canada Agency
Daryl Wig	Previous Fisheries Biologist, Fish and Wildlife Division, AEP
Dave Mayhood	Aquatic Ecologist, of Freshwater Research Ltd
Diane Casimir	Species Conservation Specialist, Parks Canada
Eric Taylor	Department of Zoology, University of British Columbia
Hedin Nelson-Chorny	Aquatic Biologist, Banff Field Unit, Parks Canada Agency
James Guthrie	Previous recovery team member, Senior Environmental Specialist, TransAlta Corporation
Jim Stelfox	Former Fisheries Biologist, Fish and Wildlife Division

Margaret Bradley	Resource Information Unit, AEP
Matthew Coombs	Fisheries Biologist, Fish and Wildlife Division, AEP
Matt Holder	Previous recovery team member, Manager, Environment, TransAlta Corporation
Richard Quinlan	Provincial Species at Risk Specialist, AEP
Shane Petry	Previous co-chair, Fish and Wildlife Division, AEP
Tracey Cove	Previous recovery team member, Lands Division, AEP

The recovery strategy - action plan does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated. In addition, consultation on the proposed recovery strategy - action plan occurred through email/meetings with the Government of Alberta, Spray Lake Sawmills, Trout Unlimited Canada, Environmental Non-Governmental Organization Coalition, and the University of Calgary.

Additional input from Canadianswas received when the proposed recovery strategy – action plan was posted on the Species at Risk Public Registry for a 60-day public comment period. Comments received have informed the final document.

Appendix C: Glossary

High water mark – the usual or average level to which a body of water rises at its highest point and remains for sufficient time as to leave a mark on the land.

Near-genetically pure –the average genetic purity at a sample site is between 0.95 to 0.98.

Genetically pure – the average genetic purity of a sample site is ≥ 0.99.

Width of the Riparian Vegetation Area: Riparian vegetation areas are continuous and extend horizontally from the high water mark to a width of 30 metres. Riparian vegetation areas provide large woody debris supply for fish habitat and maintenance of channel morphology, localized bank stability, channel movement, shade and insect and debris fall.

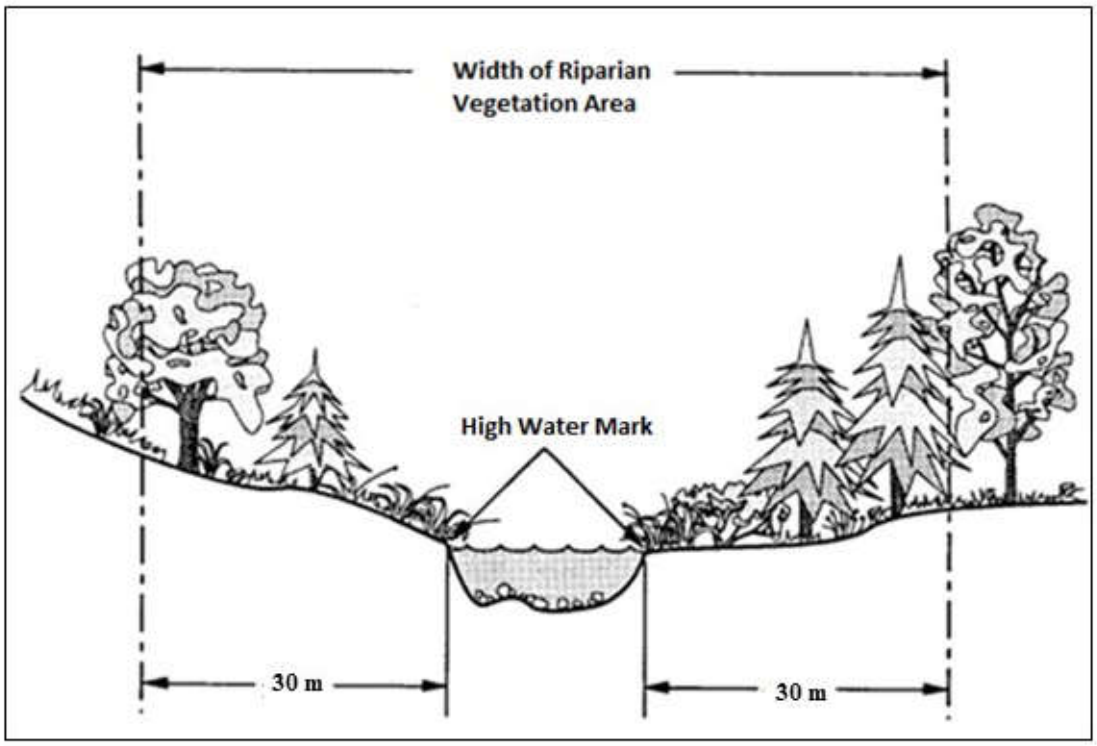

Figure 2. Width of the riparian vegetation area

Appendix D: maps and locations of critical habitat

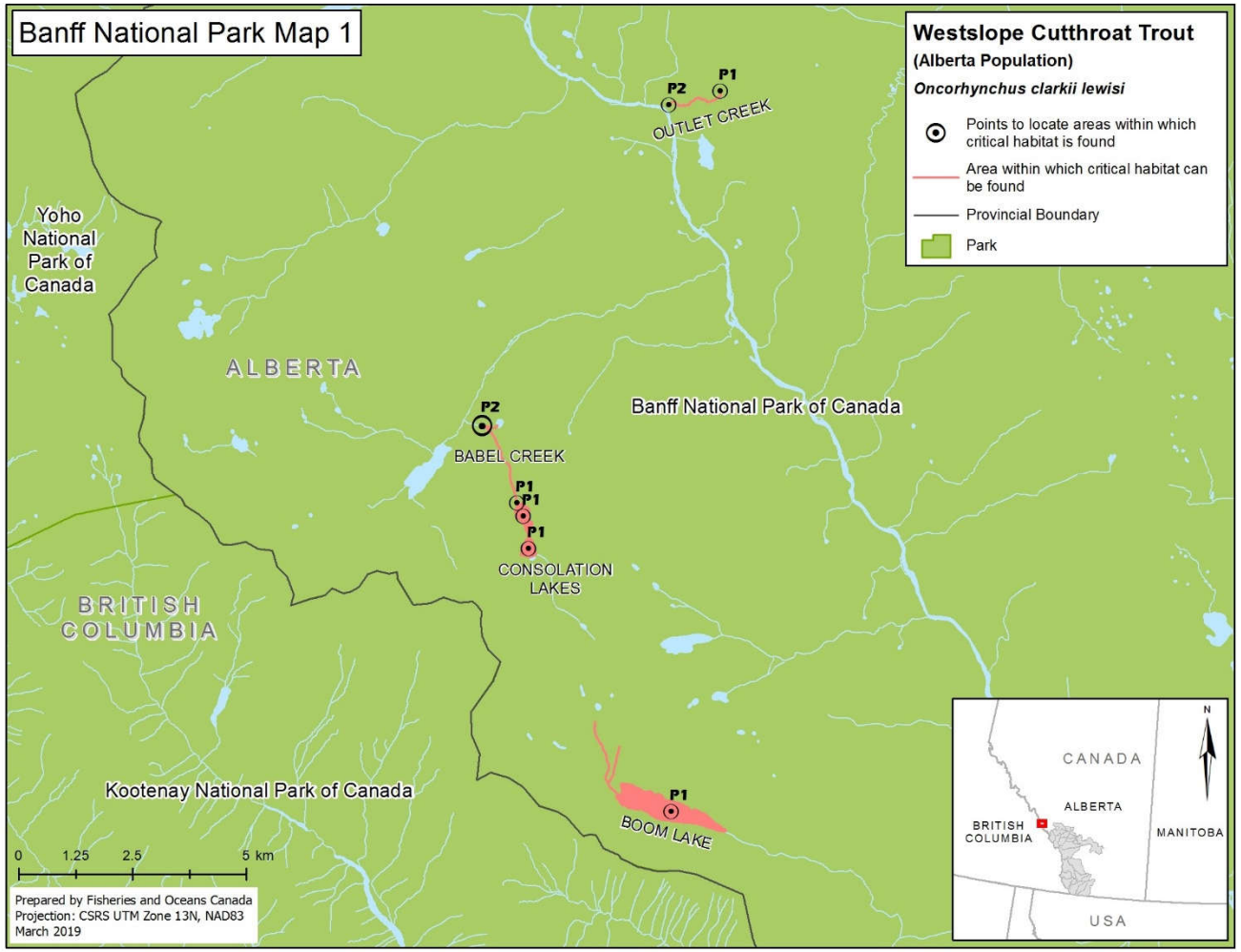

Figure 3. Critical habitat in the Upper Bow River, Banff National Park of Canada

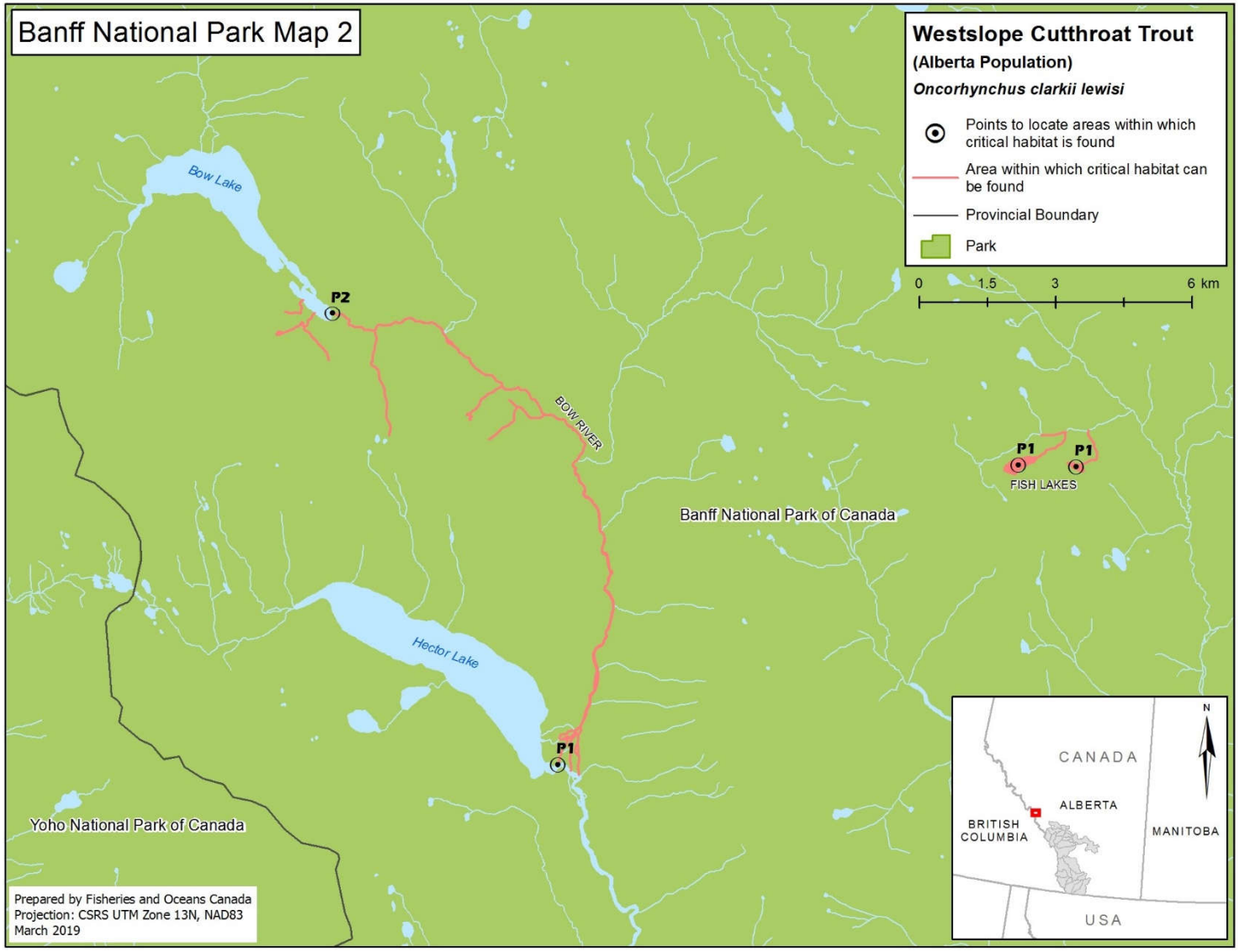

Figure 4. Critical habitat in the Upper Bow River, Banff National Park of Canada

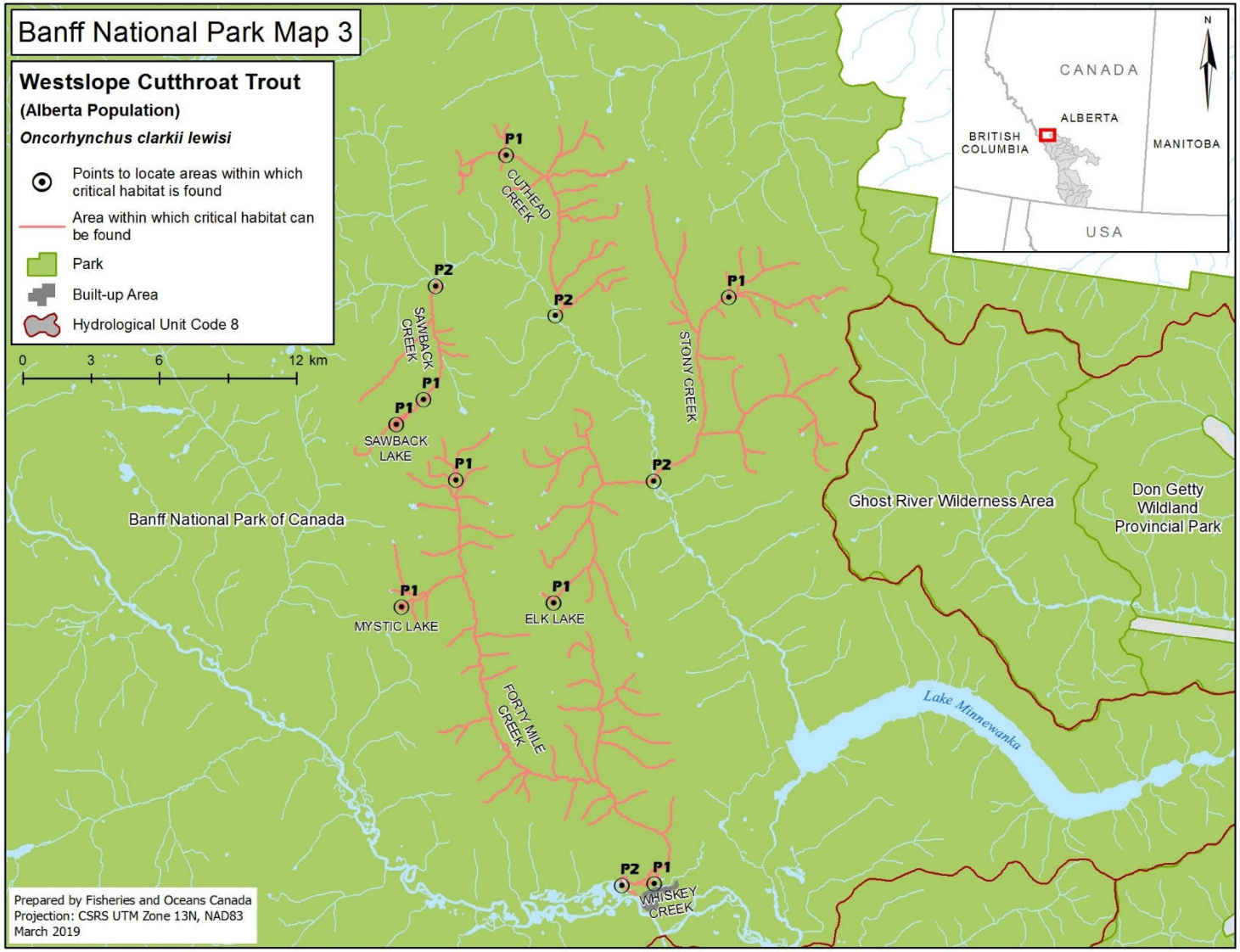

Figure 5. Critical habitat in the Upper Bow River, Banff National Park of Canada

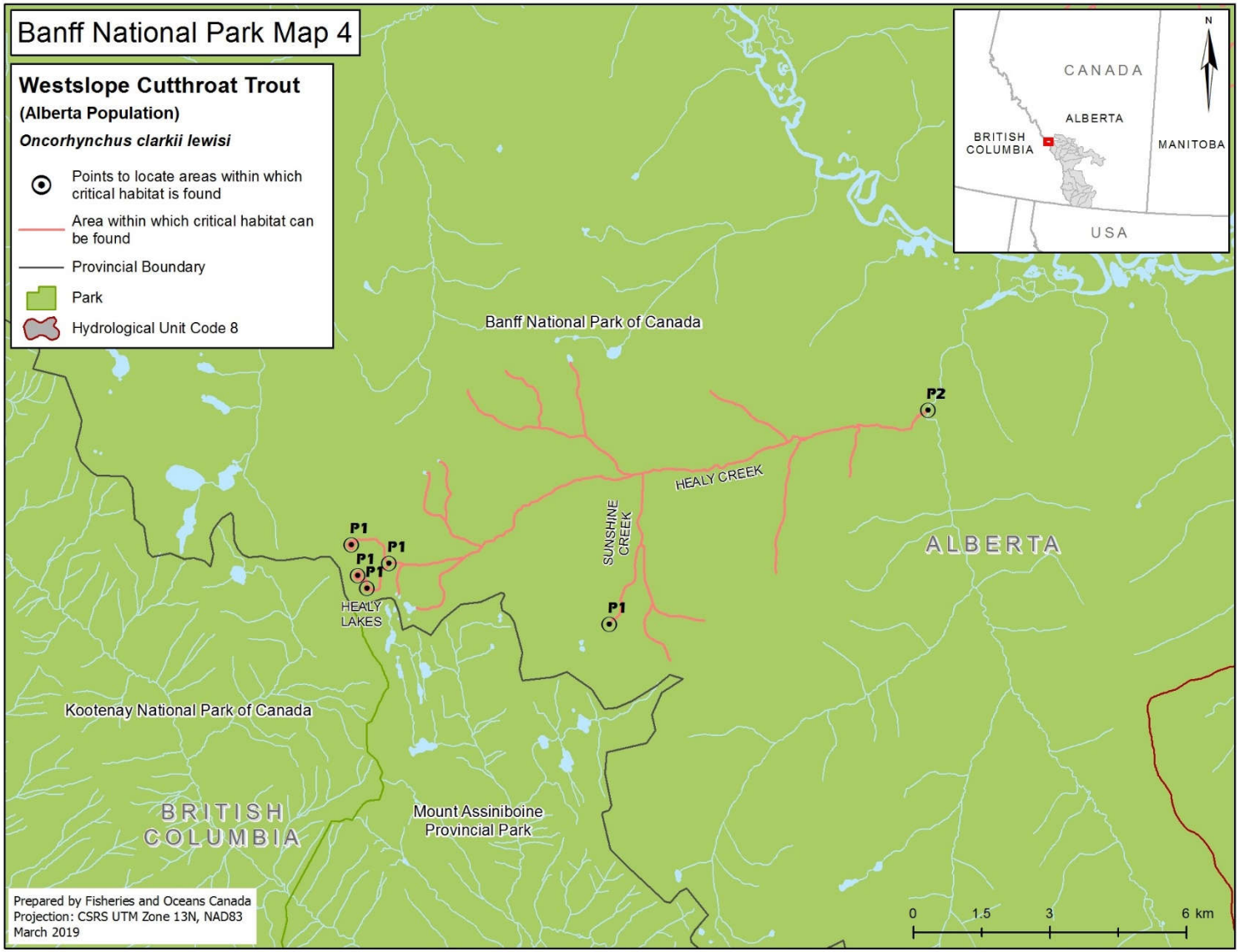

Figure 6. Critical habitat in the Upper Bow River, Banff National Park of Canada

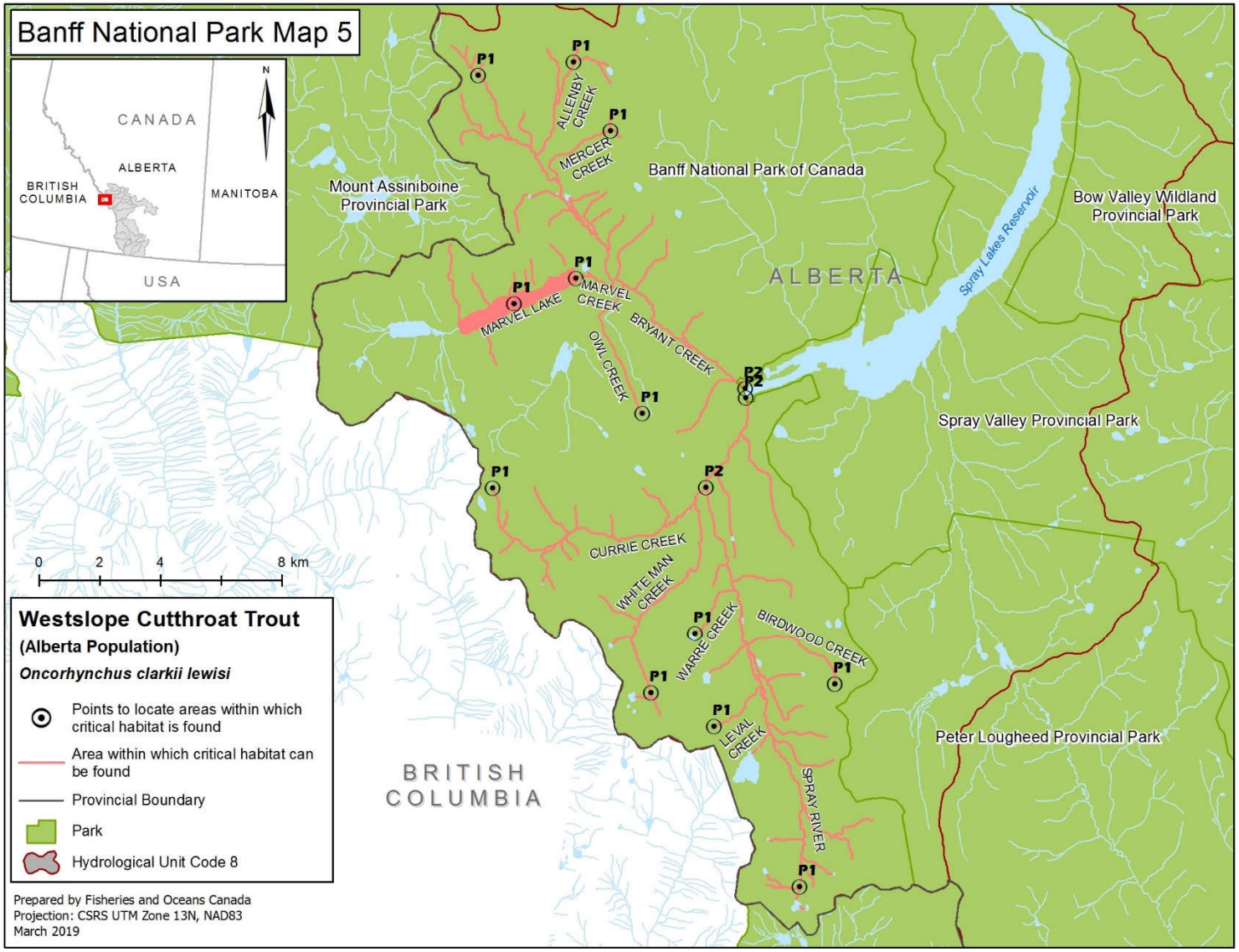

Figure 7. Critical habitat in the Upper Bow River, Banff National Park of Canada

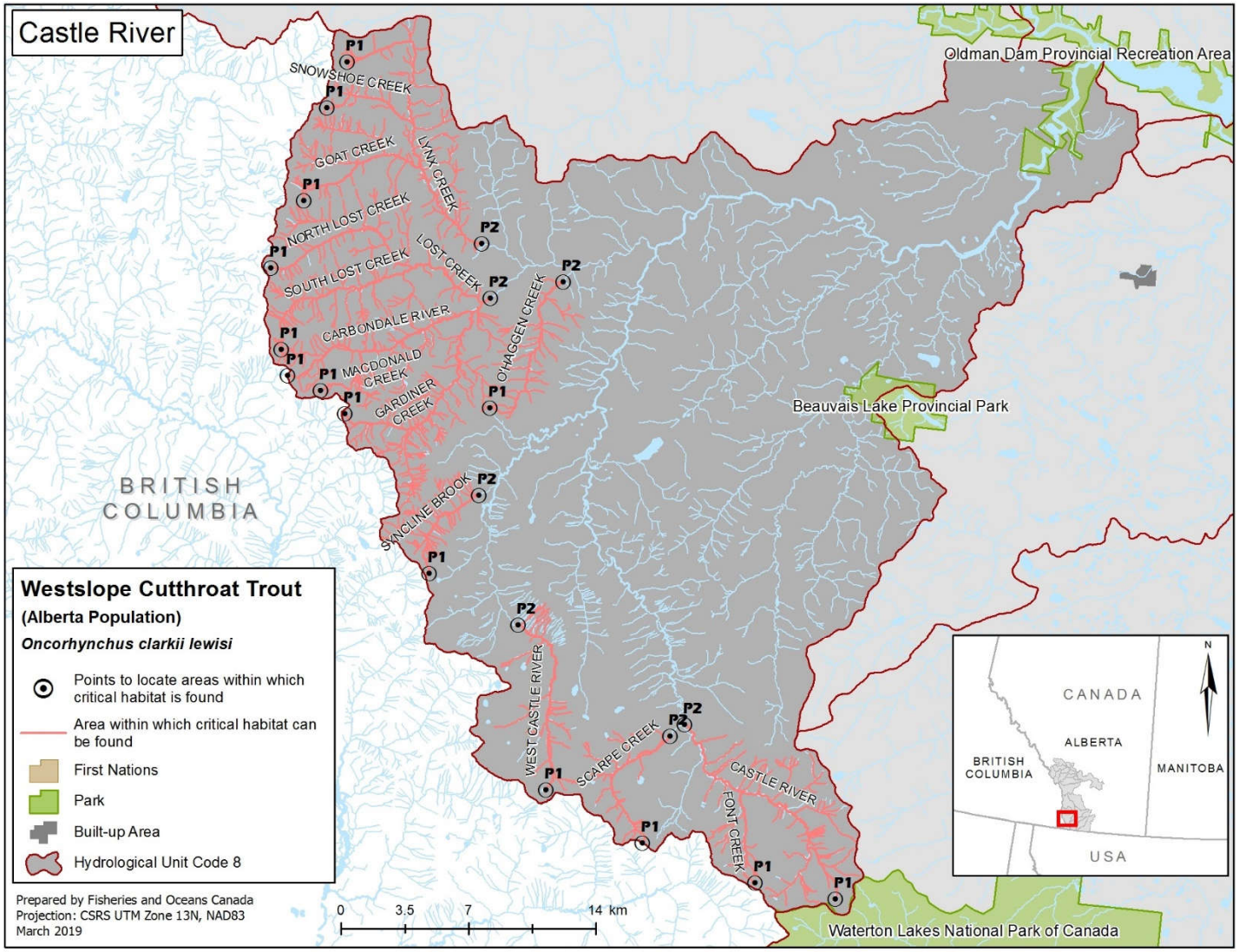

Figure 8. Critical habitat in the Castle River watershed

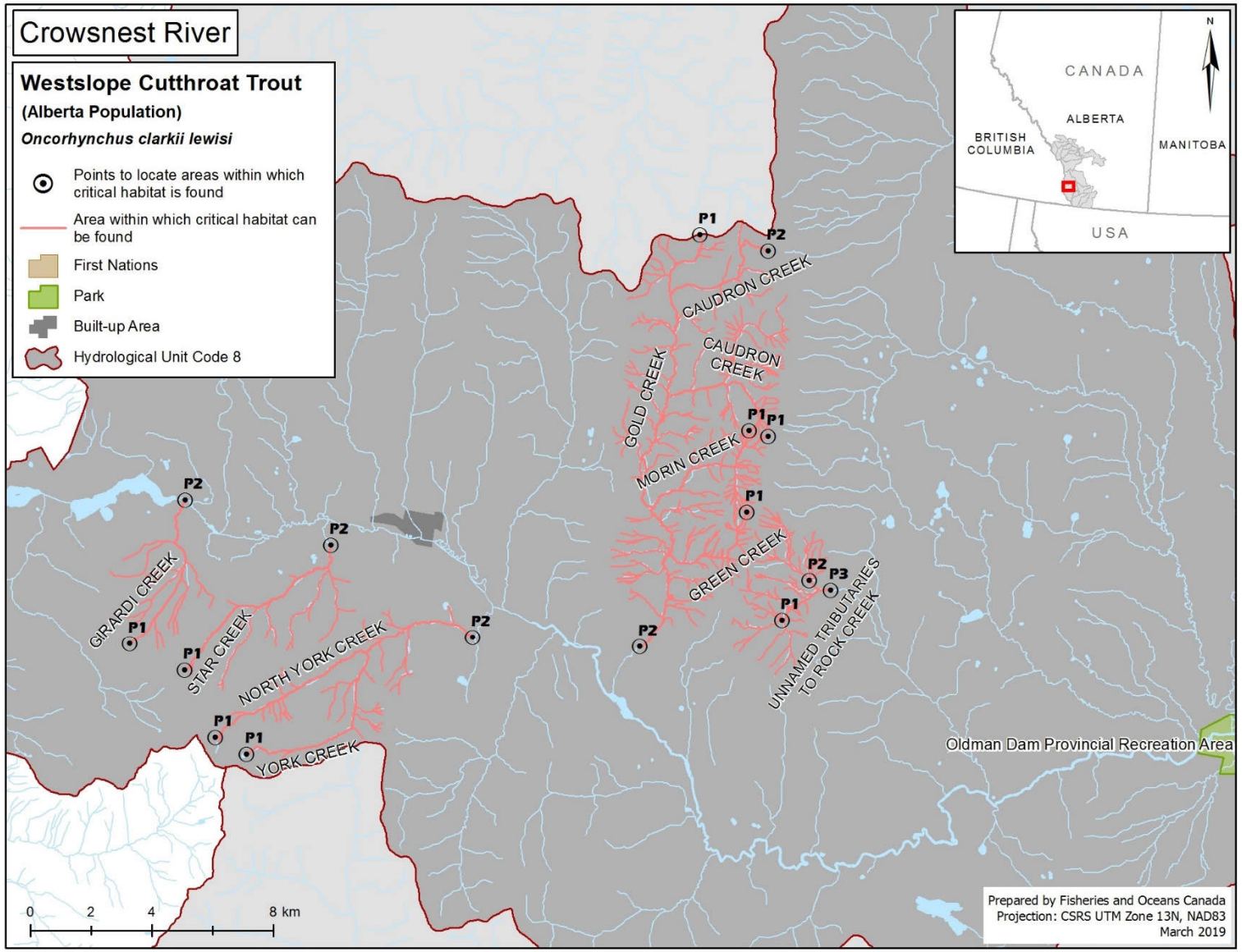

Figure 9. Critical habitat in the Crowsnest River watershed

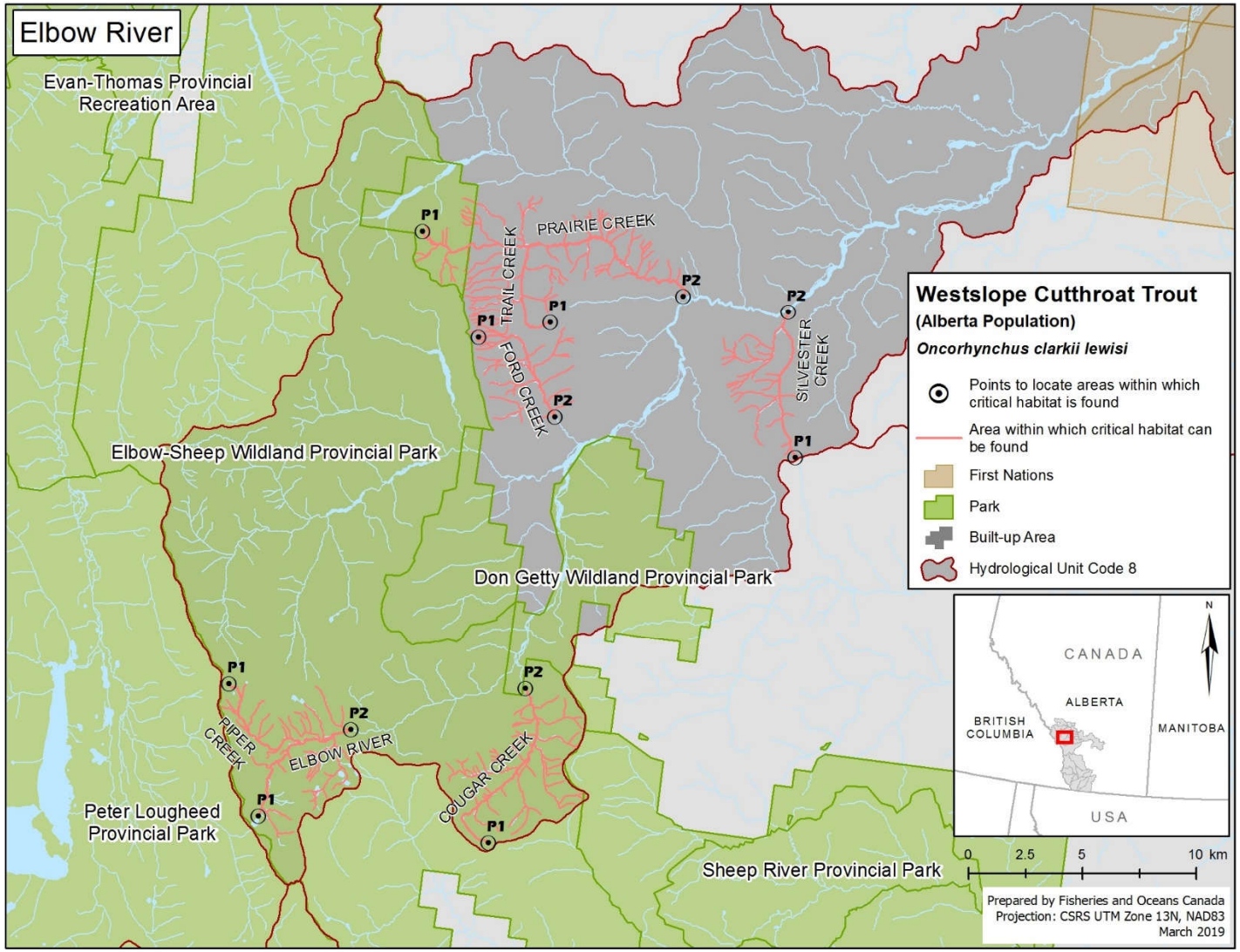

Figure 10. Critical habitat in the Elbow River watershed

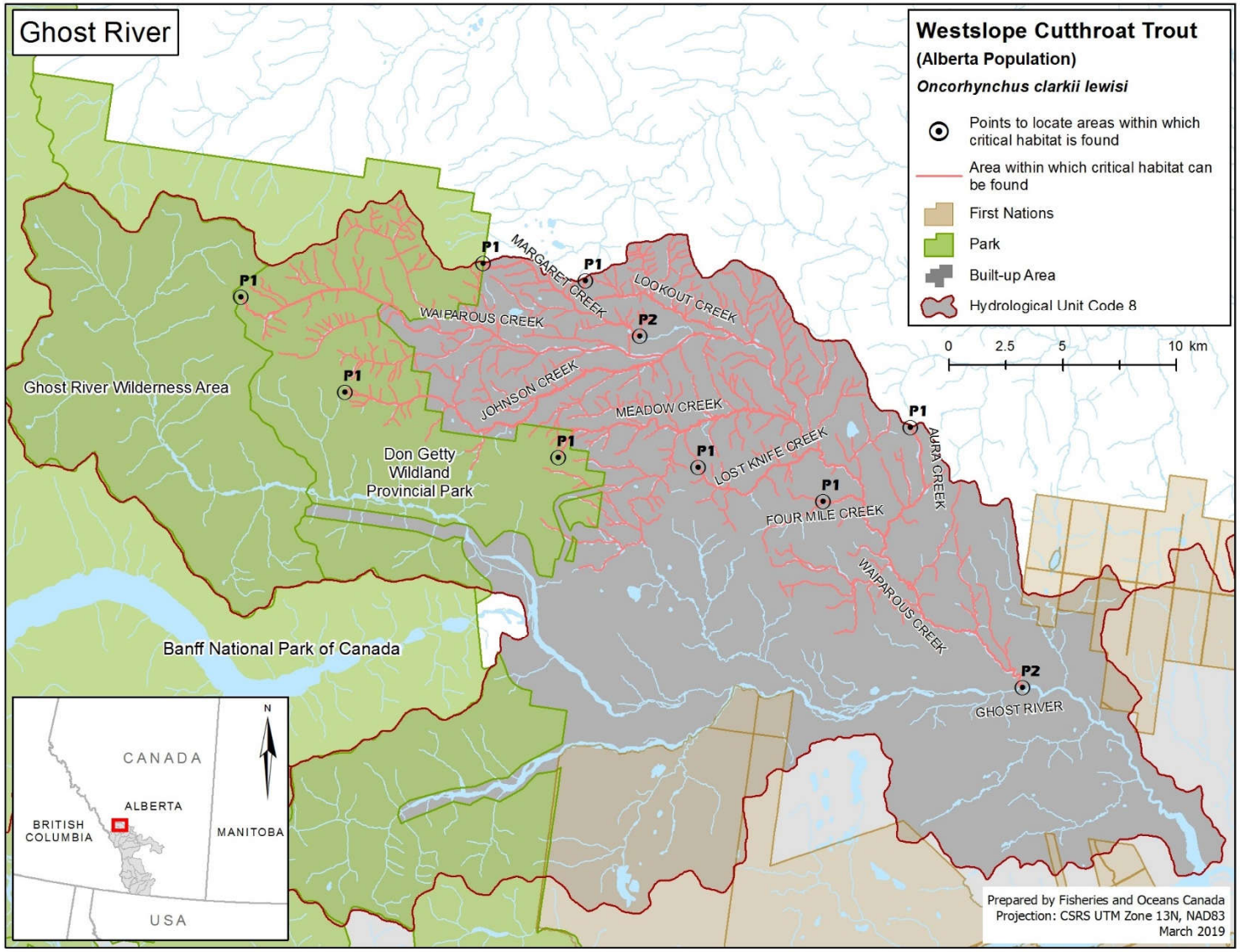

Figure 11. Critical habitat in the Ghost River Watershed

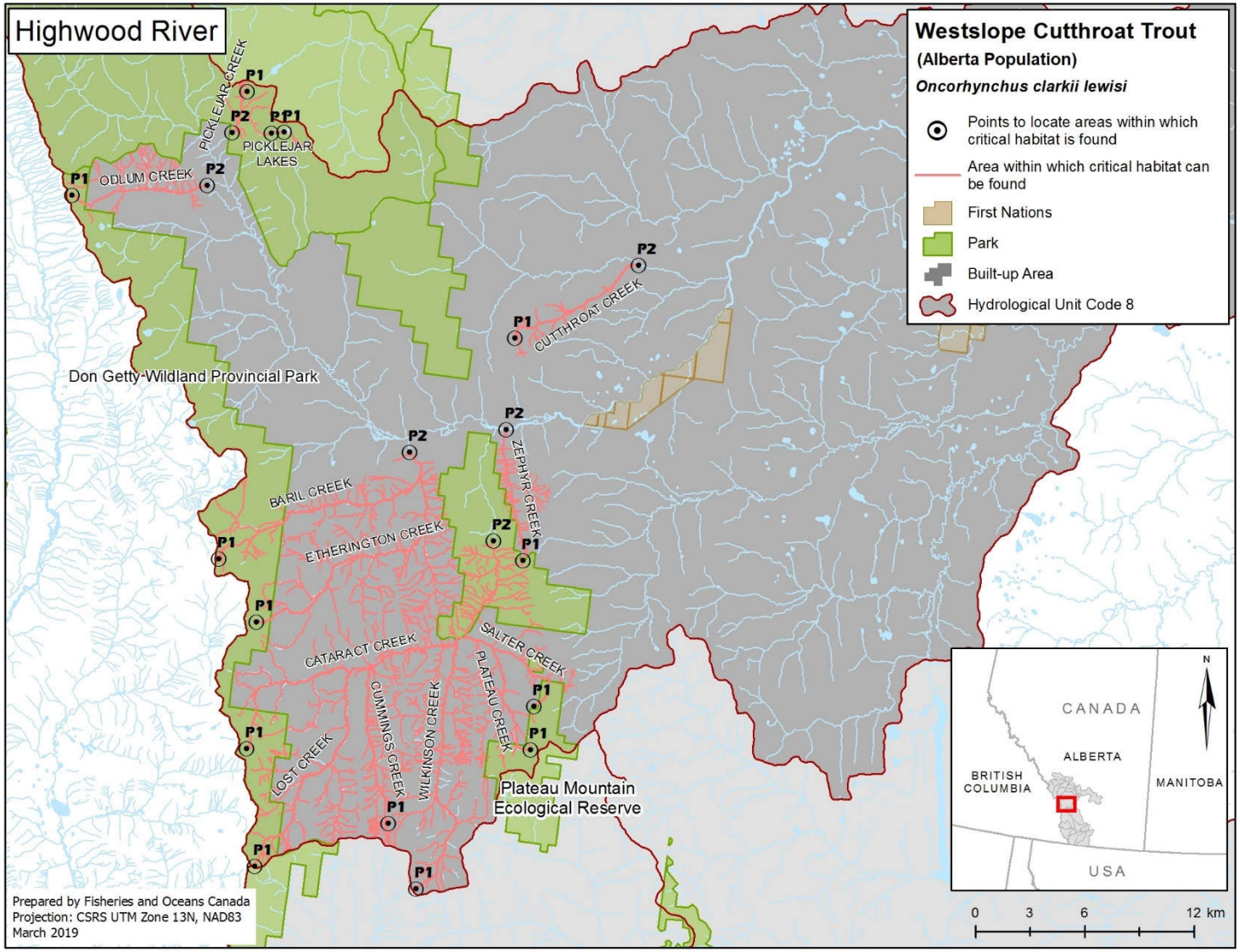

Figure 12. Critical habitat in the Highwood River watershed

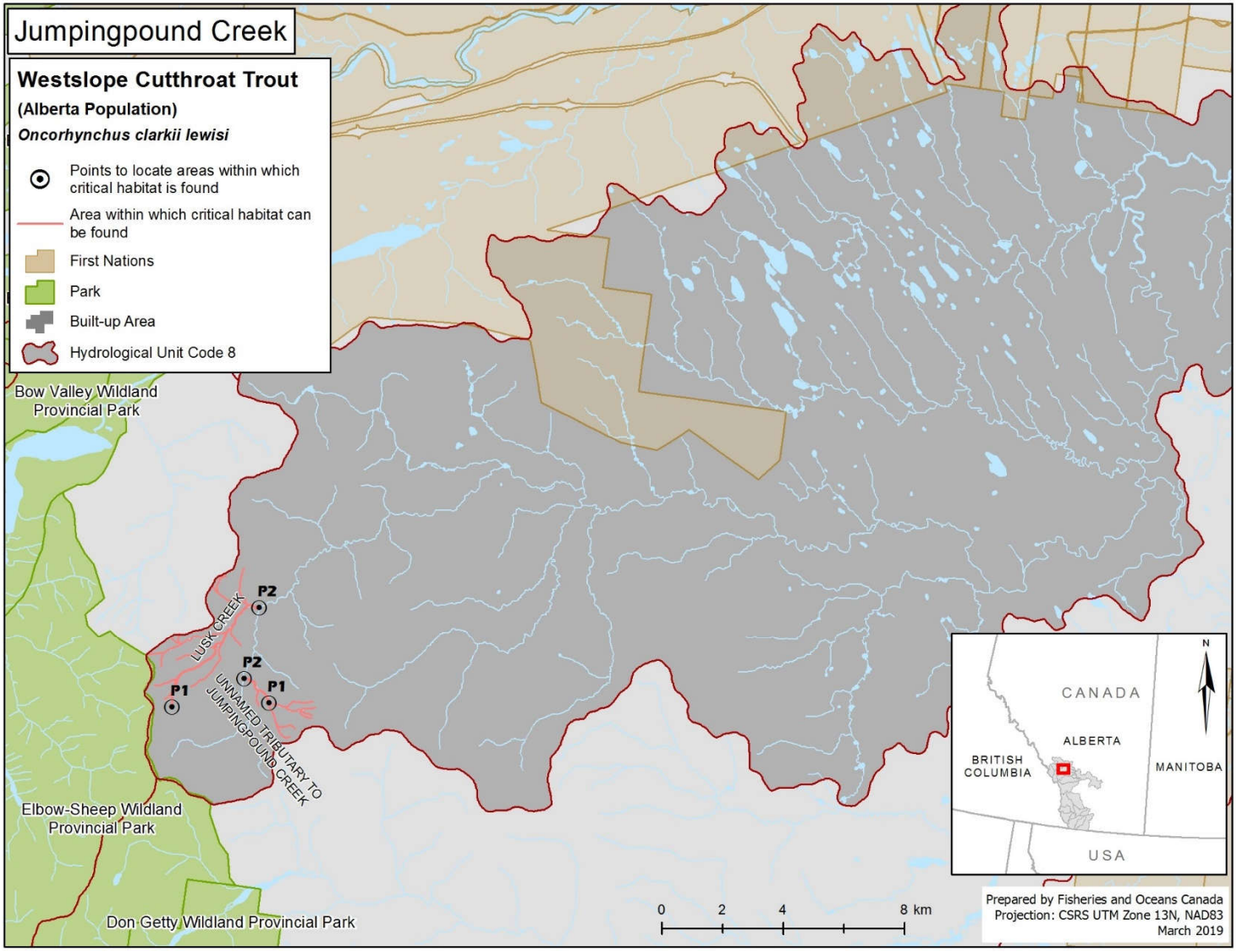

Figure 13. Critical habitat in the Jumpingpound Creek watershed

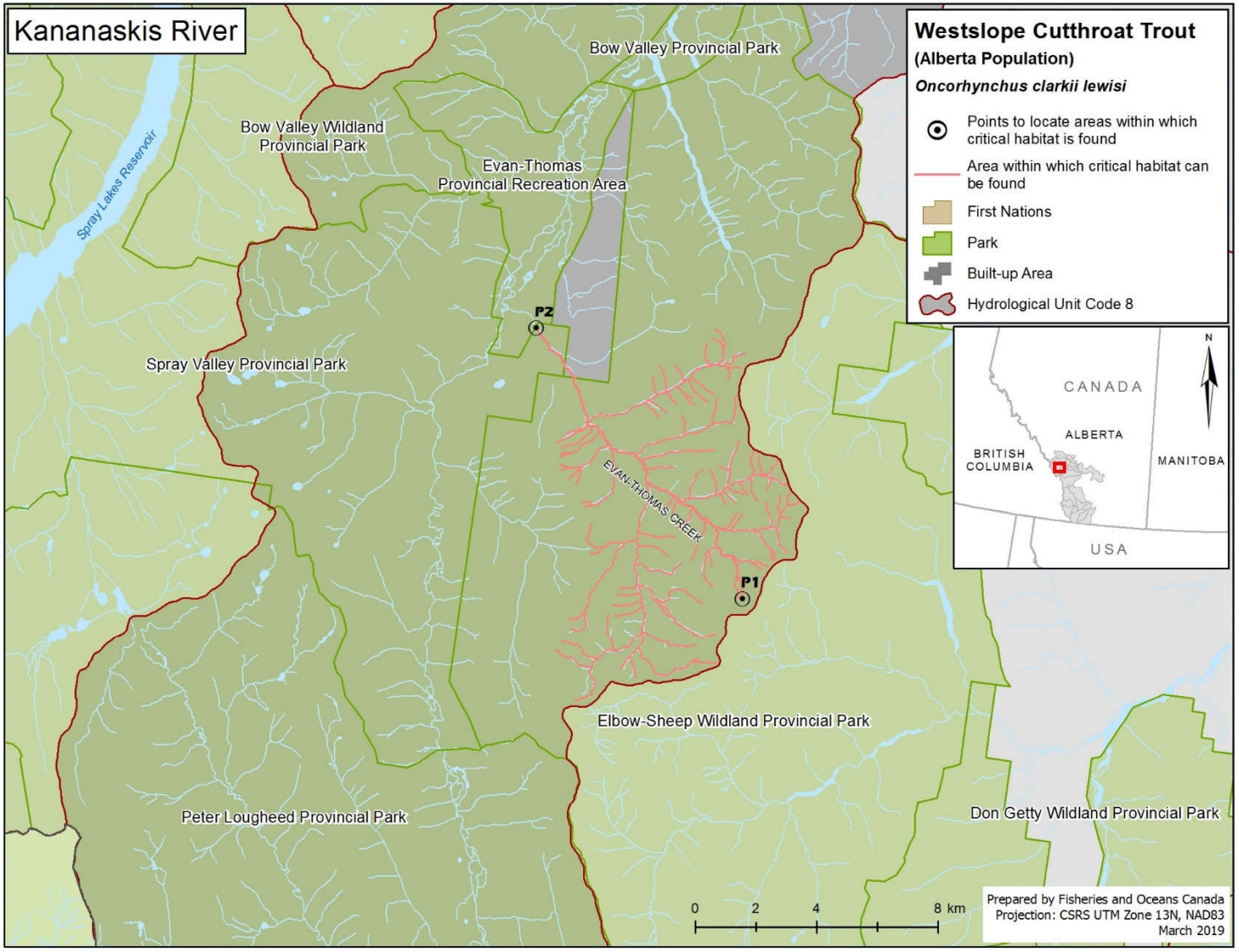

Figure 14. Critical habitat in the Kananaskis River watershed

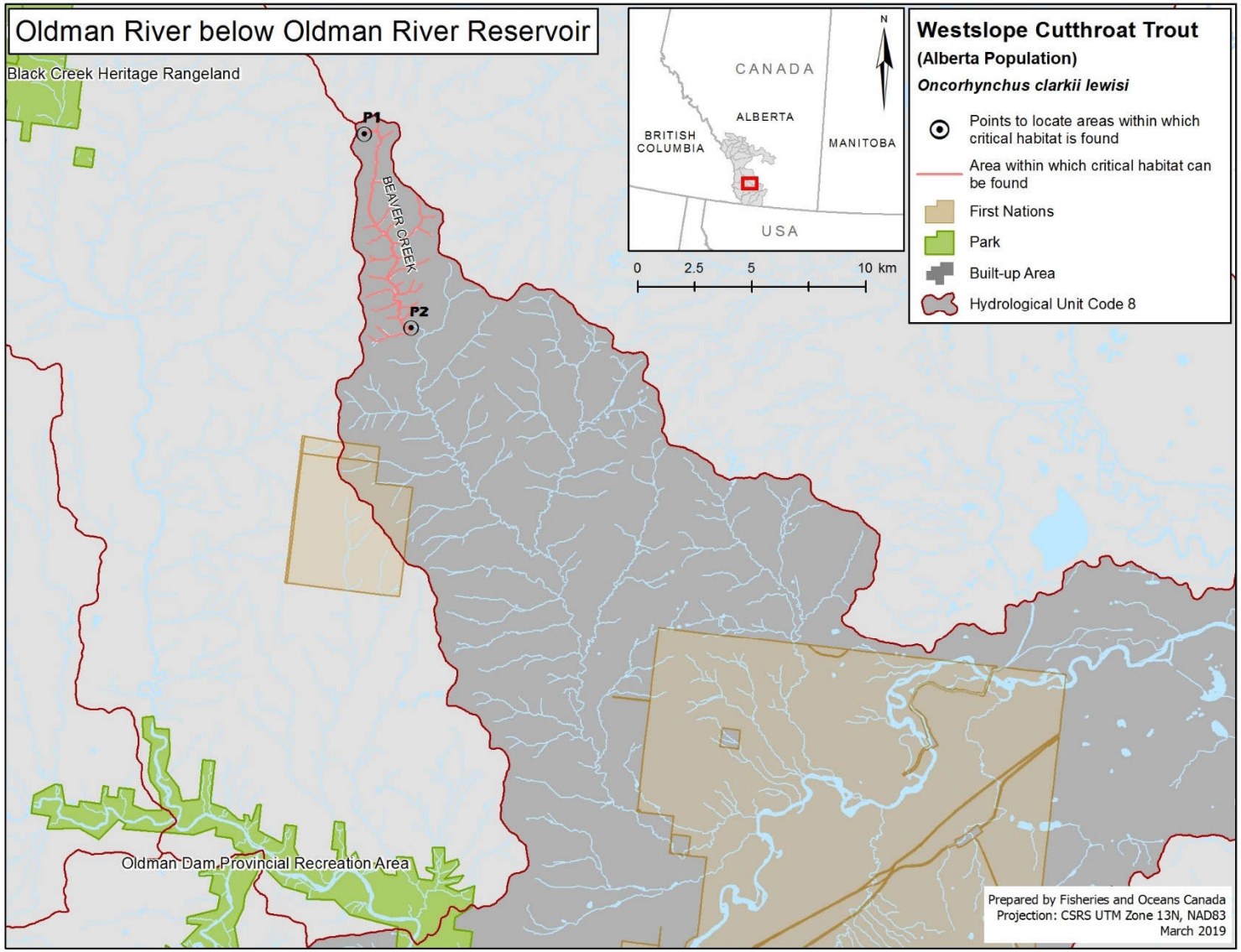

Figure 15. Critical habitat in the Oldman River watershed below the Oldman Reservoir

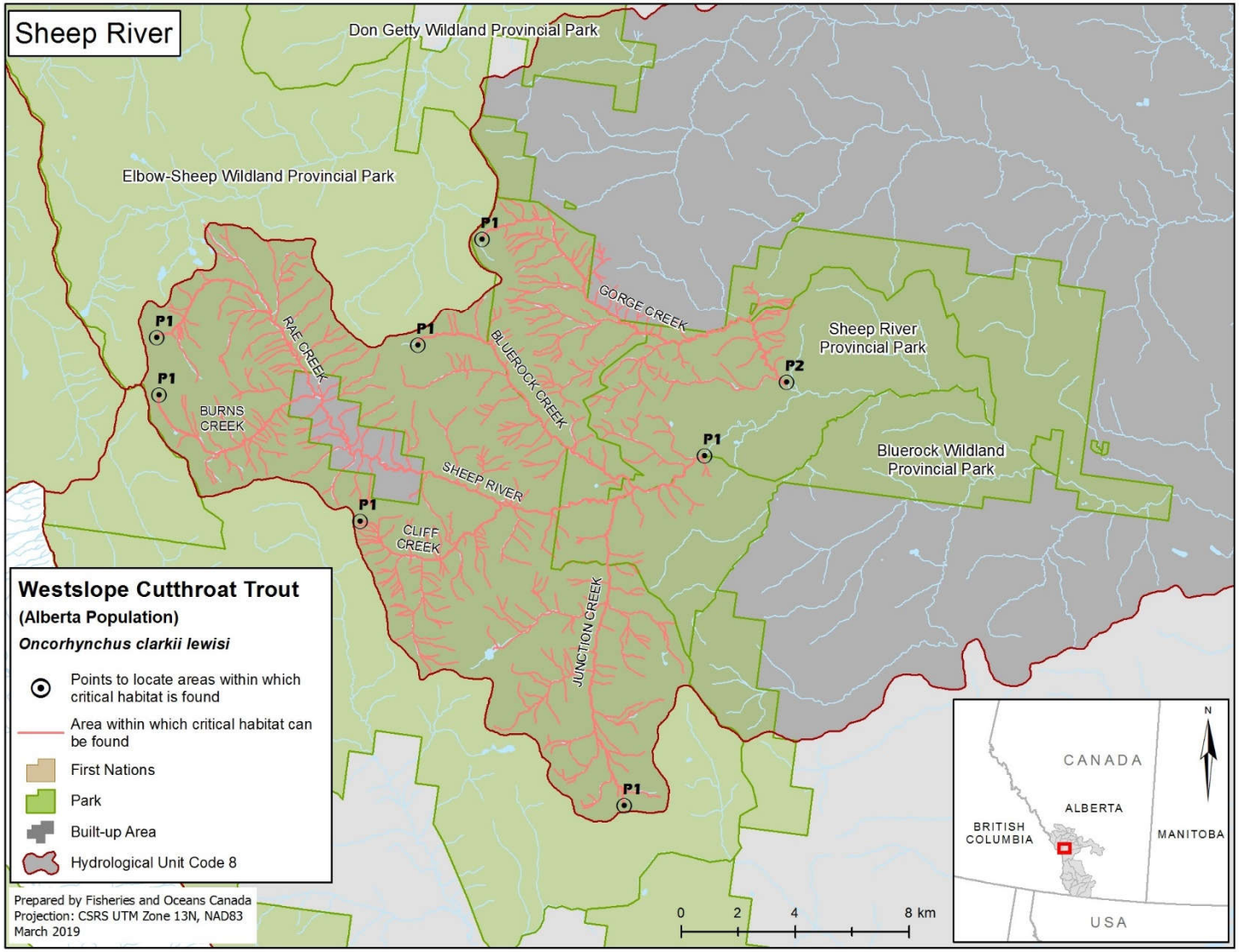

Figure 16. Critical habitat in the Sheep River watershed

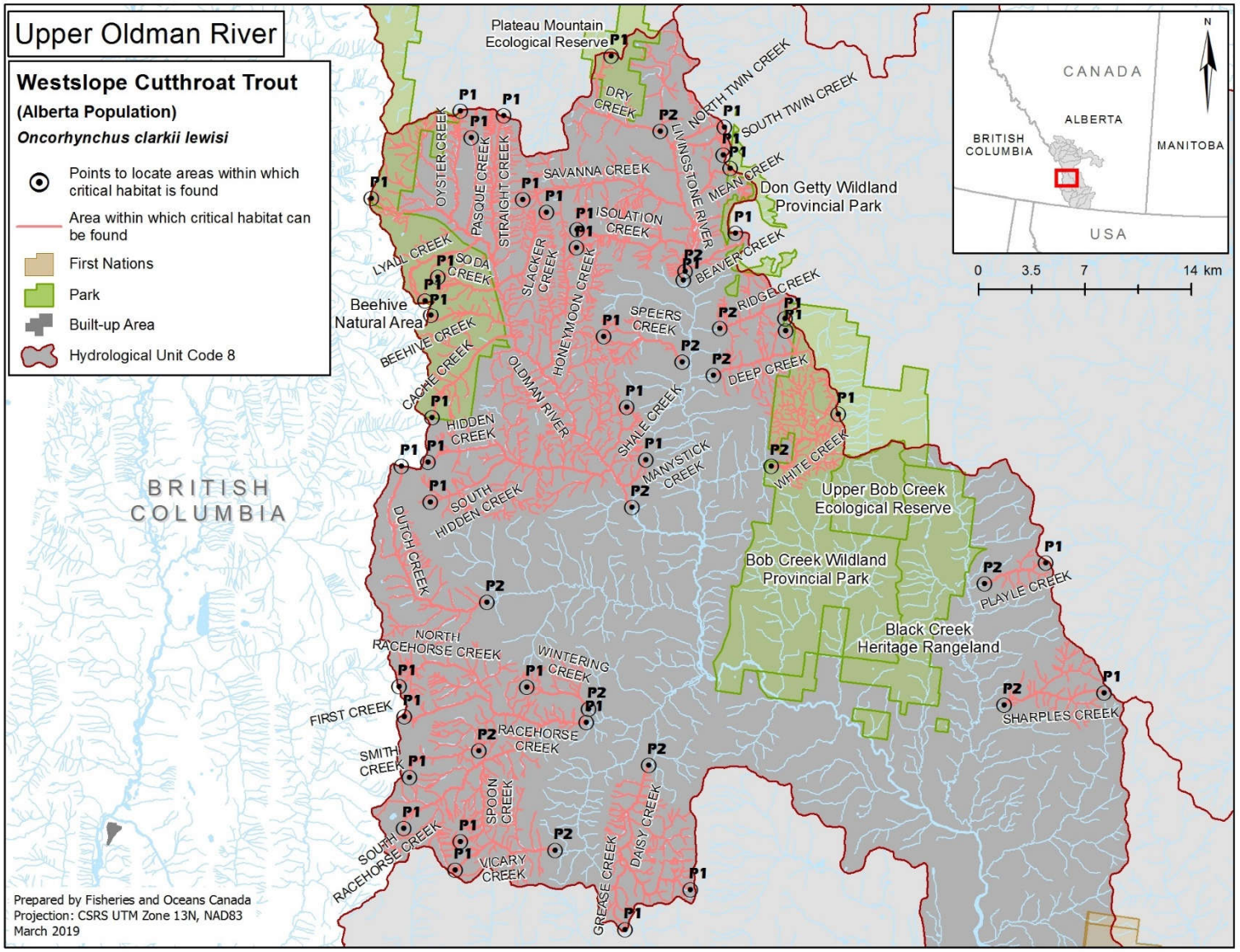

Figure 17. Critical habitat in the Upper Oldman watershed

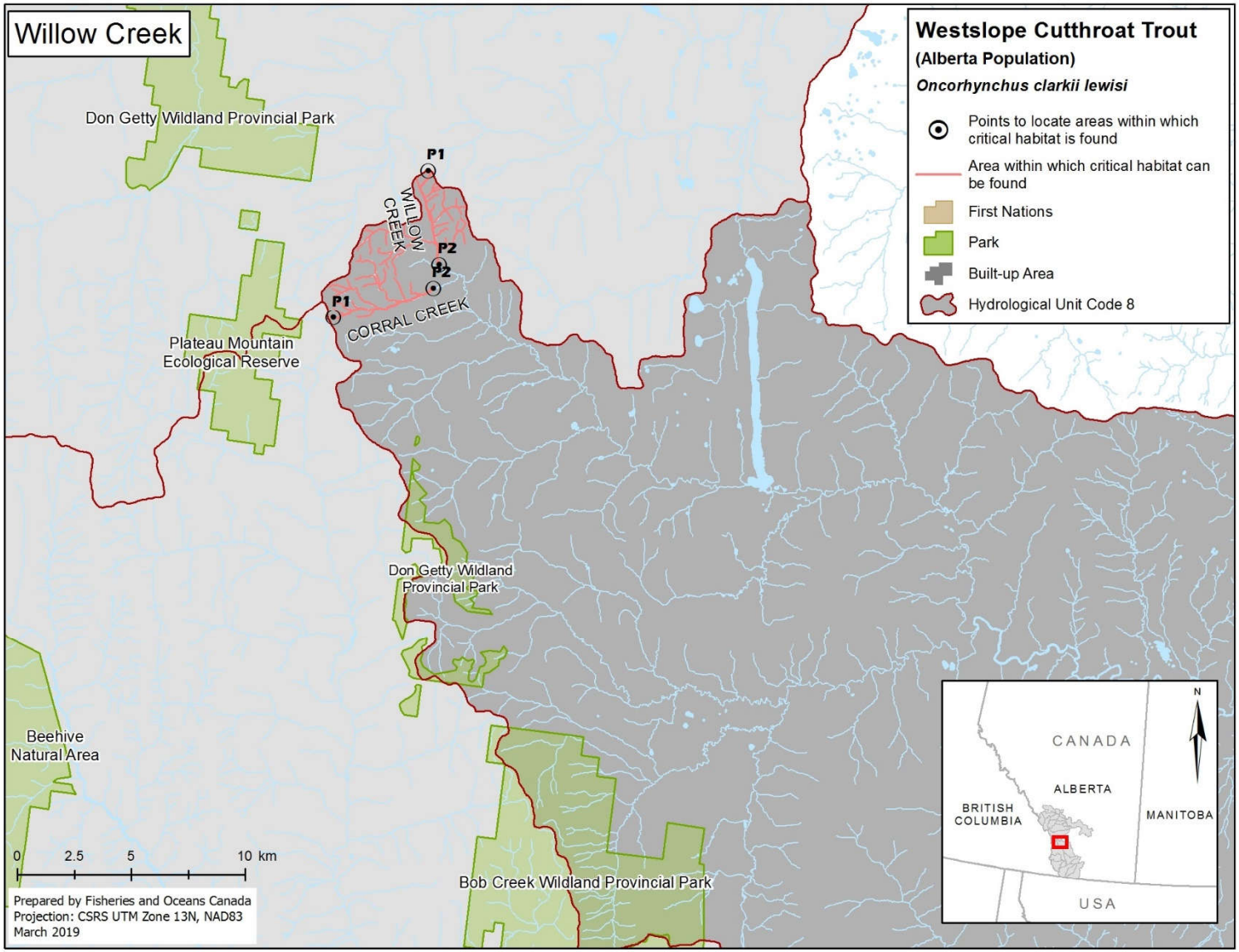

Figure 18. Critical habitat in the Willow Creek watershed

Table 5. Locations of lakes in Banff National Park of Canada, Alberta identified as critical habitat for Westslope Cutthroat Trout

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Consolation Lake 1	51.31573	-116.152595	P1	Banff National Park of Canada: Figure 3
Consolation Lake 2	51.309561	-116.149533	P1	Banff National Park of Canada: Figure 3
Boom Lake	51.2629	-116.092949	P1	Banff National Park of Canada: Figure 3
Big Fish Lake	51.642483	-116.199164	P1	Banff National Park of Canada: Figure 4
Little Fish Lake	51.643919	-116.180100	P1	Banff National Park of Canada: Figure 4
Sawback Lake	51.349694	-115.769611	P1	Banff National Park of Canada: Figure 5
Mystic Lake	51.278384	-115.749535	P1	Banff National Park of Canada: Figure 5
Elk Lake	51.288472	-115.655878	P1	Banff National Park of Canada: Figure 5
Healy Lakes 1	51.085198	-115.859104	P1	Banff National Park of Canada: Figure 6
Healy Lakes 2	51.091003	-115.862495	P1	Banff National Park of Canada: Figure 6
Healy Lakes 3	51.082976	-115.855568	P1	Banff National Park of Canada: Figure 6
Marvel Lake	50.876853	-115.558296	P1	Banff National Park of Canada: Figure 7

Table 6. Locations of flowing waters in Banff National Park of Canada, Alberta identified as critical habitat for Westslope Cutthroat Trout

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Babel Creek	51.31813860000	-116.15520320000	P1	Banff National Park of Canada: Figure 3
Babel Creek	51.33214280000	-116.16963100000	P2	Banff National Park of Canada: Figure 3
Bow River	51.57024480000	-116.32740880000	P1	Banff National Park of Canada: Figure 4
Bow River	51.65091990000	-116.41984940000	P2	Banff National Park of Canada: Figure 4
Bryant Creek	50.941799	-115.590109	P1	Banff National Park of Canada: Figure 7
Bryant Creek	50.861603	-115.446275	P2	Banff National Park of Canada: Figure 7
Cuthead Creek	51.45964550000	-115.72619730000	P1	Banff National Park of Canada: Figure 5
Cuthead Creek	51.40000510000	-115.68098430000	P2	Banff National Park of Canada: Figure 5
Forty Mile Creek	51.33064060000	-115.72770930000	P1	Banff National Park of Canada: Figure 5
Forty Mile Creek	51.18263270000	-115.58806640000	P2	Banff National Park of Canada: Figure 5
Whiskey Creek	51.20430100000	-115.54242700000	P1	Banff National Park of Canada: Figure 5
Stony Creek	51.41734300000	-115.57495220000	P1	Banff National Park of Canada: Figure 5
Stony Creek	51.341378	-115.604835	P2	Banff National Park of Canada: Figure 5
Sawback Creek	51.35988820000	-115.75511430000	P1	Banff National Park of Canada: Figure 5
Sawback Creek	51.40490200000	-115.75786260000	P2	Banff National Park of Canada: Figure 5
Healy Creek	51.08851960000	-115.84992670000	P1	Banff National Park of Canada: Figure 6

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Healy Creek	51.13361050000	-115.69081340000	P2	Banff National Park of Canada: Figure 6
Sunshine Creek	51.08300390000	-115.77931360000	P1	Banff National Park of Canada: Figure 6
Spray River	50.71883200000	-115.38865390000	P1	Banff National Park of Canada: Figure 7
Spray River	50.85894680000	-115.44529990000	P2	Banff National Park of Canada: Figure 7
Currie Creek	50.82194110000	-115.55596270000	P1	Banff National Park of Canada: Figure 7
Currie Creek	50.83108210000	-115.45788040000	P2	Banff National Park of Canada: Figure 7
Leval Creek	50.76160850000	-115.43851400000	P1	Banff National Park of Canada: Figure 7
Birdwood Creek	50.77900240000	-115.38571440000	P1	Banff National Park of Canada: Figure 7
Mercer Creek	50.93116580000	-115.52545460000	P1	Banff National Park of Canada: Figure 7
Allenby Creek	50.94964130000	-115.54711410000	P1	Banff National Park of Canada: Figure 7
Warre Creek	50.78795480000	-115.45316230000	P1	Banff National Park of Canada: Figure 7
White Man Creek	50.76882210000	-115.46959550000	P1	Banff National Park of Canada: Figure 7
Bryant Creek	50.86160290000	-115.44627530000	P1	Banff National Park of Canada: Figure 7
Bryant Creek	50.94179880000	-115.59010870000	P2	Banff National Park of Canada: Figure 7
Marvel Creek	50.88680450000	-115.53157860000	P1	Banff National Park of Canada: Figure 7
Owl Creek	50.85000430000	-115.49210470000	P1	Banff National Park of Canada: Figure 7

Table 7. Locations of lakes in Alberta (outside of national parks of Canada) identified as critical habitat for Westslope Cutthroat

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Picklejar Lakes (#4 Lake)	50.517676	-114.783222	P1	Highwood River
Picklejar Lakes (#2 Lake)	50.518489	-114.774014	P1	Highwood River

Table 8. Locations of flowing waters in Alberta (outside of national parks of Canada) identified as critical habitat for Westslope Cutthroat Trout

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Aura Creek	51.37788279320	-114.92843977400	P1	Ghost River
Baril Creek	50.30879354830	-114.78017197400	P1	Highwood River
Beaver Creek	50.12859227790	-114.39650798700	P1	Upper Oldman River
Beaver Creek	50.10270267530	-114.43820603100	P2	Upper Oldman River
Beaver Creek	49.87782648380	-113.98585424500	P1	Oldman River below Oldman River Reservoir
Beaver Creek	49.80419642790	-113.94321180500	P2	Oldman River below Oldman River Reservoir
Beehive Creek	50.05728111000	-114.66393421900	P1	Upper Oldman River
Bluerock Creek	50.64312612870	-114.84262243200	P1	Sheep River
Burns Creek	50.61673916140	-114.96622316800	P1	Sheep River
Cache Creek	49.99775314160	-114.65081976100	P1	Upper Oldman River
Carbondale River	49.38654309030	-114.57512465200	P1	Castle River
Carbondale River	49.43714228570	-114.43121550500	P2	Castle River
Castle River	49.16438975450	-114.11842045200	P1	Castle River
Castle River	49.24045664810	-114.24639685800	P2	Castle River

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Cataract Creek	50.21799923840	-114.74028936200	P1	Highwood River
Cataract Creek	50.33491737200	-114.57300562400	P2	Highwood River
Caudron Creek	49.67507483220	-114.35658520000	P1	Crowsnest River
Caudron Creek	49.72841030990	-114.35816999300	P2	Crowsnest River
Cliff Creek	50.58591649020	-114.85948341900	P1	Sheep River
Corral Creek	50.25980698410	-114.41128008400	P1	Willow Creek
Corral Creek	50.24324560630	-114.46988359300	P2	Willow Creek
Cougar Creek	50.64401138100	-114.86364514900	P1	Elbow River
Cougar Creek	50.70578432720	-114.85360718500	P2	Elbow River
Cummings Creek	50.19075043250	-114.62528534200	P1	Highwood River
Cutthroat Creek	50.43499038720	-114.57707658700	P1	Highwood River
Cutthroat Creek	50.47833570290	-114.48959053500	P2	Highwood River
Daisy Creek	49.74080076080	-114.36237324500	P1	Upper Oldman River
Daisy Creek	49.81076909930	-114.41384061900	P2	Upper Oldman River
Deep Creek	50.07509847060	-114.33968698600	P1	Upper Oldman River
Deep Creek	50.04349065920	-114.40022556100	P2	Upper Oldman River
Dry Creek	50.22293178040	-114.53054260700	P1	Upper Oldman River
Dry Creek	50.18253159970	-114.47691127200	P2	Upper Oldman River
Dutch Creek	49.96709838690	-114.67267947800	P1	Upper Oldman River
Dutch Creek	49.89403020560	-114.57900169500	P2	Upper Oldman River
Elbow River	50.64225259980	-115.00668143300	P1	Elbow River
Elbow River	50.68053164790	-114.95704508400	P2	Elbow River
Etherington Creek	50.28053908380	-114.74551530900	P1	Highwood River
Etherington Creek	50.37266738410	-114.64596296000	P2	Highwood River
Evan-Thomas Creek	50.81987447070	-115.02357266500	P1	Kananaskis River
Evan-Thomas Creek	50.89051632070	-115.13587035000	P2	Kananaskis River
First Creek	49.82077535450	-114.64081979400	P1	Upper Oldman River

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Font Creek	49.16733976100	-114.17937399400	P1	Castle River
Ford Creek	50.84009321940	-114.91136478700	P1	Elbow River
Ford Creek	50.81320607090	-114.85781431100	P2	Elbow River
Four Mile Creek	51.34430750320	-114.97659838700	P1	Ghost River
Gardiner Creek	49.37144943240	-114.52875620700	P1	Castle River
Girardi Creek	49.58952629070	-114.62314634800	P1	Crowsnest River
Girardi Creek	49.63374371650	-114.60639018800	P2	Crowsnest River
Goat Creek	49.47307593570	-114.57982540000	P1	Castle River
Gold Creek	49.73066871600	-114.39010867100	P1	Crowsnest River
Gold Creek	49.60769047680	-114.39372759600	P2	Crowsnest River
Gorge Creek	50.67899767730	-114.81825942600	P1	Sheep River
Gorge Creek	50.64686045030	-114.65969176100	P2	Sheep River
Grease Creek	49.71279178690	-114.41679208300	P1	Upper Oldman River
Green Creek	49.65101595510	-114.35299705100	P1	Crowsnest River
Hidden Creek	49.97132085160	-114.64932796200	P1	Upper Oldman River
Honeymoon Creek	50.10823320650	-114.53969646400	P1	Upper Oldman River
Isolation Creek	50.11885332890	-114.54099153500	P1	Upper Oldman River
Johnson Creek	51.36083255450	-115.28277166500	P1	Ghost River
Junction Creek	50.50834221920	-114.71187333600	P1	Sheep River
Livingstone River	50.09746446980	-114.43856771100	P1	Upper Oldman River
Lookout Creek	51.41764627070	-115.14325816800	P1	Ghost River
Lost Creek	50.16128197390	-114.72212200000	P1	Highwood River
Lost Knife Creek	51.35106578750	-115.05696514900	P1	Ghost River
Lusk Creek	50.95623620640	-114.98854431700	P1	Jumpingpound Creek
Lusk Creek	50.98897404190	-114.95470469500	P2	Jumpingpound Creek
Lyall Creek	50.06574940660	-114.67058786400	P1	Upper Oldman River
Lynx Creek	49.54281241980	-114.56058949600	P1	Castle River

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Lynx Creek	49.46301673730	-114.44273977000	P2	Castle River
Macdonald Creek	49.38124738040	-114.54902474200	P1	Castle River
Manystick Creek	49.98927148410	-114.45203793000	P1	Upper Oldman River
Margaret Creek	51.39880312920	-115.10436948900	P2	Ghost River
Margaret Creek	51.41879580040	-115.20824753500	P1	Ghost River
Meadow Creek	51.34714704540	-115.14467901400	P1	Ghost River
Mean Creek	50.16602020640	-114.40904511000	P1	Upper Oldman River
Morin Creek	49.67403386420	-114.34763367800	P1	Crowsnest River
North Lost Creek	49.43830652230	-114.59815941300	P1	Castle River
North Racehorse Creek	49.83781484480	-114.64854979400	P1	Upper Oldman River
North Twin Creek	50.18964509010	-114.41887791500	P1	Upper Oldman River
North York Creek	49.56540632230	-114.57916367800	P1	Crowsnest River
Odlum Creek	50.47616894180	-114.92920281200	P1	Highwood River
Odlum Creek	50.48981202550	-114.82677525500	P2	Highwood River
O'Haggen Creek	49.38326312280	-114.42123445800	P1	Castle River
O'Haggen Creek	49.44960916870	-114.37827052900	P2	Castle River
Oldman River	50.12134234220	-114.73174053600	P1	Upper Oldman River
Oldman River	49.96044591000	-114.45883478700	P2	Upper Oldman River
Oyster Creek	50.17922522560	-114.66112625200	P1	Upper Oldman River
Pasque Creek	50.17981247750	-114.62147756200	P1	Upper Oldman River
Picklejar Creek	50.53776394160	-114.80620012300	P1	Highwood River
Picklejar Creek	50.51686279170	-114.81318034300	P2	Highwood River
Piper Creek	50.69201343190	-115.03573471600	P1	Elbow River
Plateau Creek	50.23526536120	-114.52456468400	P1	Highwood River
Playe Creek	49.95811252860	-114.07707942600	P1	Upper Oldman River
Playe Creek	49.94156140880	-114.13056166400	P2	Upper Oldman River
Prairie Creek	50.86689383650	-114.78893841100	P1	Elbow River

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Prairie Creek	50.87854843910	-114.95483619900	P2	Elbow River
Racehorse Creek	49.83089658140	-114.47506394400	P1	Upper Oldman River
Rae Creek	50.63449600610	-114.97126100000	P1	Sheep River
Ridge Creek	50.08207106480	-114.34167687100	P1	Upper Oldman River
Ridge Creek	50.07140595450	-114.39998527800	P2	Upper Oldman River
Salter Creek	50.25684151580	-114.52598609700	P1	Highwood River
Savanna Creek	50.13224292860	-114.59423509600	P1	Upper Oldman River
Scarpe Creek	49.18019970330	-114.26706490400	P1	Castle River
Scarpe Creek	49.23384106360	-114.25623819700	P2	Castle River
Shale Creek	50.01840383850	-114.47528120700	P1	Upper Oldman River
Sharples Creek	49.88584662540	-114.00992182500	P1	Upper Oldman River
Sharples Creek	49.87179550370	-114.09944288200	P2	Upper Oldman River
Sheep River	50.62059571180	-114.69521499800	P1	Sheep River
Silvester Creek	50.80986398080	-114.70699779400	P1	Elbow River
Silvester Creek	50.86615561230	-114.72282042500	P2	Elbow River
Slacker Creek	50.12663506420	-114.57073720000	P1	Upper Oldman River
Smith Creek	49.78547620620	-114.62879076800	P1	Upper Oldman River
Smith Creek	49.80648331610	-114.56924534900	P2	Upper Oldman River
Snowshoe Creek	49.51950589000	-114.57139605100	P1	Castle River
Soda Creek	50.08055245820	-114.66234629700	P1	Upper Oldman River
South Hidden Creek	49.94828674230	-114.64244100600	P1	Upper Oldman River
South Lost Creek	49.39888385140	-114.58250840700	P1	Castle River
South Racehorse Creek	49.75547785150	-114.62825033600	P1	Upper Oldman River
South Twin Creek	50.17353233510	-114.41683491600	P1	Upper Oldman River
Speers Creek	50.05800102540	-114.50432321900	P1	Upper Oldman River
Speers Creek	50.04892784950	-114.43005302200	P2	Upper Oldman River
Spoon Creek	49.75184781940	-114.57526373500	P1	Upper Oldman River

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
Star Creek	49.58382713560	-114.59692936800	P1	Crowsnest River
Star Creek	49.62609750240	-114.53827570300	P2	Crowsnest River
Straight Creek	50.16455373520	-114.64827534100	P1	Upper Oldman River
Syncline Brook	49.29901703260	-114.45081103900	P1	Castle River
Syncline Brook	49.34014384680	-114.42116986200	P2	Castle River
Trail Creek	50.84972886470	-114.86870183900	P1	Elbow River
Unnamed Tributaries to Jumpingpound Creek	50.961377	-114.943988	P1	Jumpingpound Creek
Unnamed Tributaries to Jumpingpound Creek	50.96739	-114.957005	P2	Jumpingpound Creek
Unnamed Tributaries to Rock Creek	49.620742	-114.331051	P1	Crowsnest River
Unnamed Tributaries to Rock Creek	49.633371	-114.321088	P2	Crowsnest River
Unnamed Tributaries to Rock Creek	49.631287	-114.310915	P3	Crowsnest River
Vicary Creek	49.73495712880	-114.57690599300	P1	Upper Oldman River
Vicary Creek	49.75379173790	-114.48861020300	P2	Upper Oldman River
Waiparous Creek	51.39246866420	-115.35578142500	P1	Ghost River
Waiparous Creek	51.28224170980	-114.83683371700	P2	Ghost River
West Castle River	49.20009721940	-114.34369711600	P1	Castle River
West Castle River	49.27931712520	-114.37960665500	P2	Castle River
White Creek	50.03029101940	-114.28234090300	P1	Upper Oldman River
White Creek	49.99470720680	-114.33732502000	P2	Upper Oldman River
Wilkinson Creek	50.16060258110	-114.59787206500	P1	Highwood River
Willow Creek	50.30530065200	-114.42363480600	P1	Willow Creek
Willow Creek	50.26933919670	-114.40986717100	P2	Willow Creek
Wintering Creek	49.84702103890	-114.53307536800	P1	Upper Oldman River
Wintering Creek	49.83879208040	-114.47468921400	P2	Upper Oldman River

Waterbody Name	Latitude	Longitude	Critical Habitat Point	Map
York Creek	49.56175369690	-114.56417999400	P1	Crowsnest River
York Creek	49.60428640450	-114.46927380200	P2	Crowsnest River
Zephyr Creek	50.32735291590	-114.54869301900	P1	Highwood River
Zephyr Creek	50.38991619650	-114.57455470200	P2	Highwood River

Part 2: Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017

Alberta Westslope Cutthroat Trout Recovery Plan 2012 – 2017

Alberta Species at Risk Recovery Plan No. 28

Alberta Westslope Cutthroat Trout Recovery Plan 2012 – 2017

Prepared by:

The Alberta Westslope Cutthroat Trout Recovery Team

Tracey Cove, Operations Lead, Southern Rockies Area, Alberta Environment and Sustainable Resource Development (AESRD)
Jennifer Earle (Co-chair), Fisheries Biologist, AESRD
Lorne Fitch, P. Biol., Environmental NGO Coalition
Matt Holder, Manager, Environment, TransAlta Corporation
Shelley Humphries, Aquatics Specialist, Banff, Yoho and Kootenay, Parks Canada
Ed Kulcsar, Forestry Manager, Spray Lake Sawmills
Brian Meagher, Alberta Biologist, Trout Unlimited Canada
Charlie Pacas, Aquatics Specialist, Banff National Park, Parks Canada
Melanie Percy, Senior Park Ecologist, Kananaskis Region, Alberta Tourism, Parks and Recreation
Shane Petry (Co-chair), Species at Risk Biologist, Fisheries and Oceans Canada
Sean Rogers, Assistant Professor, Department of Biological Sciences, University of Calgary
Rob Staniland, Consultant, Canadian Association of Petroleum Producers
Daryl Wig, Senior Fisheries Biologist, AESRD
Linda Winkel (Secretariat), Fisheries Biologist, AESRD

March 2013

Alberta Government

Publication No: I/604
ISBN No. 978-1-4601-0231-2 (On-line Edition)
ISSN: 1702-4900 (On-line Edition)

Cover photos: J. Earle – Evan-Thomas Creek (top left); M. Coombs – Star Creek (top right); S. Petry (bottom).

For copies of this report visit the Alberta Species at Risk Program web site:

https://www.alberta.ca/species-at-risk.aspx

Or contact:

Information Centre – Publications
Alberta Environment and Sustainable Resource Development
Main Floor, Great West Life Building
9920 – 108 Street
Edmonton, Alberta, Canada T5K 2M4
Telephone: (780) 944-0313 or 1-877-944-0313

This publication may be cited as:

The Alberta Westslope Cutthroat Trout Recovery Team. 2013. Alberta Westslope Cutthroat Trout Recovery Plan: 2012-2017. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 28. Edmonton, AB. 77 pp.

PREFACE

Albertans are fortunate to share their province with a variety of wild species. Most plant and animal populations are healthy and secure. A small number, however, are either naturally rare or imperiled because of human activities. Recovery plans establish a basis for cooperation among government, industry, conservation groups, landowners and other stakeholders to ensure these species and populations are restored or maintained for future generations.

Alberta's commitment to the *Accord for the Protection of Species at Risk* and to the *National Framework for the Conservation of Species at Risk*, combined with requirements established under Alberta's *Wildlife Act* and the federal *Species at Risk Act*, has resulted in the development of a provincial recovery program. The overall goal of the recovery program is to restore species identified as *Threatened* or *Endangered* to viable, naturally self-sustaining populations within Alberta. The policy document Alberta's Strategy for the Management of Species at Risk (2009-2014) provides a broader program context for recovery activities.

Alberta species at risk recovery plans are prepared under the supervision of the Species at Risk Program, Alberta Environment and Sustainable Resource Development. Recovery plans are prepared by recovery teams composed of a variety of stakeholders including conservation organizations, First Nations, industry, landowners, resource users, universities, government agencies and others. Membership is by invitation from the Director of Wildlife Management, and includes representation from a diversity of interests unique to each species and circumstance. Conservation and management of these species is ongoing during preparation of the recovery plan.

Recovery plans are provided by the recovery team as advice to the Minister responsible for fish and wildlife management (the Minister) and to all Albertans. Alberta's Endangered Species Conservation Committee reviews draft recovery plans and provides recommendations to the Minister. In addition, an opportunity for review by the public is provided. Plans accepted and approved for implementation by the Minister are published as a government recovery plan. Such approved plans are a summary of the Department's commitment to work with involved stakeholders to coordinate and implement the conservation actions necessary to restore or maintain Threatened and Endangered species.

Recovery plans include three main sections: background information which highlights the species' biology, population trends, and threats; a recovery section that outlines goals, objectives, and strategies to address threats; and an action plan that delineates prioritized actions required to maintain or restore the *Threatened* or *Endangered* species. These plans are "living" documents that are revised as conditions change or circumstances warrant. Each approved recovery plan undergoes an annual review by which progress of implementation is evaluated. Implementation of each recovery plan is subject to the availability of resources from both within and outside government.

Caring for Cutthroat

Lorne Fitch, P. Biol.

Westslope cutthroat trout now exist on the edges, fringes and margins of their former range. Populations are disconnected from one another and are small enough some are at significant risk of winking out of existence. A combination of things has led to this state: changes in habitat caused by various developments; stocking of non-native trout species, some of which hybridize with cutthroat trout, others that compete with them for space and resources; and, the additive feature of multiple, synergistic cumulative effects. Most of these impacts on cutthroat trout continue to influence the status of the Alberta population, plus climate change is an added concern.

Although cutthroat trout survived and thrived for about 10,000 years the recent, rapid pace of change in as short a period as a human life span has been beyond their ability to cope and evolve. A recovery strategy is a life boat of sorts, in the face of these perils. It is a mechanism to delay the negative trajectory of the population and, over time, allow a modest recovery so the species is not so imperiled and in danger of disappearing from Alberta watersheds.

Why would we, why should we care about cutthroat trout?

Partly because governments, at various levels have committed and are mandated to ensure species do not slip through our fingers, between the cracks and sink beneath our collective consciousness. So legally we have to care.

Morally, to allow a species like cutthroat trout to disappear through apathy, ignorance, inaction or greed would be a blot on our record as stewards of shared resources. These resources have been entrusted to our care, not for our exclusive use and disposal but to pass on, unimpaired, for subsequent generations.

Functionally, protecting and restoring cutthroat populations transcends the fish. Cutthroat trout are a part, a feature of a watershed and an indicator of landscape health. The clarity of the medium cutthroat swim in should jog our sensibilities and remind us of the source of our drinking water. Having cutthroat occupy these watersheds is the gold seal of water quality. The ripples that extend outward from a pebble dropped in a stream containing cutthroat inevitably find us.

All of us, governments, industry, academia, conservationists and the public have a duty to ensure cutthroat trout are allowed to survive and recover. The debate isn't about whether they should be saved but rather how to save them and how quickly we need to act. Two essentials for these fish are place and space - cutthroats and their habitats are intertwined, interconnected and incapable of being separated.

If we can protect some places and spaces for the cutthroat and allow recovery of populations to more robust levels, the intended effects will benefit other species. It may well be that our own

species will need these healthy watersheds with natural expressions of biodiversity and ecosystem services. It truly needs them now!

Touching, seeing or knowing a wild cutthroat trout exists exposes and sensitizes us directly and immediately to the very elements from which we evolved - earth, water, air and other living kin, large and small. A cutthroat trout can help us remember our place in the fabric that connects us and upon which our lives are mysteriously and inextricably linked.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The Alberta Westslope Cutthroat Trout Recovery Team extends its sincere appreciation to many organizations that supported the development of this recovery plan with financial and/or in-kind contributions and to the people who contributed their knowledge and hard work. Portions of the recovery plan were written or informed by Dave Mayhood, Aquatic Ecologist, of Freshwater Research Ltd. and a complete version of the supporting documents has been prepared under separate cover. The recovery team would also like to recognize James Guthrie, formerly Senior Environmental Specialist at TransAlta Corporation for his significant contribution to team discussions. Funding to support Recovery Team meetings was provided by Alberta Environment and Sustainable Resource Development (AESRD), and Fisheries and Oceans Canada. Distribution maps were prepared by Margaret Bradley and Angela Braun of the Southern Rockies Area Resource Information Unit (AESRD). The recovery team would like to thank Jim Stelfox and Matthew Coombs (Fisheries Biologists, AESRD), Richard Quinlan (Provincial Species at Risk Specialist, AESRD) and Diane Casimir (Species at Risk Coordinator, Parks Canada) for their constructive reviews of the plan. The recovery team acknowledges Dr. Eric Taylor (Department of Zoology, University of British Columbia) for his contributions to genetic analyses and related discussions. Finally, the recovery team thanks the numerous individuals and organizations, especially the Alberta Conservation Association, who contributed tissue samples to help further our understanding of genetic issues.

EXECUTIVE SUMMARY

Cutthroat trout are widely distributed throughout much of western North America. There are four major subspecies that show considerable divergence from one other and they exhibit a great deal of phenotypic variation in terms of size, colouration, and life history characteristics. Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) are the only subspecies native to Alberta. Historically, westslope cutthroat trout inhabited most streams in south-western Alberta from the alpine to the prairies. Currently, genetically pure cutthroat trout occupy only a small fraction of their historic range and occur as relatively small, disconnected populations. They are largely restricted to the Rocky Mountains and foothills in the uppermost reaches of mainstem rivers and the extreme headwaters of a few major tributaries.

In fall 2009, the Minister of Environment and Sustainable Resource Development supported the listing of westslope cutthroat trout as *Threatened* under Alberta's *Wildlife Act.* This designation was due to the subspecies' small distribution and continuing decline in extent of occurrence, the severely fragmented nature of populations, continuing decline in quality of habitat, and the presence of barriers to dispersal making immigration between watersheds (and therefore rescue of the Alberta population from other jurisdictions) highly unlikely. The Committee on the Status of Endangered Wildlife in Canada has also assessed the status of westslope cutthroat trout in Alberta and has designated the Alberta population as *Threatened*. In 2013, this population was listed as *Threatened* under the Federal *Species at Risk Act*.

In 2009, a joint federal/provincial recovery team was established for the westslope cutthroat trout to produce a recovery strategy that would meet the needs of both Canada and Alberta. Membership on the recovery team includes representatives from each of the responsible jurisdictions (Fisheries and Oceans Canada, Parks Canada Agency, Alberta Environment and Sustainable Resource Development, Alberta Tourism, Parks and Recreation) and key stakeholders representing a broad range of interests.

The recovery plan has been prepared to guide the management of this *Threatened* species over the next five years and beyond. The goal of the recovery plan is: *"To protect and maintain the existing ≥ 0.99 genetically pure populations at self-sustaining levels and re-establish additional genetically pure populations to self-sustaining levels, within the species historical range in Alberta".* Key objectives of the plan are to: identify and protect critical habitat for the remaining genetically pure populations, improve knowledge of population genetics, size, distribution, and trends, identify opportunities to help recover genetically pure and near- genetically pure populations, increase education and awareness of the species for their conservation, re-establish genetically pure populations in sites within their historical range, and determine the role that introduced genetically pure westslope cutthroat trout may play in the recovery effort.

To help achieve this goal and meet the objectives, four general approaches are proposed: research, monitoring, management and regulatory actions, and education and outreach. Within each of these, a number of strategies and actions to implement them are outlined with the aim to protect and manage the species and to reduce or eliminate threats to its survival. The recovery plan will undergo periodic review during its designated life span of five years, after which it will be updated as needed

1.0 INTRODUCTION

1.1 Provincial and National Status

In December 2007, Alberta's Minister of Environment and Sustainable Resource Development (the Minister) approved listing the westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) as *Threatened* under Alberta's *Wildlife Act* based on the recommendations from the Endangered Species Conservation Committee (ESCC). The species was formally listed under Schedule 6 of the Alberta Wildlife Regulation in fall 2009. This designation was due to the subspecies' small distribution and continuing decline in extent of occurrence, the severely fragmented nature of populations, continuing decline in quality of habitat, and the presence of barriers to dispersal making immigration between watersheds (and therefore rescue of the Alberta population from other jurisdictions) highly unlikely.

The national status of westslope cutthroat trout was reviewed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2006 (COSEWIC 2006a, 2006b). Two designatable units for the species were formalized at the time, consisting of one population in British Columbia, and one population in Alberta. This determination was made on the basis of the marked difference in conservation status and distinctive ecozones inhabited by the two groups, and the lack of current dispersal opportunities between them (separated by the Rocky Mountains). It should be noted that this assessment includes only genetically pure native populations of the species (i.e., where genetic analyses elucidate that 99% of a population's genome originates from westslope cutthroat trout) occurring within their historical range. The population in British Columbia was designated as Special Concern by COSEWIC due to habitat loss and degradation, as well as competition and hybridization with introduced species. The British Columbia population is listed as Special Concern on Schedule 1 of the Federal *Species at Risk Act* (*SARA*) (February 2010).

In Alberta, COSEWIC determined that genetically pure populations of westslope cutthroat trout, once found in a wide range in Alberta, have become severely isolated and depressed in response to a variety of factors including habitat loss and degradation, exploitation by anglers, and competition and hybridization with introduced species. It was therefore recommended that the Alberta population be listed as *Threatened*, and this designation was made under *SARA* in 2013.

1.2 Recovery Team

In 2009, a joint federal/provincial recovery team was established for the westslope cutthroat trout to produce a recovery strategy that would meet the needs of both Canada and Alberta. Membership on the Alberta Westslope Cutthroat Trout Recovery Team (herein, the recovery team) includes representatives from each of the responsible jurisdictions (Fisheries and Oceans Canada, Parks Canada Agency, Alberta Environment and Sustainable Resource Development, Alberta Tourism, Parks and Recreation) and key stakeholders including Trout Unlimited Canada, the University of Calgary, TransAlta Corporation, Spray Lake Sawmills, the Canadian Association of Petroleum Producers, and a consortium of non-government environmental conservation groups. The Alberta Fish and Game Association and Representatives from Treaty 7

First Nations were also invited to participate as members of the recovery team but declined. The primary role of the recovery team is to develop a recovery plan that consists of a broad based recovery strategy accompanied by an action plan which details how specific components of the recovery strategy will be implemented. The recovery team may have an ongoing role in overseeing, monitoring, and evaluating the implementation of the recovery plan.

2.0 SPECIES BIOLOGY

Most of the information in this section is specific to the westslope cutthroat trout subspecies. However, surrogate data describing other subspecies of cutthroat trout have been used where necessary. Several terms related to species biology and genetic description have been defined in a glossary located at the end of the document.

2.1 Species Description

Cutthroat trout exhibit a great deal of phenotypic variation in terms of size, colouration, and life history characteristics, which has led to considerable taxonomic confusion. Fourteen subspecies of cutthroat trout are generally recognized (Allendorf and Leary 1988; Behnke 2002). Four major subspecies (coastal, westslope, Lahontan and Yellowstone cutthroat trout) are widely distributed and show considerable divergence from each other. Westslope cutthroat trout are the only subspecies native to Alberta.

In general, cutthroat trout exhibit the streamlined body typical of salmonids, characterized by a terminal mouth, small cycloid scales, and the presence of an adipose fin. Colouration consists of dark spots on a lighter background. Body colour ranges from silver to yellowish-green with lower sides and belly somewhat reddish to bright red in some individuals at spawning time (Nelson and Paetz 1992). A narrow pink band may also be present along the sides of the fish. When present, this is much less prominent than similar markings on the closely related rainbow trout (*Oncorhynchus mykiss*). Bright orange to red slashes in the skin folds along the inner edge of the lower jaw give this fish its common name and distinguish it from other fish. The spotting pattern characteristically forms an arc from the pectoral fin back to the anterior base of the anal fin, with the spots becoming more numerous at the posterior end and concentrated above the lateral line. Spots are also located on the dorsal, adipose and caudal fins (Figure 1). Introgressive hybridization between westslope cutthroat trout and rainbow trout produces a wide diversity of spotting patterns, as well as individuals which may lack the characteristic slash below the jaw, or have a slash which is faded in colour.

Figure 1. Westslope cutthroat trout (photo: S. Petry)

2.2 Genetic Description

Westslope cutthroat trout are subject to introgressive hybridization with closely related species (such as other cutthroat subspecies or rainbow trout) which have been introduced into their range (ASRD and ACA 2006). The ongoing spread of introgression in the wild (e.g., Rubidge *et al.* 2001; Hitt *et al.* 2003; Taylor and Gow 2007) suggests that at least some hybrids survive and are capable of successful reproduction. Hybridization and introgression present significant threats to the persistence of native strains of cutthroat trout due to outbreeding depression (disruption of local adaptation through introduction of foreign alleles) (Miller *et al.* 1989; Rhymer and Simberloff 1996; Allendorf *et al.* 2001).

The genetic population structure of cutthroat and rainbow trout was investigated in Banff and Waterton Lakes National Parks between 1997 and 2002 (Potvin *et al.* 2003). The aim of the study was to determine the relative impact of stocking rainbow trout on the genetic integrity of cutthroat trout populations, as well as determine the genetic structure of the latter populations. The researchers found "low" levels of hybridization between cutthroat trout and rainbow trout in the areas tested. While roughly half of the waterbodies surveyed contained genetically pure cutthroat trout, they were from populations which originated from stocking (i.e., previously fishless lakes). Results of the study also showed that within-population genetic diversity was low but the populations were significantly different genetically, either within or among drainages. Therefore, the authors recommended that they should be managed independently, even for populations that were stocked or founded by stocking. Evidence of hybridization between westslope cutthroat and introduced Yellowstone cutthroat trout was also found as part of the study.

Recent studies have been undertaken in Alberta to investigate the genetic population structure of westslope cutthroat trout (Taylor and Gow 2007, 2009). Genetic diversity at nine microsatellite DNA loci was assayed in trout (*Oncorhynchus* spp.) sampled from localities in south-western Alberta and adjacent British Columbia to investigate the extent of: (i) hybridization and introgression between westslope cutthroat trout and rainbow trout (*O. mykiss*), and between westslope cutthroat trout and Yellowstone cutthroat trout (*O. c. bouvieri*), as well as (ii) population subdivision among genetically pure westslope cutthroat trout populations.

The genetic purity data were summarized by reporting the "westslope cutthroat trout ancestry coefficient" for each fish and the average across the populations of fish analyzed for each locality. The coefficient is an index of the proportion of each fish's genome that originates from westslope cutthroat trout (e.g., "genetically pure" westslope cutthroat trout would have a coefficient = 1.0, F_1 hybrids a value of 0.5 and genetically pure rainbow trout a value of 0).

Analyses of genetic purity in populations outside the national parks indicated that genetically pure populations were well distributed at sites in the Oldman River drainage but were concentrated in a small number of sub-basins in the Bow River drainage, especially in the Highwood River drainage. Genetically pure rainbow trout were generally found in tributaries to lower reaches of rivers and often below impassable barriers. Genetically pure populations of westslope cutthroat trout were usually located in the upper reaches of streams and often above impassable barriers (both natural or man-made).

An initial examination of population subdivision established that an extensive degree of genetic independence among populations exists which appears to be concentrated at the level of individual stream (rather than among major watersheds). This implies some level of demographic independence among these populations, such that they may have individual responses to environmental changes or different management regimes (Taylor and Gow 2007).

Taylor and Gow (2007, 2009) suggested that the actual value of any measure of introgression which is used to define genetic "purity" (e.g., 0.99 versus 0.95, etc) is the subject of some debate (see Allendorf *et al.* 2005; Campton and Kaeding 2005; Taylor and Gow 2007). A study by Muhlfeld et al. (2009a) on non-native rainbow trout and native westslope cutthroat trout showed that small amounts of hybridization markedly reduced fitness of male and female trout, with reproductive success sharply declining by approximately 50%, with only 20% admixture. These results strongly support the view that less or no hybrid content is preferable. A criterion of 0.99 is the most conservative, and is based on the rationale that there is good evidence for natural and historical hybridization between westslope cutthroat trout and rainbow trout (hence a value of 1.0 is not biologically expected) and that such historical effects appear to be at a level of about 0.01 or less (Taylor and Gow 2007). Results of the genetic analyses clearly indicated that few native genetically pure populations still exist in provincial waters, and those that do are often remnant populations isolated above barriers.

For the purposes of this plan, the recovery team decided to define a genetically pure population as one with an average purity of ≥0.99. This means that a small number of hybridized fish may have existed in the sample, however, the overall average of all fish tested was ≥0.99.

COSEWIC guidelines suggest that "populations exhibiting >1% introgression may be considered hybridized and will generally be excluded from COSEWIC status assessments." While the recovery team generally supports adhering to this stringent level of purity, it has also been recognized that slightly hybridized populations (e.g., ≥0.95 but <0.99 on average) may be important for species conservation and recovery. While the emphasis is on protecting the native genetically pure populations, the recovery team acknowledges the importance of introduced genetically pure populations, as well as those exhibiting slight hybridization.

2.3 Life History

Westslope cutthroat trout are highly diverse in their life history. Fluvial and resident populations are common throughout Alberta, as well as some adfluvial populations. Mixed life history strategies may also be present within the same population. Stream-resident westslope cutthroat trout seldom exceed a fork length of 250–300 mm, whereas fluvial and adfluvial fish often attain sizes greater than 300 mm and 0.9–1.4 kg in weight (Shepard *et al.* 1984; McIntyre and Rieman 1995).

Spawning usually occurs in small gravel bottomed streams where the female prepares a redd in the gravel. Males reach sexual maturity as early as two years of age, and females mature as late as five or six years (Scott and Crossman 1973; Nelson and Paetz 1992). The average age at first spawning is two to four years. Spawning takes place between May and July depending on location, and usually occurs when water temperatures reach 10˚C (Nelson and Paetz 1992) (6˚C in high elevation populations; S. Humphries pers. comm.). Incubation is also temperature dependent and generally lasts six to seven weeks. Following emergence, fry migrate to low energy lateral habitats, which are areas with low water velocity and appropriate cover. Cutthroat trout are iteroparous and some may reproduce every year or every alternate year.

Although mortality rates are rarely known and likely vary both within and between different populations, the time of greatest mortality likely occurs early in life, from the egg to juvenile stage (ASRD and ACA 2006). Adult fish are vulnerable to a variety of predators, as well as harvest. In general few adults are thought to survive past five years of age, although in rare cases some fish from unproductive high elevation lakes may live to 12 years (A. Costello pers. comm. 2006 *in* ASRD and ACA 2006).

The diet of westslope cutthroat trout is specialized to focus on invertebrates even in instances when forage fish are abundant (Shepard *et al.* 1984). Chironomid (midges) larvae are an important food source for young-of-the-year fry, while older juveniles and adults feed on a variety of terrestrial and aquatic insects. The most important dietary components for larger size classes are ephemeropterans (mayflies) and dipterans (crane flies etc.). Trichopterans (caddisflies) are an important dietary component for larger fish, and increasing fish size has been correlated to an increasing diversity of diet (Liknes and Graham 1988). Zooplankton can also be an important food source during the winter months (Shepard et al. 1984).

Westslope cutthroat trout exhibit a preference for cooler water temperatures and higher gradient streams than other trout species. This appears to make them a superior competitor at higher elevation stream reaches, supporting the “temperature/elevation refugia” theory for this species (Griffith 1988; Fausch 1989; Paul and Post 2001; Rasmussen *et al.* 2010). Westslope cutthroat trout populations are less likely to coexist with introduced brook trout (*Salvelinus fontinalis*) than with other native salmonids due to the latter’s competitive advantage (Griffith 1988). The introduction of brook trout in a number of locations has resulted in the disappearance of westslope cutthroat trout (Varley and Gresswell 1988; Paul and Post 1996).

2.4 Habitat

In general, habitat requirements consist of cold, clean water and varied forms of riparian and instream cover (such as undercut banks, pool-riffle habitat, and riparian vegetation) (ASRD and ACA 2006, COSWEWIC 2006b). Stream temperature is an important habitat parameter for cutthroat trout. This species is sensitive to changes in water temperature and are not usually found in waters where temperatures repeatedly exceed 22˚C (Behnke and Zarn 1976). Their preferred temperature range is 9 to 12˚C (ASRD and ACA 2006). In Alberta, westslope cutthroat trout historically occupied a variety of habitats ranging from headwater streams and tributaries to mainstem river sections extending out onto the plains. Currently this subspecies is largely restricted to headwater streams and lakes and the upper reaches of mainstem rivers.

Spawning habitat for cutthroat trout consists of small, low gradient streams with unsilted gravels and cold, well-oxygenated water (ASRD and ACA 2006). It often occurs at the downstream edge of deep pools during moderate to high flow events that are short in duration (Brown and Mackay 1995; Schmetterling 2001). Shoal spawning does not appear to be common (e.g., Carl and Stelfox 1989). Cover is also an important requirement, and spawning habitat is characterized by the proximity of large woody debris, boulders, or bedrock.

Rearing for this species occurs in small streams (ranging from first to third order) that remain permanently wetted and offer a diversity of cover. Young-of-the-year cutthroat trout migrate to shallow riffles or backwaters with protective cover and low water velocities, while larger juveniles move into pools.

Adult cutthroat trout utilize a variety of habitats depending on life history type. Resident individuals may remain in their natal stream for their entire life cycle, whereas migratory forms leave small natal streams to move into larger systems or mainstem habitat. Fluvial cutthroat trout frequently occupy pools adjacent to fast water with abundant nearby cover such as undercut banks, boulders or large woody debris. Adfluvial and lacustrine adults inhabit lakes and reservoirs with water temperatures lower than 16 ˚C (McIntyre and Rieman 1995).

The suitability of overwintering habitat for this species is largely determined by the absence of anchor ice and the presence of groundwater influx (Brown and Mackay 1995). During winter months fluvial adults will congregate in slow deep pools sheltered from high flows (ASRD and ACA 2006). Juveniles often overwinter in cover provided by boulders and other large instream structures. Adfluvial fish will often overwinter in lakes.

2.5 Distribution

2.5.1 Global distribution

Westslope cutthroat trout originally occupied parts of Montana, Wyoming, Idaho, Oregon, Washington, British Columbia and Alberta in the upper Missouri, upper Columbia, upper Fraser and upper South Saskatchewan basins in the United States and Canada (Behnke 1992, Figure 2). The Saskatchewan basin cutthroat trout are native only to the upper Bow River and upper Oldman River drainages (McIllrie and White-Fraser 1983 (re 1890); Sisley 1911; Prince *et al.* 1912; Nelson and Paetz 1992).

Figure 2. Original global distribution of westslope cutthroat trout (shaded) Figure modified from AESRD and ACA (2006). Distribution data primarily from Behnke (1992) (see text).

The present global distribution of westslope cutthroat trout is vastly reduced from the historical range. In the United States, just six percent of the original range is still occupied by this species (eight percent if mixed populations holding some unhybridized individuals are counted) (Shepard *et al.* 2003). In British Columbia, genetically-pure westslope cutthroat trout populations were recently found in only 22% of the original range in the upper Kootenay River drainage (Rubidge and Taylor 2005). In Alberta the range currently occupied by westslope cutthroat trout is also severely reduced to approximately five percent of the original range (Mayhood 1995, 2000).

2.5.2 Alberta Distribution

2.5.2.1 Historical Distribution

Westslope cutthroat trout originally occupied the Bow and Oldman River drainages and accessible tributaries (i.e., below waterfalls and other impassable barriers) out onto the plains at least to the current cities of Calgary and Lethbridge, and may have extended downstream into the upper Milk River drainage of Alberta from the Montana headwaters (Figure 3; Prince *et al.* 1912; Behnke 1992). Numerous historical records indicate that these trout were abundant throughout most of the native range in Alberta (Mayhood *et al.* 1997; Mayhood unpublished data).

2.5.2.2 Present Distribution

At present, native westslope cutthroat trout occupy considerably less than five percent of the native range in the Bow drainage, where they appear to be restricted to the extreme headwaters of a few of the major tributaries and the upper mainstem (Figure 4; Mayhood 1995, 2000). The extent of hybridization in various populations has not been firmly established, but is currently under investigation (Taylor and Gow 2007 and 2009; ASRD 2008; Robinson 2008). Many remaining Bow drainage populations within the native range appear to be or are known to be hybridized (McAllister *et al.* 1981; Carl and Stelfox 1989; Strobeck 1994; Bernatchez 1999; Janowicz 2005; Taylor and Gow 2007, 2009; ASRD 2008; Robinson 2008). Nearly all remnant populations are small and isolated (Mayhood 2000; ASRD 2008).

In the Oldman River drainage westslope cutthroat trout still occupy much of the native range in the upper Oldman basin (Figure 4), but have been lost from native waters in the mainstem east of the mountain front and most of its fish-accessible tributaries (Radford 1975, 1977; Fitch 1977–80; Mayhood *et al.* 1997). Westslope cutthroat trout are uncommon to rare in the St. Mary and Belly River drainages and may no longer exist except as hybrids even in the headwaters of these drainages. They have been all but extirpated from their native waters in the Crowsnest River drainage (Fitch 1977–80; Mayhood *et al.* 1997; ASRD 2008).

Distribution of this species in the national parks in Alberta is variable. The only genetically pure populations (in native range) occur in Banff National Park (Figure 4). Other populations in Banff National Park exhibit a range of hybridization or have been extirpated. It is thought that all of the westslope cutthroat trout populations within the historic range of the species in Waterton Lakes National Park are hybridized with either stocked rainbow trout or Yellowstone cutthroat trout (McAllister *et al.* 1981; Potvin *et al.* 2003). In Jasper National Park there are two genetically pure westslope cutthroat trout populations that occur outside the historic range for the species; these populations were stocked, and now potentially threaten Athabasca rainbow trout.

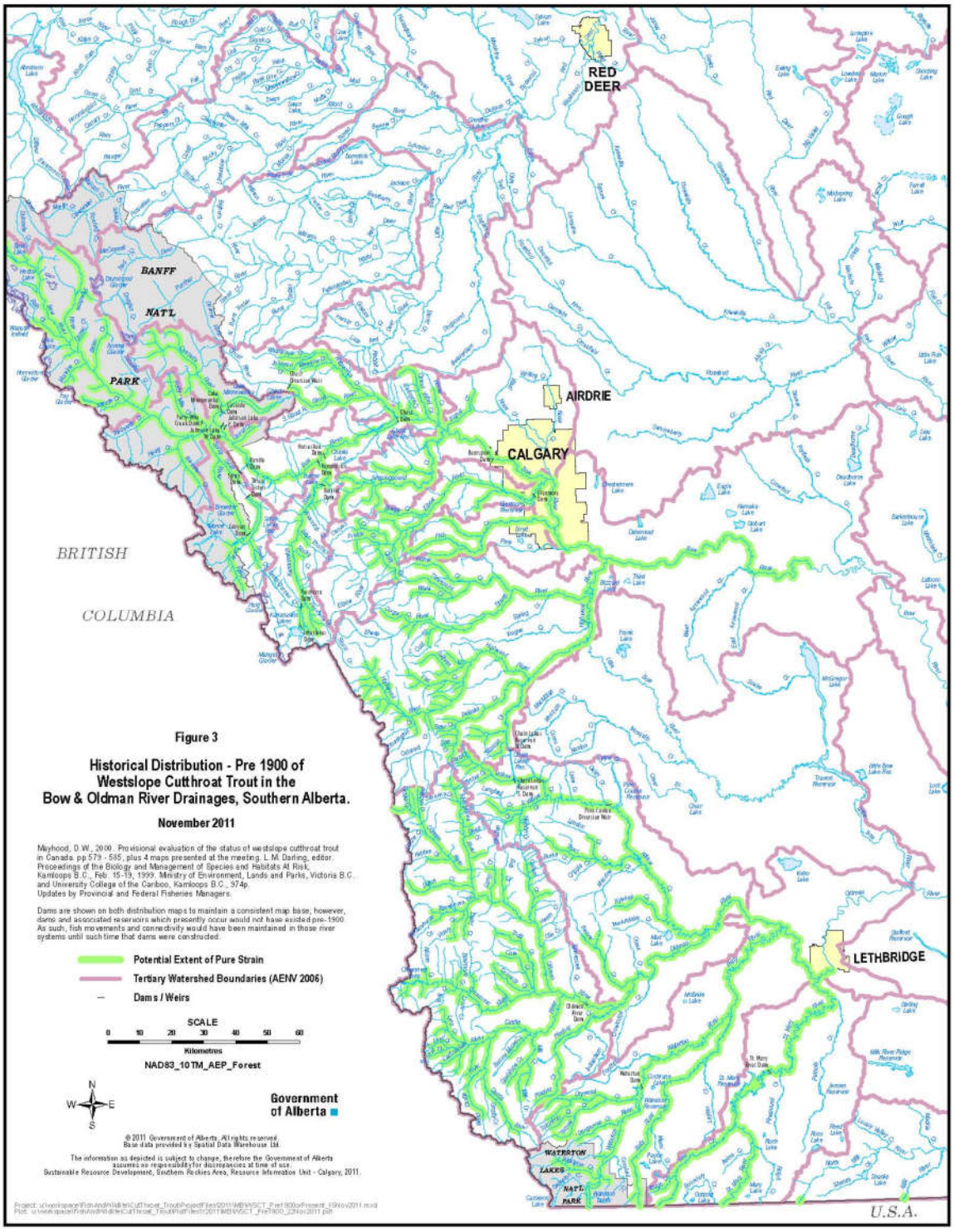

Figure 3. Historical distribution – pre-1900 of westslope cutthroat trout in the Bow and Oldman River drainages, southern Alberta.

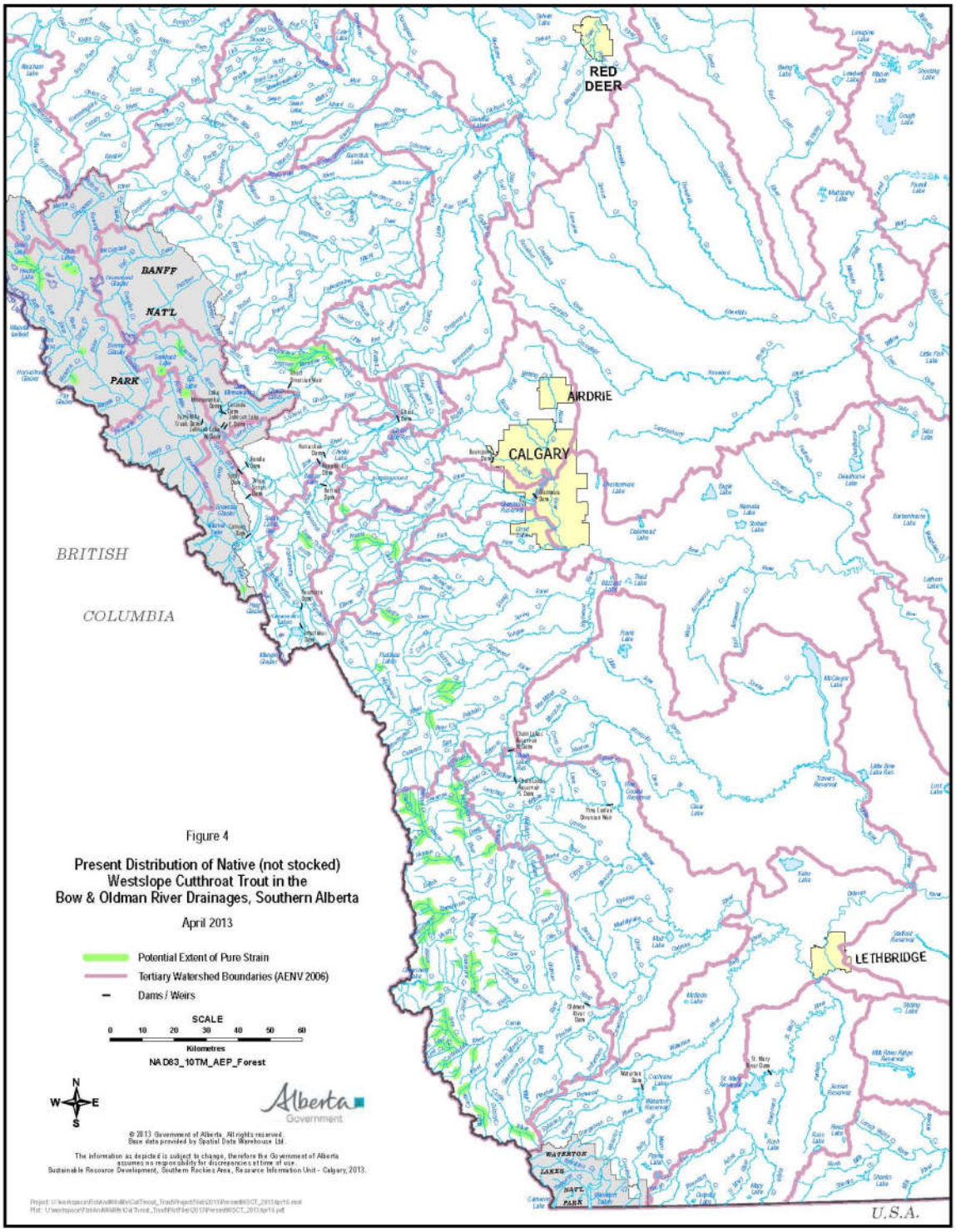

Figure 4. Present distribution of native (not stocked) westslope cutthroat trout in the Bow and Oldman River drainages, southern Alberta.

2.6 Population Size and Trends

2.6.1 Historical Abundance

In Alberta, very large declines in westslope cutthroat trout abundance are evinced by the loss of entire historical populations and the virtual absence of the subspecies from large parts of the documented historical range (Nelson 1965; Mayhood 1995, 2000). Although exact numbers of westslope cutthroat trout for given waterbodies or watersheds are not known, it is estimated that 274 streams or rivers in Alberta historically contained native populations of this species (ASRD and ACA 2006). Numerous historical accounts attest to there being large numbers of westslope cutthroat trout in the streams throughout the native range (e.g., Aldous 1881; Miles 1890; MacMillan 1909; Vick 1913; Miller and MacDonald 1949; Mayhood *et al.* 1997).

2.6.2 Present Abundance

A combination of factors led to the severe depletion of populations of westslope cutthroat trout. Currently, an estimated 51 genetically pure populations of westslope cutthroat trout remain in their documented native range in Alberta. This number is based on the best information available to date and is subject to change pending additional field surveys and genetic work. It should be noted that most of these populations currently occupy only portions of their former range in streams and lakes. The recovery team's definition of a genetically pure population is consistent with the COSEWIC assessment and status report (COSEWIC 2006), in that at a population level there is an average purity of ≥0.99. This means that a small number of hybridized fish may have existed in some of the samples, thereby suggesting a potential threat of further hybridization which will need to be monitored.

In the Bow River basin an estimated minimum of 63 populations have been lost from a combination of factors including habitat changes, competition, and hybridization (Mayhood 2009 and unpublished data). These losses include apparent complete eradication of the species from the Bow River below Lake Louise and the lower mainstems of the Highwood, Elbow, Spray, Jumpingpound, Sheep, and Kananaskis rivers. Extensive hybridization is apparent in the upper reaches of most of these mainstems. In every case genetically pure westslope cutthroat trout are restricted to small habitats in the extreme headwaters. As a consequence, it appears certain that the migratory fluvial and adfluvial life-history forms are no longer present. Only small stream-resident populations are likely to remain.

The situation is similar in the Oldman River basin. An estimate in the order of 49 westslope cutthroat trout populations have been lost, primarily due to hybridization, habitat changes, and competition (Mayhood 2009 and unpublished data). The subspecies appears to be extirpated from the Crowsnest River mainstem, and exists only as heavily-introgressed stocks in the mainstems of the mid to lower Oldman, Belly and Castle rivers. The fluvial and adfluvial life-history forms (at least in their genetically-pure state) have been completely lost from the Oldman River basin. Only small stream-resident populations still exist in the upper headwaters.

Alberta's present total population of wild, native westslope cutthroat trout has been estimated at no more than 5 100 mature individuals (Note: this is down from the 7 000 estimate given in ASRD and ACA (2006) due to the revised smaller number of genetically pure populations). The

estimated average size of each population is 100 (range 30 — 200) mature fish (ASRD and ACA 2006; COSEWIC 2006b). If we accept these estimates, the relevant figures for judging extinction risk for this subspecies in the province therefore would be approximately 51 populations, each comprised of 100 adults. However, applying the average number of mature individuals per population may overestimate the actual number (ASRD and ACA 2006). Furthermore, not every adult will spawn, those that do will not do so every year, and post-spawning mortality appears to be high (Shepard *et al.* 1984; Liknes and Graham 1988; McIntyre and Rieman 1995). Of those that do spawn, a few will be much more successful than others: larger females produce more eggs, for example. As a result of these and other issues, the reproductively effective size is likely much smaller than 100 per population. Based on this, the extinction risk is very high for individual populations of 200 adults or fewer in the absence of human assistance. For additional details and a discussion of extinction risk, see Mayhood and Taylor (2011).

3.0 THREATS AND LIMITING FACTORS

3.1 Overview

Historical human activities are perhaps the single greatest threat and limiting factor confronting native westslope cutthroat trout and their prospects for recovery in Alberta. Historical actions are, in many cases, irreversible, and their consequences have created several intractable problems for conserving this species.

3.2 Threats Assessment

The recovery team undertook a detailed assessment of threats to the species based on both published information and local knowledge. Six primary categories of threat were identified:

- Invasive species
- Adverse effects on habitat
- Consumptive use/exploitation
- Stocking
- Pollution
- Climate change

These threats are not mutually exclusive, and can interact to have cumulative and synergistic effects on the species. A brief description of the methods and assessment of threats is provided in Appendix A. The results are summarized in Table 1 and are discussed in more depth below. A more detailed threats assessment is provided in the technical report prepared by Mayhood (2009).

Table 1. Detailed threats assessment for westslope cutthroat trout in Alberta.

Threat Category	Threat[14]	Activity/ Detail	Likelihood of Occurrence [15,16]	Extent of Occurrence[2,3]	Severity of Impact[2,3]	Immediacy of Impact[3,17]	Threat Significance[2,3]	Mitigation Potential[2,3]	Comments
Invasive Species	Hybridization and competition	Rainbow trout	**H**	**H** **M (NP)**	**H** **M (NP)**	**P,C,F**	**H**	**L**	No stocking currently occurs in areas where rainbow trout could threaten genetically pure remnant westslope cutthroat trout populations but stocking policy to be reviewed. Opportunities to mitigate in stream systems is low but in lakes may be moderate-high.
		Yellowstone cutthroat trout	**H**	**L**	**L**	**P,C,F**	**M**	**L**	Found in some national park waters and in Island Creek (Crowsnest drainage). Severity high for Island Creek population. Opportunities to mitigate in stream systems is low but in lakes may be moderate-high.
		Golden trout	**?**	**L**	**?**	**P,C,F**	**?**	**M**	Four lakes in Castle drainage and possibly in Temple Lake (BNP). Uncertain if lake populations have migrated into downstream systems. Also uncertain if the two species hybridize. Opportunities to mitigate in stream systems is low but in lakes may be moderate-high.
	Competition	Brook trout	**H**	**H**	**H**	**P,C,F**	**H**	**M**	Includes competition, range constriction or elimination of native species. No stocking currently occurs in areas where brook trout could threaten genetically pure remnant westslope cutthroat trout populations but stocking policy to be reviewed. Opportunities to mitigate in stream systems is low-moderate but in lakes may be moderate-high.

[14] Threats are not listed in any particular order.
[15] H= High, M=moderate, L=Low. Codes are further explained in Appendix A.
[16] Where a separate rating is not given for National Parks, the rating is the same inside and outside National Parks, unless the comments indicate this threat does not apply.
[17] P=Past, C=Current, F=Future, ? = data deficient, NP=National Parks). Codes are further explained in Appendix A.

Invasive Species	Competition	Brown trout	**H**	**M**	**M-H**	**P,C,F**	**M** **H (NP)**	**L**	Includes competition, range constriction or elimination of native species. No stocking currently occurs in areas where brown trout could threaten genetically pure remnant westslope cutthroat trout populations but stocking policy to be reviewed. A serious threat where they occur, but more of an issue in medium to large systems e.g., Bow, Kananaskis, Crowsnest, lower Oldman, Waterton rivers.
		Lake trout	**L** **H (NP)**	**L** **M (NP)**	**M** **H (NP)**	**P,C,F**	**L** **H (NP)**	**L** **L-M (NP)**	Lake trout stocked into some waterbodies and others thought to be in native range. Found in Crowsnest, Waterton Lakes as well as in Spray Lakes, Ghost and Bearspaw Reservoirs. Possibly naturally co-occurring in Lake Minnewanka. In reservoirs, native species have typically been reduced in abundance or extirpated. Where the two species naturally co-occur the threat significance is low, however, where lake trout are introduced, the threat significance is high. Bow and Hector lakes mitigation potential is low to moderate.
	Algae	*Didymosphenia geminata*	**?**	**L**	**?**	**C,F**	**?**	**?**	Freshwater algae; single cells are capable of expanding into large mats that can completely cover stream bottoms, reducing available habitat for fish and invertebrates. Insufficient information to further evaluate at this time.
	Pathogens	Parasites	**L**	**L**	**H**	**C,F**	**L**	**M**	Limited information available. Whirling disease is of concern but does not currently occur in Alberta. Moderate mitigation potential in terms of introduction of pathogen. If whirling disease were to enter Alberta, the waters most likely to be affected would be the lower portions of watersheds, as opposed to the headwater streams where most of the remaining westslope cutthroat trout populations are found (see text for explanation).
Adverse Effects on Habitat	Changes in flow	Dam/Reservoir operation	**H**	**M** **H (NP)**	**H**	**P,C,F**	**H**	**L-M**	Loss of riverine and spawning habitat, transform flow regime in downstream habitats, reduce downstream flow (e.g., irrigation dams and weirs), decreased high flows and increased low flows, decreased movement of stream bed material and LWD. Depends on purpose i.e., power, municipal, irrigation. Possible future dams and diversions.
Adverse Effects on Habitat		Forest removal - harvest	**H**	**M-H** **L (NP)**	**M** **L (NP)**	**P,C,F**	**M-H** **L (NP)**	**M**	Increased peak flow, altered snow interception and melt processes, increased run-off, increased summer temperatures (due to changes in channel form i.e., widening of channel and shallower) and reduced late summer and winter flows. Appropriate riparian buffer

									width required. Uncertainty regarding effects of changes in flow depending on timing of change. Severity may change depending on space and time.
		Forest removal - fire	**H**	**H** **L (NP)**	**L-H** **L (NP)**	**P,C,F**	**M-H** **L (NP)**	**L**	Increased summer temperatures. Ratings would depend on forest fire severity.
		Water extraction – surface and groundwater	**H**	**M**	**M** **L (NP)**	**P,C,F**	**M-H** **L (NP)**	**M-H** **M (NP)**	Snow making, gas plants, hydrostatic testing, instream construction (upset). Uncertainty for groundwater extraction which could result in high threat significance, unknowns concerning connectivity between ground and surface water.
	Sedimentation	Forest harvest, linear disturbance, grazing, OHVs, recreational access, instream construction, municipal run-off	**H** **M (NP)**	**H** **L (NP)**	**M-H** **M (NP)**	**P,C,F**	**H** **L (NP)**	**M-H** **H (NP)**	Especially a problem if occurs in or upstream of spawning areas. Potential for high severity impact on small, isolated populations. Use of OHVs as an activity is unpredictable, therefore, the extent and severity are hard to assess.
	Habitat loss	Dam and reservoir creation	**H** **H (NP)**	**M**	**M-H**	**P,C,F** **P,C (NP)**	**M-H**	**L-M**	Associated with dams, smaller scale water storage, often stocked with non-native species, often low productivity, water level fluctuations destroy littoral zone. Destroy fluvial spawning habitats. Resulting in decreased bedload movement to areas downstream, as well as lack of scouring flows to clean fines out of substrate. Severity moderate to high – extirpation could be related to combination of introduction of non-native species and habitat loss. Mitigation potential could be moderate for any new dams or reservoirs (location, fish passage).
Adverse Effects on Habitat	Habitat fragmentation (loss of connectivity)	Dams, culverts	**H**	**H**	**H**	**P,C,F**	**H**	**L-H**	Block upstream and/or downstream fish movements. Loss of migratory life history forms (fluvial, adfluvial). Inability to access habitats to meet all life history requirements. Mitigation potential is low for dams but moderate to high for culverts. Consider impassable barriers that separate natives and non-natives before initiating corrective actions.

	Habitat alteration and loss	Linear disturbance (e.g., roads, pipelines, railway, OHVs, recreational trails, culverts)	**H**	**H**	**H**	**P,C,F**	**H**	**M**	Increased surface erosion and run-off, fine sediment deposition, increased access, physical loss of habitat from construction and use (e.g., footprint), barriers to movement (e.g., impassable culverts). Impact of each linear disturbance may be local but cumulatively can result in significant overall negative effects on habitat quality and quantity.
		Grazing	**H**	**H**	**M**	**P,C,F**	**M**	**M**	Riparian disturbance, changes to stream structure, fine sediment delivery. Common land-use throughout species range. Can result in redds being trampled or silted in and destruction of riparian habitat and undercut banks. Typical entry/exit dates for cattle grazing are early June to mid-October. Not applicable to national parks.
		River training	**H**	**L**	**M-H**	**P,C,F**	**M**	**M**	Bank armouring, channelization from a variety of causes e.g., road crossings, protection of property, flood prevention, urban areas. Loss of high quality habitat (e.g., undercut banks, sweepers and log jams). Extent of occurrence and severity are high in urban areas.
Consumptive Use/ Exploitation	Harvest	Intentional mortality	**M** **L(NP)**	**L**	**L**	**P,C,F** **P (NP)**	**L**	**H**	Legal harvest. Catch-and-release, size limits implemented for sensitive fisheries. Most harvest permitted on stocked fisheries.
		Incidental or accidental mort	**H**	**M** **L(NP)**	**L-M?**	**P,C,F**	**L?**	**M**	Hooking mortality of released fish, fish misidentification resulting in harvest, scientific sampling. Uncertainty around angler pressure.
		Illegal (poaching)	**H**	**M**	**L-M?**	**P,C,F**	**L-M?**	**M**	Consider potential for closing fisheries to result in increase in poaching and illegal introductions. Could also include angler misidentification.
Stocking	Current legal stocking of native fish	Westslope cutthroat trout	**L**	**M**	**L**	**C,F**	**L**	**H**	Stocking on top of native populations may have occurred in the past but records are frequently unreliable or unavailable. Stocking is currently limited to high mountain lakes or beaver ponds with no or limited connectivity to downstream habitats but stocking policy to be reviewed. Likelihood of occurrence is rated high as a result of past stocking practices which have had an unknown effect on some populations. Not applicable to national parks.

	Current legal stocking of non-native fish	Rainbow trout, brook trout, brown trout	**H**	**M**	**M-H**	**C,F**	**L**	**H**	Severity high as a result of past stocking practices. No stocking currently occurs on top of or upstream of existing genetically pure remnant westslope cutthroat trout populations. However, it may occur in a few areas where populations are already severely hybridized or where triploid fish are used. Stocking policy to be reviewed. No stocking in national parks.
	Illegal stocking of non-native fish	Many potential species	**H** **L (NP)**	**M** **L (NP)**	**L-H** **L (NP)**	**P,C,F**	**L-H** **L (NP)**	**M** **H (NP)**	Depends on the species, locations of introductions. Could compromise small systems currently dependent on a barrier.
Pollution	Water quality and fish habitat degradation	Point source - includes accidental spills associated with road/rail and pipeline crossings	**H**	**L-H**	**L-H**	**C,F**	**M**	**L-M**	Effects depend on substance released, location of spill, potential to mitigate impacts.
		Non-Point source - surface run-off (e.g., road salt, incr. nutrients as a result of fires)	**H**	**M**	**M**	**P,C,F**	**M**	**M**	High flows, agricultural and urban run-off, elevated sediment, nutrients etc.
Climate Change	Climate change and severe weather	Increasing temperature trend, altered flow regimes, droughts, high flow events	**H**	**H**	**M-H**	**C,F**	**M-H**	**L**	Changes in water temperature, basin hydrology, channel morphology, riparian habitat, stream flows, habitat quality and availability, competitive advantage to non-native fish. Threats evaluation based on modeling scenarios for changes in mean annual precipitation and temperature from 2020s to 2080s. See Mayhood (2009) for details. Severity range based on various modelling scenarios. Depends on location and timing of changes.

3.2.1 Invasive Species

Invasive species may include fish or species such as algae or pathogens. Mechanisms by which non-native invasive species may be (or have been) introduced into westslope cutthroat trout habitat include the legal or illegal stocking of fish and the unintentional translocation of invasive species.

3.2.1.1 Fish Species

A number of invasive fish species threaten the continued existence of native westslope cutthroat trout populations and limit prospects for recovery of the subspecies. They impact westslope cutthroat trout through hybridization, introgression, competition, predation, or possibly as vectors and reservoirs of parasites and agents of disease.

Rainbow Trout

Rainbow trout are the single greatest threat to the continued existence of native westslope cutthroat trout stocks in Alberta. Early trout hatcheries were established in Banff (1913), Jasper (early 1920s) and Waterton Lakes (1928), with the first trout hatchery in the province, outside the national parks, established in 1936 in Calgary (Nelson and Paetz 1992). All of these hatcheries contributed trout for introduction into the native range of westslope cutthroat trout in Alberta (Department of Marine and Fisheries 1914; Mayhood 1992; Nelson and Paetz 1992). When native cutthroat trout eggs proved to be difficult to obtain in sufficient numbers (around 1914 to 1920; see Department of Marine and Fisheries (1914) and subsequent annual reports), the more readily-produced hatchery stocks of rainbow trout were used and distributed widely on top of the depleted cutthroat trout populations. Rainbow trout readily hybridize with westslope cutthroat trout and produce fertile offspring which can then interbreed among themselves and with either parental species. In many cases the ultimate outcome of this process is a fully-introgressed hybrid population called a hybrid swarm.

While genetically pure westslope cutthroat trout appear to be competitively superior in cooler headwaters, they appear to be inferior competitors to rainbow trout and rainbow-cutthroat hybrids in warmer waters, where rainbows trout and hybrids dominate (Paul and Post 2001; Robinson 2007; Muhlfeld *et al.* 2009c; Rasmussen *et al.* 2010). As a result, genetically pure westslope cutthroat trout stocks are now almost exclusively confined to small, higher elevation headwater streams. The populations are small and isolated from each other, making rescue effects unlikely and increasing susceptibility to extirpation from the effects of inbreeding and stochastic events. In national parks, most of the native westslope cutthroat trout populations are found in headwater lakes and above barriers or are in tributary streams above barriers. Based on this, competition from brook trout is the larger concern.

Yellowstone Cutthroat Trout

Yellowstone cutthroat trout likewise introgressively hybridize with westslope cutthroat trout in a similar manner as do rainbow trout. Yellowstone cutthroats, however, appear to be less effective in competition with westslope cutthroat trout, which suggests that the hybrids of the two subspecies may likewise be weaker competitively than the native westslope cutthroat stocks. In Glacier National Park, Montana, introduced Yellowstone cutthroat trout have been unable to replace or significantly hybridize with native westslope cutthroat trout in any lake in which the

latter is indigenous (Marnell *et al.* 1987). The non-native subspecies has successfully colonized only small, high-elevation lakes in that park that were previously barren of fish. Similarly, Yellowstone cutthroats have been singularly unsuccessful in colonizing waters throughout North America and elsewhere, despite 818 million eggs being shipped from Yellowstone National Park for this purpose (Varley and Gresswell 1988). Yellowstone cutthroats are less competitive in a number of respects in comparison to rainbow trout in laboratory experiments (Seiler and Keeley 2007a, b, 2009). Hybrid populations of westslope cutthroat and Yellowstone cutthroat subspecies are primarily found in Banff and Waterton Lakes National Park waters. However, the degree to which they may be invasive is unknown (Taylor and Gow 2007).

Golden Trout

Golden trout (*Oncorhynchus mykiss aguabonita*) have been introduced into four lakes in the Castle River drainage and possibly into Temple Lake in Banff National Park. While golden trout and westslope cutthroat trout are closely related, it is unknown if they hybridize in these systems, and it is also uncertain if lake populations have migrated into downstream systems.

Brook Trout

Brook trout are also a non-native invasive species. Some populations have greatly expanded their range in certain watersheds over time, while other populations have not (Adams *et al*. 2000, 2001; Peterson and Fausch 2003; Carlson *et al*. 2007). If successful, brook trout may displace -- and often replace, native salmonids -- especially various subspecies of cutthroat trout (Behnke 1992; Stelfox *et al.* 2001; Peterson *et al.* 2004; Fausch 2007; McGrath and Lewis Jr. 2007; Peterson *et al.* 2008; Earle *et al.* 2010 a, b). The mechanism of replacement may sometimes be related to differential susceptibility of native cutthroat trout to harvest (MacPhee 1966; Stelfox *et al.* 2001; Paul *et al.* 2003), because this species is notably susceptible to anglers (MacPhee 1966; Schill *et al.* 1986; Varley and Gresswell 1988; Stelfox *et al*. 2001). Displacement mechanisms involve competition effects from brook trout on survival of cutthroat trout at early life-history stages (Shepard *et al.* 2002; Peterson *et al.* 2004; McGrath and Lewis Jr. 2007), and high immigration from well-established brook trout populations, typically situated downstream (Peterson *et al.* 2004; Benjamin *et al.* 2007), but sometimes from populations stocked into headwater lakes (Adams *et al.* 2001). They can be particularly difficult to eradicate, but successful attempts have yielded greatly increased numbers of native westslope cutthroat trout in some cases (Shepard *et al.* 2002). As such, brook trout populations within Alberta's westslope cutthroat trout native range are a serious threat to the continued existence of westslope cutthroat trout populations.

Brown Trout

Brown trout are an invasive species that have replaced westslope cutthroat trout in certain native habitats, notably the lower-gradient, larger, and warmer mainstem rivers to which the former seem largely to be confined. The mechanism of exclusion (if it exists) is not clear, but several possibilities have been suggested in the literature. These include competition between early life stages for habitat (Griffith and Smith 1993) and more aggressive behaviour observed by juvenile brown trout during interactions with juvenile cutthroat trout (Wang and White 1994). Cutthroat trout are also much more susceptible to angling than are brown trout (Behnke 1992). In the US Southwest, brown trout are a serious predator of at-risk Rio Grande cutthroat trout, Gila trout and

Apache trout (Rinne and Calamusso 2007). The evidence of this literature survey and additional studies reviewed in Mayhood (2009) strongly suggest that brown trout can exclude or seriously reduce cutthroat trout populations where the two occur together, both through competition and predation. There are nevertheless some indications that the two species can coexist in some circumstances despite these negative impacts (Aitken 1997; Hepworth *et al*. 2001). Attempts to restore native westslope cutthroat trout to those habitats currently occupied by brown trout would likely be limited by the presence of this species.

Lake Trout

Lake trout are native to parts of Alberta but have also been introduced into lakes and reservoirs in westslope cutthroat trout range. Lake trout are believed to be native in headwater lakes of the South Saskatchewan River drainage including Waterton Lake and Lake Minnewanka (Donald and Alger 1993). From the latter, they are thought to have migrated further down the Bow River and taken up residence in the Ghost and Bearspaw Reservoirs. This species was also stocked into the Ghost Reservoir between 1948 and 1952. They were introduced into Crowsnest Lake as well as into Spray Lakes Reservoir, where they were stocked numerous times between 1951 and 1987 to provide recreational fishing opportunities. In lakes and reservoirs where lake trout have been introduced, native species including westslope cutthroat trout have typically been reduced in abundance or are extirpated (AESRD file data; Schindler and Pacas 1996; Anderson *et al.* 1996; Pacas and Hunt 2004).

3.2.1.2 Algae and Pathogens

The freshwater algae *Didymosphenia geminata* are capable of expanding into large mats that can completely cover stream bottoms, reducing available habitat for fish and invertebrates. This species has been documented in the upper Bow River in Banff National Park and in the upper reaches of the Oldman watershed, including in the Waterton and Belly Rivers, and tributaries in Waterton Lakes National Park (Kirkwood *et al.* 2007; B. Johnston, pers. comm.), as well as in the Bow River near Calgary (Kirkwood *et al.* 2007). Unlike most other bloom-forming algae, it proliferates under high water quality (i.e., low turbidity and low nutrient) conditions. Analysis of three years of data from one study river (Red Deer River) revealed consistently higher *D. geminata* cell densities at a dam site compared to the upstream reference. In regards to the link between dam proximity and *D. geminata* occurrence, the overarching mechanism is likely lower discharge velocities and less variation in discharge. Currently, there is insufficient information to further evaluate the threat of this species to westslope cutthroat trout.

Whirling disease (caused by the myxosporidean *Myxobolus cerebralis*) is of particular recent concern because it is strongly pathogenic to cutthroat trout (Hedrick *et al.* 1998), although there is some variation in the susceptibility among different stocks and subspecies (Wagner *et al.* 2002; DuBey *et al.* 2007). This pathogen is not currently in Alberta but is widespread in Montana waters immediately south of remnant cutthroat trout stocks in Alberta, and it has been feared that the organism would soon invade Alberta trout waters (e.g., via mud on waders and angling equipment) (Gates *et al.* 2007). Whether or not it could become a major threat to Alberta native westslope cutthroat trout populations if it became established here is unclear. Headwater streams where the remnant westslope cutthroat trout populations now exist are not likely to hold the obligate intermediate host (*Tubifex tubifex*) which reaches significant populations mainly in mud substrates of lower-elevation mainstem rivers. Should *M. cerebralis*

enter Alberta waters, it may present an additional obstacle to restoring mainstem fluvial cutthroat trout populations by further isolating populations in headwater reaches.

3.2.2 Adverse Effects on Habitat

Issues associated with habitat loss/degradation include changes in flow, sedimentation, habitat loss (including river training), habitat fragmentation, and grazing. Since these issues can be the result of multiple activities and land uses, and in turn these activities themselves frequently have more than one impact, separating the individual impacts is complex. A cumulative effects analysis with related range of natural variability reference points will inform the discussion. An overall assessment of habitat related threats is provided below and a breakdown by detail is provided in Table 1. For a more detailed assessment of habitat-related threats, including a summary of major dams in westslope cutthroat trout habitat and their effects and limits on recovery and restoration, see Mayhood (2009).

The westslope cutthroat trout range in Alberta is heavily impacted by human land-uses. Linear disturbance density (a good measure of the intensity of land use) within the native range in Alberta is high — among the highest observed in western North America (Sawyer and Mayhood 1998; Alberta Environment and Olson + Olson Planning and Design 1999). One consequence is that stream channels in most watersheds are at moderate to high risk of damage from the combined effects of increased peak flows and increased surface erosion as a result of forestry, oil and gas, urbanization, mining, recreation and other land-uses. There are many examples of actual damage to westslope cutthroat trout habitat due to linear disturbances throughout the native range, including within national parks (e.g., TransCanada Highway, Canadian Pacific Railway; see Taylor and Helms 2008; Blank and Clevenger 2009). At-risk basins have been at risk for many decades to as much as a century. Many channels have probably been damaged for a long time, so restoration success may be both more difficult and less likely. In some cases additional changes have happened in those channels such that returning them to pre-impact conditions may not be possible.

Higher road densities have been associated with reduced population densities of cutthroat trout (Eaglin and Hubert 1993), including the westslope subspecies (Valdal and Quinn 2010; Dunnigan *et al*. 1998; Huntington 1998), as has higher watershed surface disturbance (Shepard 2004). Fine sediment deposition in spawning areas, barriers to movement such as hanging culverts, cutoff side channels, channel straightening and rerouting, and improved access for anglers may be the most important proximate causes of reduced cutthroat trout population densities associated with watershed surface disturbance and roads.

Roads are the principal source of fine sediments to streams, typically being much greater than that from all other land management activities combined (Furniss *et al.* 1991). Measures of road development in watersheds commonly are correlated with the amount of fine sediment deposition in streams (Shepard *et al.* 1984; Leathe and Enk 1985; McCaffery *et al.* 2007). Problems often arise at crossings of small, intermittent, and ephemeral headwater streams (Shaw and Thompson 1986; Chamberlin *et al*. 1991), because protection for such minor watercourses may be given less priority. Unfortunately small headwater streams or the headwater mainstems into which they drain are disproportionately important ecologically (Chamberlin *et al.* 1991),

often providing important habitat for cutthroat trout (Rosenfeld *et al.* 2000, 2002; Robinson 2008).

Even small increases in fine sediment loading to spawning areas can cause dramatic losses of early life-history stages of salmonids (Weaver and Fraley 1993; Irving and Bjornn 1984, cited by Weaver and Fraley 1993). Fine sediment levels in the substrate are a major limitation (natural or otherwise) on the carrying capacity of streams for westslope cutthroat trout. Fine sediment deposition is thus a major limiting factor affecting the recovery prospects of westslope cutthroat trout.

Road culverts represent a major artificial limitation on stream carrying capacity for westslope cutthroat trout (Furniss *et al.* 1991; Eaglin and Hubert 1993). Improperly placed and obstructed culverts are very common, blocking fish access to the upstream stream network. If fish cannot move past culverts to complete their life-history the amount of habitat lost is potentially very large. For example, a survey of 188 crossing locations assessed for fish passage in Banff National Park found that 55 percent were full barriers, 36 percent were partial barriers, and only 9 percent were passable to salmonids (Taylor and Helms 2008). Conversely, barrier culverts may protect remnant westslope cutthroat trout stocks above them from non-native rainbow, brook and brown trout. For this reason it will be important to carefully evaluate the function of every existing barrier before a decision is made to remove it or make it passable as part of westslope cutthroat trout restoration efforts.

Protection and management of westslope cutthroat trout involves the management of public access and trails for recreation. In particular, use of off-highway vehicles (OHVs) can result in sedimentation, physical destruction of stream habitats and riparian areas, and increased angler access where trails run along or cross streams. Current land management practices in Alberta allow for OHV activity that is largely unpredictable through space and time, therefore the extent and severity of effects are difficult to assess.

Forestry operations take place throughout the east slope watersheds where westslope cutthroat trout occur. Potential impacts on aquatic ecosystems can include changes in flow (at macro and micro scales), water storage (as groundwater), water temperature, sediment, access, riparian impacts, and sources of large woody debris. The impacts of some of these (e.g., sediment, road access) have been discussed above. Flow-related changes which have been reported in the literature (Meehan 1991; Brewin and Monita 1998; Peterson 2011) include increased peak snowmelt, increased spring run-off (Beaudry 1998), increases in suspended sediment and channel widening (McCleary *et al.* 2004). The effects and severity of flow-related changes will depend on timing and spatial extent. Other effects reported in the literature may include changes in water temperature (e.g., increased mean temperatures; Macdonald *et al.* 2003), changes to invertebrate communities (e.g., decreased invertebrate diversity and abundance; Clare and Bothwell 2003), and changes in the availability and transport of large woody debris (Hauer *et al.* 1999).

Dams are another major threat and limiting factor affecting westslope cutthroat trout recovery. Dams block movements of fish both upstream and downstream, transform upstream habitats from running water to standing water, substantially transform flow regimes in downstream

habitats, and reduce downstream flows (in the case of irrigation dams and diversion weirs), among many other effects. Reservoirs are often heavily stocked with non-native fishes to mitigate the loss of native stocks. Dam maintenance activities or catastrophic failure can result in either de-watering downstream riverine sections or in extreme flushing flows while work is undertaken within the dam or generation facility. These events may be more common in the future as these facilities age and require major upgrades. All of these effects have the potential to severely disrupt fish populations, and have done so to native westslope cutthroat trout populations in Alberta.

Ten major dam projects now modify native westslope cutthroat trout habitat in the Bow River basin, and four more do so in the Oldman (Mayhood 2009). Dams could be proposed in the native range in response to increased demand for water and summer streamflow reductions arising from climate change. As well, there are many smaller dams on tributaries in the Oldman and Bow river basins, and a very large number of impassible road culvert crossings of streams that have many of the effects of dams. All of these dams have seriously affected native westslope cutthroat trout habitat, populations, and range. All pose limitations on the possibilities for recovering the subspecies.

Grazing livestock (cattle) has impacts on riparian integrity, channel form, and fine sediment delivery, which are well-known within the Alberta native range of westslope cutthroat trout (Adams and Fitch 1995; Paul and Boag 2003) and elsewhere (Gresswell *et al.* 1989; Platts 1991; Armour *et al*. 1994; Wohl and Carline 1996). Grazing is a common land use throughout the native range outside of national parks, so habitat damage from that source could be widespread within the native range of westslope cutthroat trout in Alberta. However, actual impacts in Alberta have not been measured.

River training includes bank armouring and channelization. It can be the result of a variety of activities such as road crossings, protection of property, and is especially severe in urban areas. These activities can result in significant losses of high quality habitat such as undercut banks, sweepers and log jams. This practice eliminates habitat diversity thus negatively impacting westslope cutthroat trout.

3.2.3 Consumptive Use/Exploitation

Current angling regulations are highly restrictive, and would appear to permit very little legal harvest of native or potentially native remnant populations, in part because of high minimum size limits in many stream populations that make them effectively catch-and-release only fisheries. There is a question of whether the size limits have some undesirable selective effects which would require further research to evaluate. However, it is likely that harvests (legal and illegal) are promoted by some of the highest road densities in western North America (Sawyer and Mayhood 1998; Alberta Environment and Olson + Olson Planning and Design1999), which make nearly all remnant populations easily accessible. Angling regulations (since 1993) in Banff National Park and Waterton Lakes National Park (modified in 2011) prohibit the retention of native cutthroat trout from all waters at any time. In Jasper National Park, the total catch and possession limit for cutthroat trout is two.

Recent simulations of angling effects on small-stream westslope cutthroat trout populations under various regulatory scenarios (Sullivan 2007) suggest that presently depressed cutthroat trout stocks could recover under catch-and-release management that allows only low angler effort. Healthy populations of westslope cutthroat trout could be maintained through the use of angler education and catch-and-release angling if fishing effort is no more than moderate. It would be important to limit accidental hooking mortality and illegal harvest to maintain and recover these populations. For a more detailed assessment of angling regulations and angling-related impacts, see Mayhood (2009).

3.2.4 Stocking

Massive numbers of fish were removed from streams and rivers by almost every conceivable means in the earliest years of European settlement. Brook trout and rainbow trout, then brown trout, lake trout, and Yellowstone cutthroat trout, all of them not native to the region, were introduced on top of native westslope cutthroat trout stocks. As a result, the remnant native fish were permanently displaced, replaced or hybridized out of existence. In Banff National Park 1 686 different fish stocking events resulted in over 38 million fish and fish eggs being deposited into 249 different waterbodies within the Bow River watershed (C. Pacas, pers. comm.). This severe manipulation of the fisheries resource constitutes a major factor limiting both the opportunities and the probability of success of many recovery actions.

In addition to stocking of non-native species, westslope cutthroat trout have also been stocked into previously fishless waters, as well as on top of existing native westslope cutthroat trout populations. In some cases records of past stocking efforts and locations are unreliable or unavailable making it difficult to assess the extent of the threat.

3.2.5 Pollution

Point sources of pollution include accidental spills associated with road/rail and pipelines particularly at stream crossings. The inadvertent release of a toxic substance at or near a stream crossing could have serious consequences. The extent and severity of any damage to the aquatic community including westslope cutthroat trout and their habitat would depend on the substance, the amount released, the location of spill, timing of the spill, and the potential to mitigate impacts.

Non-point sources of pollution may include surface run-off such as road salt, sediment and increased nutrients (e.g., as a result of fires). Similar to point sources of pollution, the extent and severity of damage to the aquatic community would depend on the substance and amount, location deposited, time of year and the potential to mitigate the impacts.

3.2.6 Climate Change

Alberta (and the planet as a whole) is presently experiencing an increasingly variable but warmer climate. These changes are expected to alter the habitat and biotic interactions of remnant westslope cutthroat trout stocks.

Measured air temperatures across the prairies have increased an average of 1.6°C since 1895, with more extensive regional warming over the last 50 years, particularly in certain winter and spring months (Sauchyn and Kulshreshtha 2008 *in* Mayhood 2009). There have been large

contemporary decreases in Rocky Mountain glacier extent, mass, and water yield over the same period (Schindler and Donahue 2006). This is a serious issue because in the Bow River basin, glaciers provide a large proportion of streamflow during summer, when flows would otherwise be low and declining.

These climate changes suggest warmer fall, winter, and spring temperatures combined with higher precipitation during those seasons (more precipitation as rain). Fall streamflows might be somewhat higher, and peak spring runoff may also be higher and earlier. Higher-volume peak spring streamflows in particular can be expected to change stream channel morphology and the physical structure of the riparian zone. In contrast, higher summer temperatures combined with perhaps lower summer precipitation implies higher evapotranspiration, less runoff and lower summer streamflows. The higher air temperatures will shorten winters, lengthen summers, shift spring to start earlier and shift fall to start later. Even slightly higher air temperatures will have disproportionately strong physical and ecological effects when baseline air and water temperatures ordinarily would be close to the freezing point, as they are in spring and fall (Mayhood 2009).

Climate change is both creating and interacting with other changes in watersheds in ways that will negatively impact westslope cutthroat trout habitat. Warming climate is expected to increase the frequency, intensity, and extent of wildfires, increase drought frequency, and is believed to be enabling (in part) the recent outbreak of mountain pine beetle infestations in Alberta (British Columbia Forest Practices Board 2007; Sauchyn and Kulshreshtha 2008). Major effects of these changes are to increase runoff and soil erosion from affected watersheds (Beschta *et al.* 1995; Karr *et al*. 2004; Rhodes 2007). A current policy to salvage log and pre-emptively remove beetle-infested lodgepole pine on Alberta's east slopes is likely to exacerbate this issue with increased peak runoff and soil erosion (fine sediment deposition) from the killed forests (Beschta *et al.* 1995; Karr *et al.* 2004; British Columbia Forest Practices Board 2007; Rhodes 2007). Differences in effects may occur between fire-killed stands (if under severe burning conditions that burn off all lesser vegetation and duff) and beetle-killed stands that still retain all the lesser vegetation and duff that can filter out silt from surface flow.

The climate model scenarios examined for the prairies (Lemmen *et al.* 2008; Sauchyn and Kulshreshtha 2008) suggest that there will be substantial changes in the near future to basin hydrology, channel morphology, riparian physical structure and streamflows in westslope cutthroat trout native range in Alberta, particularly in the 2050s to at least the 2080s, and probably well beyond. Since trout are poikilotherms ("cold-blooded"), higher temperatures will directly affect every biological function of westslope cutthroat trout, including their physiology, behaviour, life history functions, interactions with invasive species, responses to habitat features, and exploitation. These changes may already have been initiated, and are now unavoidable. Uncertainty exists as to how westslope cutthroat trout will adapt to these changes. Land use planning requires informing land users how to make westslope cutthroat trout habitats more resilient to climate change.

4.0 CRITICAL HABITAT

Habitat that is important for the survival and recovery of westslope cutthroat trout in Alberta is referred to in this document as "critical" habitat. Although not a requirement for imperiled species listed pursuant to the Alberta *Wildlife Act*, the identification of critical habitat for *Threatened* and *Endangered* species is a requirement of the federal *Species at Risk Act* (SARA).

For the Alberta population of westslope cutthroat trout, critical habitat was discussed in detail by the recovery team and has been identified to the extent possible, using the best information currently available. The approach taken by the recovery team to identify critical habitat was an area of occupancy approach which means that all areas currently occupied by genetically pure-strain populations within historic range would be considered critical habitat (see section 2.5.2.2). The decision was based primarily on the small number (of both individuals and populations) and the small size and limited distribution of areas still occupied by genetically pure-strain westslope cutthroat trout. However, the current areas identified will be insufficient to achieve the recovery goal for this species. As such, a schedule of studies will be included in the federal document that is consistent with the associated research items in the action plan. Critical habitat for this species would be further discussed and refined as part of the federal recovery strategy for the Alberta population of westslope cutthroat trout.

An important component of critical habitat is the absence of hybridization. Muhlfeld *et al.* (2009b) indicated that the timing and location of spawning is critical in determining the potential for hybridization. Their study provided evidence that hybridization increases the likelihood of reproductive overlap in time and space, promoting extinction by introgression. Genetically pure-strain populations are not currently subject to genetic swamping by rainbow trout, therefore, the areas occupied by genetically pure-strain populations are critical to the survival and recovery of this species.

5.0 KNOWLEDGE GAPS AND RESEARCH NEEDS

5.1 Biology

Populations chosen for recovery and restoration work require careful life history studies to identify potential problems with the proposed conservation activity, and to serve as a baseline for monitoring to determine the success of the project. This will include collecting information on population structure (e.g., size and age distribution, size at maturity, number of adults, survival of early life stages), as well as life history characteristics such as determining the existence of remnant populations of fluvial and adfluvial fish.

5.2 Habitat

Although general habitat requirements for this species are well described, information is required to describe habitat attributes and geographic locations that constitute critical habitat (e.g., spawning and overwintering areas). Planned recovery actions could involve manipulating habitat by placing barriers within stream sections. It would be particularly important to understand the target populations' use of the habitat being manipulated as well as any peripheral effects to other species (such as whether the population is going to be cut off from critical habitat). Baseline information needs to be collected on habitat use, as well as biophysical and chemical parameters of westslope cutthroat trout habitat.

A complete inventory of barriers to upstream fish passage is needed. This is important for two main reasons: 1) to know where genetically pure populations might be secure from upstream invasion of non-natives and 2) to gain a better understanding of connectivity issues for future recovery actions. For example, there are a number of research questions which should be addressed including whether there are barriers (natural or man-made) that will prevent populations from being reconnected, and if it is desirable to try and eliminate some barriers if reconnecting populations means potential for invasion by non-natives.

One of the best opportunities to salvage critical westslope cutthroat trout populations at immediate risk may be to introduce them into secure, unoccupied habitat. Such locations (usually lakes and streams above barriers to dispersal) are becoming increasingly rare as the common Spray/Marvel/Job Lake stock is distributed into such locations by stocking. This activity should now stop, and a thorough and comprehensive inventory of the remaining secure habitats should be completed. These locations need to be reserved (a) as fish-free refuges for species unable to coexist with fish, such as many invertebrates (b) as benchmark ecosystems, and (c) as potential refuge sites for imperiled populations of westslope cutthroat trout and other threatened taxa.

5.3 Distribution and Abundance

The most urgent data requirement is to complete surveys to identify all remaining unhybridized populations of westslope cutthroat trout in Alberta. This will give managers a clear idea of what

populations remain to work with, which populations need protection, and what type of protection is required. Conservation of these populations has the highest priority because there is every reason to believe that most remnant stocks are at very high risk of extirpation, but have high value for future recovery of lost and at-risk populations. Baseline information is needed for these populations to evaluate population size and trends and evaluate the possibility of using some genetically pure populations to aid in recovery. Based on recovery targets and modeling, the minimum viable population sizes required to persist over *x* generations needs to be defined.

Additional survey work is needed to identify and characterize the distribution and status of hybrid populations, the degree of hybridization, and its conservation implications. Surveys should also be conducted of the distribution and status of Alberta populations outside of native range. Surveys of these populations should be conducted to determine their origin, genetic and conservation status, their life histories and use of the occupied habitat. Some of these populations may prove to be of great value as the only remaining examples of certain stock types, such as fluvial migratory life-history types.

5.4 Threats

Some potential threats cannot be fully evaluated because information on stressors and the mechanisms by which they affect westslope cutthroat trout are not well understood. Insufficient information exists on the effects of the following on westslope cutthroat trout populations:

- Location of populations with respect to various land-use activities and their extent, including a measure of road density and an assessment of the number and condition of existing road and trail crossings and evidence of riparian damage;
- Impacts of angling-related mortality and illegal mortality (e.g., poaching) on the recovery of westslope cutthroat trout;
- Water quality and habitat effects from development (e.g., siltation at watercourse crossings), trail use, and natural events (e.g., fire, *D. geminata*);
- Extent and risk associated with various water withdrawals (e.g., hydrostatic testing);
- Impact of water impoundments (e.g., changes to water temperature and flow regime) on westslope cutthroat trout habitat;
- Effects of timber harvest on hydrologic response at fine scales, and responses of stream flows and potential sedimentation during various periods for westslope cutthroat trout;
- Cumulative effects;
- Analysis and trends on a landscape/watershed scale;
- Spatial variation of hybridization. For example, in the absence of an impassable barrier, why are some streams in similar geographical areas more hybridized than others? This would involve an assessment of differences in physical habitat, chemical parameters or biological characteristics of populations which may make some populations more or less susceptible to widespread hybridization; and
- Current status of threats. This needs to be evaluated specifically relative to each of the remaining genetically pure populations, so populations can be prioritized for protection and the most pressing threats can be addressed.

5.5 Sources of Uncertainty

Sources of uncertainty were examined as part of the Recovery Potential Assessment conducted by Fisheries and Oceans Canada (Cleator *et al.* 2009). The main points are summarized below.

While a concerted effort has been made in recent years to obtain genetic information on westslope cutthroat trout to estimate the degree of introgression at the population level, there are still some uncertainties. Small sample sizes, limited spatial and temporal sampling and evolving genetics methods have contributed to this problem. There has been debate in the literature about what threshold is appropriate for deciding that an individual fish or population is genetically pure versus hybridized. Also, advanced-generation backcross hybrids with introgression levels greater than 1% can look indistinguishable from genetically pure westslope cutthroat trout, and past estimates of introgression levels are "snapshots" and can change with time.

6.0 RECENT CONSERVATION AND MANGEMENT EFFORTS

A number of activities related to conservation and recovery of westslope cutthroat trout have already been completed or are ongoing, and are described below:

- Extensive genetic sampling has been conducted since 2006 in the Bow and Oldman river drainages to delineate the distribution and genetic status of westslope cutthroat trout populations;
- As part of the above studies, habitat data have been collected, including habitat limitations such as degraded riparian areas or water quality issues;
- Catch-per-unit-effort statistics have been generated for those populations sampled;
- Population estimates have been conducted at several sites using removal-depletion or mark-recapture methods;
- Barrier surveys have been conducted at a subset of streams to locate barriers to upstream fish passage, particularly where barriers are preventing upstream migration of non-native species;
- Thermographs have been used to collect temperature data at several sites found to be fishless during surveys and which may have potential as refuges;
- A non-native brook trout suppression project on Quirk Creek has been ongoing (since 1995) to monitor changes in fish composition and abundance in attempt to restore native cutthroat trout and bull trout;
- Angling regulations in Waterton Lakes National Park (modified in 2011) prohibit the retention of westslope cutthroat trout from waters with native or genetically pure introduced populations; and
- A fact sheet describing the westslope cutthroat trout has been completed by Fisheries and Oceans Canada and is available to the public.
- In 2009 seventy-six sites were sampled for *D. geminata* in the seven mountain national parks. The study included sites that were expected to be near pristine as well as a number of focal or test sites. Most sites (67 of the 76) were positive for *D. geminata* presence. Additional genetic work for the samples is underway at the University of Calgary.

- Genetic sampling of genetically pure individuals in certain areas is being followed up with a genome-wide approach to characterize permeability of the westslope cutthroat trout genome and identify the genes that differentiate genetically pure and hybrid individuals. Genetically pure individuals that are profiled will be integrated in a recovery colonization strategy.
- The upper Corral Creek watershed in Banff National Park will be the site of a pilot multi-year restoration proposed to commence in 2011. The project will have three objectives: 1) secure a downstream westslope cutthroat trout population that is at risk of brook trout invasion from a headwater lake and stream, 2) re-establish westslope cutthroat trout in the headwater lake and stream above a natural waterfall barrier, and 3) test feasibility of new genetic tools to salvage genetically pure fish from a high density stream resident population with low levels of introgression.
- The genetic integrity of westslope cutthroat trout in the Cascade River watershed, Banff National Park, is being restored following their hybridization with rainbow trout. The Cascade watershed contains a viable population of westslope cutthroat trout, but with varying degrees of introgression. The source of rainbow trout genes is a small headwater lake that creates the potential for these fish to disperse downstream and further compromise westslope cutthroat trout genetics. A multi-year project has begun to remove the rainbow trout and hybrids. The specific objectives of this project are: 1) secure genetically pure westslope cutthroat trout downstream of Rainbow Lake from further risk of hybridization, 2) develop phenotypic tools to identify rainbow trout x cutthroat trout hybrids, and 3) create a new population of westslope cutthroat trout by stocking Rainbow Lake with genetically pure westslope cutthroat trout from a neighbouring lake.
- A second location in the front country of Banff National Park is also being restored. Cascade Creek is a small creek that flows out of Minnewanka Dam. This creek contains exclusively brook trout. These brook trout are confined to Cascade Creek by an upstream dam and a downstream barrier. However, their removal and subsequent replacement with genetically pure westslope cutthroat trout will secure an additional population of cutthroat trout in Banff National Park.
- In 2011 and 2012, riparian health inventories were conducted by the Alberta Riparian Habitat Management Society (Cows and Fish) on several reaches of streams containing westslope cutthroat trout. These inventories form key benchmarks for physical habitat condition.

7.0 RECOVERY STRATEGY

7.1 Core, Conservation and Sportfishing Populations

It is clear that genetic considerations are a major issue to be addressed as part of the recovery strategy. The number of genetically pure populations in Alberta is exceptionally small and the strategy has to address the role of hybridized, introduced genetically pure and hatchery-sustained populations in recovery efforts. In order to adopt a consistent approach to describe the status, priority and management options for populations, the recovery team has decided to use three categories for classifying populations of westslope cutthroat trout. A similar approach has been adopted for cutthroat trout subspecies in the United States (MCTSC and MCTTC 2007 and

RYCTCT 2009). While genetic status is one of the criteria used to determine the class of a population, it is not the sole determinant and populations may be classed as *Conservation* populations (see below) provided they are considered potentially recoverable.

In the context of this document it should be clarified that the term *Sportfishing* population applies to those populations that are managed primarily for the benefit of recreational fisheries. This is not to imply that the other categories of populations will not be open to angling opportunities, but this will be determined on a population specific basis.

The criteria used to define the three categories of populations are described below:

- **Core population** - a population that has no evidence of recent or contemporary introgression as determined by genetic testing (i.e. ≥0.99 genetically pure on average). Populations should be within native range (i.e., did not originate from stocking) and be self-sustaining. These populations can potentially serve as donors of fish or gametes for restoration efforts. These populations should not receive genetic material from other population sources unless there is evidence that loss of fitness, reduced reproduction, or reduced survival has put the population in jeopardy. As stocking records are unclear or ambiguous in many instances, professional judgment will also be considered for some populations, (i.e., where stocking has occurred on top of genetically pure, native populations or where a stocking location is unclear such as above or below a barrier).

- **Conservation population** – a naturally self-sustaining population of native westslope cutthroat trout that is managed to preserve the unique ecological and behavioural traits of the subspecies. This may include populations with limited hybridization, ideally just below that of *Core* populations but ones which suggest high conservation value with various criteria making it potentially recoverable (e.g., habitat conditions, barriers, status of non-native species). These populations may have migratory or adfluvial life history forms, be adapted to unique environments, be the least introgressed populations within a geographic area, or have distinctive phenotypes or behaviours that local experts deem important enough to conserve. This category may include introduced genetically pure populations both inside and outside of native range if they do not fit under *Sportfishing* populations but have high conservation value. In some circumstances *Conservation* populations may be managed through periodic stocking for the purpose of maintaining a genetic refugium, or when "genetic swamping" is being attempted to increase the purity level of the population.

- **Sportfishing population** – a wild or hatchery-sustained westslope cutthroat trout population that is managed primarily for the benefit of recreational fisheries and only stocked into waters where they cannot negatively affect *Core* or *Conservation* populations. However, populations classified as *Sportfishing* populations, especially extant wild populations, may have conservation value, but their value is uncertain or of lower priority than the *Core* or *Conservation* populations based (for example) on level of hybridization. This category could include genetically pure stocked populations in previously fishless areas (such as lakes) and hybridized populations. Populations may or

may not be self-sustaining and as such, may be supplemented or maintained solely by stocking. This category may include populations both inside and outside of native range.

7.2 Biological and Technical Feasibility

It must be realized that neither this recovery plan nor any other regulatory or voluntary planning effort will result in complete restoration of westslope cutthroat trout throughout their historical range. Many of the threats that have led to the current status of westslope cutthroat trout in Alberta are irreversible. For example habitat loss, through dams and flow controls and introductions of non-native species, have eliminated westslope cutthroat trout from portions of their range (especially in mainstem rivers) or compromised their genetic integrity due to introgression. Because of the size and complexity of the waters where these introduced species have become established it may not be technically possible to remove non-native species from many of them. For some waters it may not be socially acceptable to remove non-native fish even if their removal is technically feasible. Therefore, this recovery plan strives to reduce threats to the viability of westslope cutthroat trout by concurrently protecting, restoring, establishing, and expanding westslope cutthroat trout populations to ensure their long-term persistence in Alberta. A similar approach has been proposed for the state of Montana and this preamble is borrowed from a recent Conservation Agreement (MCTSC and MCTTC 2007).

Notwithstanding the above commentary, the following criteria are considered to form the basis from which the recovery team made a recovery feasibility determination.

1. Individuals of the species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Although specific population numbers have not been obtained, it is likely that there are sufficient individuals available that are capable of successful reproduction to improve abundance in core populations of fish that exist. These core populations mostly contain a small number of adults and the size of adult fish is very small compared to fluvial or adfluvial fish. Therefore it can be expected that smaller females equate to fewer and smaller eggs. Ideally, increasing reproductive potential would be achieved by increasing the number of adults, provided that habitat is not a limiting factor. Mortality rates are not known but early life stages are highly sensitive to environmental disturbance, especially sedimentation. As a result, protection from environmental disturbance could increase population numbers. It is important to recognize that this species exhibits three life history strategies – stream resident, fluvial, and adfluvial. Currently, the last two types are largely absent in native range. Opportunities to re-introduce fluvial and adfluvial populations are limited and the feasibility is uncertain.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Suitable habitat for westslope cutthroat trout itself is not likely limiting in terms of biophysical parameters; however, limits exist relative to the presence of non-native fish in these habitats. As a result, finding suitable habitat for re-introduction will be difficult and will include examining areas where non-natives are present at low enough levels that it might be feasible to suppress

them and re-introduce westslope cutthroat trout, or supplement existing populations. It may also be feasible to introduce westslope cutthroat trout into barren waters as refuges, but this will have to be carefully examined in each case. Reconnecting habitat will also be examined but will have to consider allowing access to non-natives. As cold-water salmonids, westslope cutthroat trout are sensitive to changes in water temperature. Climate change may further limit the species' distribution in the future by rendering some habitat unsuitable (Robins 2009).

3. The primary threats to the species or its habitat can be avoided or mitigated.

The potential for mitigating threats identified for the westslope cutthroat trout ranges from low to moderate, except for a small number of threats for which mitigation potential is high. There is uncertainty surrounding the mitigation of some threats such as climate change. The potential impact from many of the habitat related threats may be reduced, or eliminated, if appropriate regulatory reviews and management actions are exercised, and using current best management practices (e.g., standards in the Enhanced Approval Process (EAP), operating conditions in Operating Ground Rules (OGR) for forestry) as applied to existing or proposed projects. However, some threats cannot be easily mitigated (i.e., presence of dams) and this puts severe constraints on the species recovery in some areas. Non-native invasive species and hybridization are also a major problem. The potential for successfully eradicating these threats is low to moderate in most systems where they already exist. In most cases where genetically pure populations exist, the threat mitigation will be to ensure non-native species do not invade systems where they are not already present. Targeted removal of non-native species (complete removal or suppression) will be evaluated in systems which might have some chance of success.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Many of the techniques likely to be contemplated for the conservation of westslope cutthroat trout populations are well-founded in current science and management practices. The focus of recovery efforts should be on protecting habitat of existing genetically pure populations, augmenting the size of these populations (e.g., through transfers of fish or increasing available habitat quality and quantity or implementing catch-and-release regulations), and preventing non-native species introductions where they do not already exist, or managing non-natives where possible through reduction or elimination.

In considering recovery of westslope cutthroat trout it is necessary to make the distinction between population maintenance and population recovery. The reality is that maintenance will be the objective for some populations, while for other populations, the objective will be recovery. Given the above analysis, maintenance and recovery of the westslope cutthroat trout is deemed to be biologically and technically feasible across parts of its native range and for some life history types, but restoration of westslope cutthroat trout throughout their historical range is not feasible.

7.3 Guiding Principles

The recovery and management of westslope cutthroat trout in Alberta will be guided by the following principles:

- A cooperative approach with stakeholders (e.g., anglers, land managers, landowners, industry, and other agencies) is essential to the success of the recovery plan. It is recognized and acknowledged that all stakeholders have a role to play in protecting and restoring westslope cutthroat trout.
- It is necessary to prevent the further loss of habitat or individuals.
- Actions necessary to achieve the goals of the recovery plan should not be impeded by lack of information or scientific certainty.
- The recovery process will be guided by the concept of adaptive management, wherein specific actions are implemented, evaluated, and altered to ultimately improve the outcome. This process should include recovery actions and projects that are designed using scientific principles with peer-reviewed proposals and monitoring programs.

7.4 Recovery Goal

As discussed in the preceding section, complete restoration of westslope cutthroat trout throughout their entire historical range is not considered feasible. The recovery goal and objectives reflect that for some populations the focus will be on maintenance, while for others, a recovery or restoration approach will be pursued. As such, the recovery goal for westslope cutthroat trout is as follows:

Protect and maintain the existing ≥ 0.99 genetically pure populations (currently believed to be approximately 51) at self-sustaining levels, and re-establish additional genetically pure populations to self-sustaining levels, within the species' historical range in Alberta.

7.5 Recovery Objectives

A number of objectives are proposed to meet the maintenance and recovery goal and address threats to the survival of the species. The recovery objectives are as follows:

1. Identify and protect critical habitat for remaining genetically pure populations.

2. Improve knowledge of population genetics, size, distribution, and trends.

3. Identify opportunities to help recover genetically pure and near- genetically pure populations of westslope cutthroat trout, partly by restoring habitat and eliminating or suppressing populations of non-native fish that are having negative impacts on westslope cutthroat trout.

4. Increase education and awareness of westslope cutthroat trout for their conservation.

5. Re-establish genetically pure populations of westslope cutthroat trout in sites within their historical range that recognizes the diversity of their life history strategies in Alberta. While the recovery team discussed a target number of populations, it was decided that too many unknowns currently exist (e.g., feasibility of recovering populations in areas with non-natives and success of suppression efforts) to provide a realistic number at this time.

6. Determine the role that introduced genetically pure westslope cutthroat trout may play in the recovery effort.

7.6 Recovery Approaches and Strategies

Strategies proposed to address the identified threats, and to guide appropriate research and management activities to meet the recovery goal and objectives, are discussed under the broader approaches of:

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

Each strategy has been designed to assess, mitigate, or eliminate specific threats to the species; to address information deficiencies that might otherwise inhibit species recovery; or to contribute to the species' recovery in general.

7.6.1 Research

Sound scientific knowledge must form the basis of any recovery efforts for the westslope cutthroat trout. Information gaps regarding life history, biology, genetics, habitat requirements, population structure and abundance, and threats exist and need to be addressed to refine the recovery strategy and ensure that the species is adequately protected in Alberta. It is implicit in strategies R1-R3 that they may include populations which exhibit some degree of hybridization. To address the need for scientific research, the following strategies are recommended:

R1. Elucidate life-history requirements and characteristics: Conduct studies to understand the life history, ecology, current distribution within native range, population dynamics and population structure (e.g., number of mature fish) of westslope cutthroat trout.

R2. Elucidate habitat requirements: Conduct studies to determine biophysical attributes of habitat required seasonally by each life stage of the westslope cutthroat trout, with a specific focus on identifying habitat attributes and geographic locations that constitute critical habitat for the species. This will include habitat characteristics (e.g., barriers, temperature) that limit the intrusion of non-native species.

R3. Improve knowledge of population genetics: Complete surveys and genetic analyses to characterize genetic status of westslope cutthroat trout populations throughout native range. This should include consideration of the degree of population subdivision among genetically pure populations.

R4. Develop population models: Conduct studies to establish reliable population models, including population viability estimates, as well as appropriate surrogate measures relying on relative abundance, presence/absence and population structure data.

R5. Conduct feasibility studies of recovering populations within historical range: Evaluate the feasibility of re-establishing populations of diverse life-history strategies, as well as increasing current population levels.

R6. Identify and understand limiting factors: Conduct studies to better understand the potential threats associated with human activities including water regulation, connectivity/fragmentation, land-use practices, resource extraction, species introductions, climate change, angling and cumulative effects.

R7. Clarify distribution and status of introduced populations within and outside of native range: Surveys of these populations should be conducted to determine their origin, genetic and conservation status, their life histories and use of the occupied habitat. Some of these populations may prove to be of great value as the only remaining examples of certain stock types such as fluvial migratory life-history types.

7.6.2 Monitoring

Regular monitoring, with appropriate frequency, intensity, and methodology is necessary to establish trends in abundance of westslope cutthroat trout, as well as to describe the availability and quality of habitats once identified. The following strategies are recommended to address monitoring needs:

M1. Population monitoring: Develop an appropriate monitoring protocol to track relative abundance, population estimates, population structure, distribution, genetic status, and habitat use for westslope cutthroat trout as well as non-native species.

M2. Habitat monitoring: Develop an appropriate protocol to monitor physical and chemical environmental parameters, including water temperature and habitat conditions.

M3. Monitor effectiveness of mitigation and restoration measures: Refine or develop protocols to monitor the effectiveness of applied mitigation and restoration measures for threats.

7.6.3 Management and Regulation

Management and regulatory actions are necessary to protect the westslope cutthroat trout and its habitat. Such actions will assist in reducing or eliminating identified threats, including habitat loss and degradation, and the introduction of non-native species. Because the recovery strategy is focused on both maintenance and recovery, approaches should focus on ways to maintain and protect the species, as well as recover populations in historic range. Recommended strategies include:

MR1. Limit the spread of non-native species: Where non-native species are negatively influencing remaining populations of westslope cutthroat trout, targeted removal or suppression of non-natives should occur where feasible. This strategy should also include evaluating the use of migratory barriers to protect the genetically pure westslope cutthroat trout from invasion by non-native species.

MR2. Apply mitigation measures for threats: Evaluate current practices and associated threats to westslope cutthroat trout at both site and landscape/watershed scales, with a view to refining or developing mitigation measures as well as consideration of management and/or regulation changes. Avoidance of negative impacts is the first, best, (and sometimes only) option for mitigating impacts on westslope cutthroat trout.

MR3. Stocking program rationalization: Reduce or eliminate the potential for stocking-related impacts to westslope cutthroat trout.

MR4. Sportfishing regulations: Evaluate existing sportfishing regulations for effects on westslope cutthroat trout, as well as opportunities to permit angling, especially for the targeted removal of non-native species.

MR5. Recover populations within historical range: Based on the results of the feasibility studies, recover populations of diverse life-history strategies within historical range. This would include both re-establishing populations of diverse life-history strategies, as well as increasing current population levels, distribution and connectivity.

MR6. Intergovernmental cooperation: Work with federal and provincial agencies co-operatively to implement the recovery plan.

MR7. Data conservation and management: To provide continuity and the ability for future reference, all samples and information (historical, current and future) must be appropriately preserved and/or archived within known repositories.

MR8. Manage and reduce footprint of human activities: Apply cumulative effects considerations to manage effects of resource extraction, land and water use. Improve land-use planning through application of monitoring and evaluation results *(e.g., Land-Use Framework, Water for Life strategy, Cumulative Effects Management Framework, and Integrated Land Management).*

7.6.4 Education and Outreach

Educating anglers, the general public, industry, and governments is essential to gain acceptance of, and compliance with, the overall recovery strategy. Support can be gained through increased awareness of the westslope cutthroat trout and through involvement in stewardship programs. The following strategies are recommended:

E1. Improve awareness of the species: Develop and distribute information describing the species and its needs, as well as the need for the recovery strategy with a variety of forums and methods *(e.g., mandatory fish ID testing for a harvest license in the Eastern Slopes Region).*

E2. Encourage stakeholder participation: Promote and encourage stakeholder involvement in stewardship initiatives.

E3. Facilitate information exchange: The exchange of information with regard to research, recovery, and management activities related to the westslope cutthroat trout should be facilitated among researchers, stakeholders, and fisheries agencies from across the historic range of the sub-species.

E4. Discourage species introductions: To prevent species introductions that threaten existing populations of westslope cutthroat trout and recovery efforts, develop and support education programs that heighten awareness of this issue.

8.0 ACTION PLAN

8.1 Introduction

The actions outlined in this action plan are in support of the goal of the Recovery Strategy: *"Protect and maintain the existing ≥ 0.99 genetically pure populations, and re-establish additional genetically pure populations to self-sustaining levels within the species' historical range in Alberta."* Some emphasis of this action plan is focused on increasing knowledge of the species' life history, population structure, and locations of genetically pure-strain fish and habitat requirements in Alberta. This information is needed to further define and refine habitat for the species, and to improve threat assessment and mitigation.

It is expected that the recovery plan, as well as information collected to address the identified data gaps, will provide guidance for preparation of operational plans at a regional or watershed level. These more detailed plans would address the specific actions necessary to protect and maintain each population. Such plans would involve classification of existing populations into categories (i.e. *Core, Conservation,* and *Sportfishing* populations) and level of threats (or risk of extirpation), as well as recommendations for specific management actions based on an assessment of the likelihood of success.

The following sections outline the recommended actions the recovery team deemed necessary to address the objectives of the recovery strategy. These sections have been organized by strategy. The Implementation Schedule (Section 9) following these sections prioritizes actions, links them to objectives, provides timeframes, and identifies the lead agency for each action. If westslope cutthroat trout are listed pursuant to the federal *Species at Risk Act,* a permit must be obtained from the Minister of Fisheries and Oceans and/or the Minister responsible for the Parks Canada Agency prior to engaging in any activities potentially affecting westslope cutthroat trout or its habitat (refer to Section 73 of *SARA*). This includes some of the research and monitoring activities highlighted in this section, and any instream activities that may impact the species.

8.2 Research

The recommended actions related to research focus on gaining a better understanding of species biology, population genetics, habitat requirements, and improving understanding of threats. It is implicit in strategies R1-R3 and their associated actions that they may include populations which exhibit some degree of hybridization. The following actions are recommended to address the research strategies:

Strategy R1. Elucidate life-history requirements and characteristics

Associated Actions:

> **A1** Describe life history requirements and characteristics by life stage for westslope cutthroat trout by conducting fish sampling for spawning, rearing, summer feeding (for juveniles and adults), migratory behaviour, and overwintering life stages.

A2 Conduct sampling within the known populations of westslope cutthroat trout to determine population structure (e.g., number of mature fish, length-at-age) and population dynamics (e.g., changes in abundance and size structure over time).

A3 Conduct paleolimnological investigations on *Core* and *Conservation* populations where uncertainty exists concerning the origin of fish in a waterbody. In some cases, this additional information may be required to resolve the issue as to whether or not a population is native to a particular waterbody.

Strategy R2. Elucidate habitat requirements

A4 Describe habitat use by life stage for westslope cutthroat trout. This will include describing key habitat components for each life stage (e.g., spawning and overwintering areas), as well as locations of critical habitat and habitat characteristics that limit invasion by non-native species (e.g., temperature, barriers).

Strategy R3. Improve knowledge of population genetics

Associated Actions:

A5 Conduct surveys to characterize the genetic status of westslope cutthroat trout populations in native range. Particular consideration should be applied to areas with no or incomplete information to determine whether additional populations of westslope cutthroat trout exist within their historic range.

A6 Genetic status of populations, especially those not isolated by barriers, should be periodically evaluated (e.g., every one to two generations, or four to eight years). Populations isolated by barriers could be evaluated less frequently, primarily for the purposes of determining whether barriers had failed, or illegal introduction of non-native fish had occurred and was threatening the westslope cutthroat trout population.

Strategy R4. Develop population models

Associated Actions:

A7 Evaluate the feasibility of modeling population viability and size estimates using population structure and abundance estimates.

Strategy R5. Conduct feasibility studies of recovering populations within historical range

Associated Actions:

A8 Classify and prioritize existing stream and lake populations according to status of threats and determine how threat elimination and mitigation might contribute to an

increase in population levels. Where desirable, examine the feasibility of enhancing existing populations by stocking, keeping genetic diversity issues of utmost priority.

A9 Identify candidate sites for re-establishing populations of westslope cutthroat trout and determine feasibility of re-establishment, including an assessment of existing and future threats, source population, genetics, connectivity, and impacts to existing ecosystems.

Strategy R6. Identify and understand limiting factors

Associated Actions:

A10 To accurately prioritize populations according to type and magnitude of threats, a map of land-use activities overlaid on westslope cutthroat trout distribution should be completed in concert with a cumulative effects analysis.

A11 Assess the impacts of angling-related mortality (e.g., catch-and-keep and catch-and-release mortality) and illegal mortality (e.g., poaching) on the recovery of westslope cutthroat trout.

A12 Evaluate the environmental and biological factors that promote and/or limit hybridization between westslope cutthroat trout and rainbow trout.

A13 Identify and classify barriers (natural and man-made) in westslope cutthroat trout habitat. Classify according to value of barrier to reconnection of fragmented habitat versus risks posed to genetically pure populations. Create a priority list of barriers for removal where it is functional and appropriate to restore fish passage, or a list of barriers that should be enhanced to reduce the chance of non-natives invading westslope cutthroat trout habitat. Communicate this information through the use of the AESRD reservation system and a spatial layer available to resource managers.

A14 Assess selected watercourse crossings (roads and OHV crossings) in drainages that contain genetically pure westslope cutthroat trout for severity of stream siltation especially during rain events at low flow conditions.

A15 Model and assess the impact of water impoundments on westslope cutthroat trout habitat. This should include assessment of changes to water temperature (especially below impoundments) and flow regime.

A16 Investigate effects of forest harvest on westslope cutthroat trout habitat (e.g., stream temperature changes, magnitude and timing of run-off flows).

A17 Model and assess the impact of temporary diversion licenses (e.g., used for pipeline hydrostatic testing). Determine the quantity, location and timing of current temporary diversion licenses.

A18 Review current work on climate change specific to the range of westslope cutthroat trout and determine how recommendations from these studies can be incorporated into future recovery efforts.

A19 Evaluate the feasibility of modeling cumulative effects using a spatial model. Assessment should include investigation of the use of common corridors and road density in westslope cutthroat trout habitat. The latter parameters could be investigated currently with available data.

Strategy R7. Clarify distribution and status of introduced populations within and outside of native range

Associated Actions:

A20 Conduct surveys of introduced populations within and outside of native range to estimate population size, distribution, and life-history strategy. Collect tissue samples to determine genetic status.

8.3 Monitoring

Regular monitoring, with appropriate frequency, intensity, and methodology is necessary to establish trends in abundance of westslope cutthroat trout, as well as to describe the availability and quality of habitats once identified. The following strategies are recommended to address monitoring needs:

Strategy M1. Population monitoring

Associated Actions:

A21 Conduct population monitoring at least once every five to ten years on selected *Core* and *Conservation* populations. Monitoring should include population estimates, relative abundance, distribution, population structure (e.g., size-frequency distribution, life history stage), genetic status, as well as abundance and distribution of non-native species. Frequency will depend on the priority of the population and whether monitoring is related to a restoration or mitigation project.

- Genetic status of *Core* and high priority *Conservation* populations should be regularly evaluated (once every one to two generations, or four to eight years).
- Genetic status of medium priority *Conservation* populations should be evaluated less frequently (e.g., once every three to four generations, or 12 to 16 years).

A22 Conduct a Fish Sustainability Index (FSI) assessment on westslope cutthroat trout following Alberta protocol. The purpose of the FSI is to provide a landscape-level overview of fish sustainability to allow for broad temporal comparisons of changes; further, the FSI supports broad-level comparisons between fish sustainability and

management and recovery actions, and it provides information to assist in planning priorities for these actions.

Strategy M2. Habitat monitoring

Associated Actions:

A23 Conduct regular water quality and habitat monitoring at a subset of sites to establish baseline information and track trends (e.g., temperature, dissolved oxygen, sedimentation, substrate, depth, riparian health, and benthic invertebrates). The timing of monitoring should coincide with population monitoring. Collaborate where possible with groups collecting similar data (e.g., Bow River Basin Council).

Strategy M3. Monitor effectiveness of mitigation and restoration measures

Associated Actions:

A24 The tools used to monitor the success of mitigation and restoration measures will depend on the goal of a particular initiative. For example, to monitor recovery of westslope cutthroat trout populations, metrics may include one or more of the following: presence/absence, number of populations, length of occupied stream, number of adults, and/or number of fish per area. If the purpose of a program is to remove or suppress non-native species then appropriate monitoring parameters may include measures of abundance and distribution of the target non-native species. Success of mitigation and restoration should be measured against structural, functional, and biological attributes of habitat (e.g., test if the new habitat is functioning as predicted). Regardless of the initiative, the monitoring component will include an evaluation and reporting of the results, as well as refinement of future actions using an adaptive management approach.

8.4 Management and Regulation

Management and regulatory actions are necessary to protect the westslope cutthroat trout and its habitat. Such actions will assist in reducing or eliminating identified threats including habitat loss and degradation and the introduction of non-native species. Because the recovery strategy is focused on both maintenance and recovery, approaches should focus on ways to maintain and protect the species, as well as recover populations in historic range. Recommended strategies include:

Strategy MR1. Limit the spread of non-native species

A25 Prepare a priority list of waterbodies where suppression or removal of non-native species or a genetic recovery may be feasible. Based on this list, conduct pilot projects on candidate waterbodies and evaluate effectiveness before proceeding with additional

projects. A review of existing literature on similar projects should be consulted when designing methods.

A26 Prepare a list of waterbodies where genetically pure populations exist in the absence of a migratory barrier and evaluate the threat of upstream invasion by non-natives. In cases where a threat exists, evaluate the use and consequences of installing a barrier to protect the genetically pure population.

Strategy MR2. Apply mitigation measures for threats

A27 Current practices that should be evaluated to ensure mitigation measures specific to westslope cutthroat trout are incorporated include, but are not limited to, the following:

- Land-use application reviews – e.g., use of protective notations (PNT) and consultative notations (CNT) to flag locations of priority populations and critical habitat; approval standards may include timing restrictions.

- Range management plans –consider timing of livestock use, reduced stocking rates, herding, and fencing.

- Enhanced Approval Process (EAP) for Upstream Oil and Gas activity – e.g., standards, operating conditions, best management practices.

- Timber Harvest Planning and Operating Ground Rules – e.g., conditions related to watercourse crossings, hydrological response and water quality monitoring, site reclamation, road construction and run-off control and annual monitoring activities.

- The *Water Act*, Code of Practice for Watercourse Crossings

- Recreation component – management-related criteria for recreation in Public Land Use Zones and crown land – e.g., designated trail networks, trail bridges, signage, trail closures, camping, staging areas, Public Lands Administration Regulation, Respect the Land initiative.

A28 Develop a Public Land Use Zone (PLUZ) for the Livingstone/Porcupine area to allow the implementation of a range of management tools to mitigate recreational access impacts.

A29 Ensure priority waters for protection of westslope cutthroat trout populations are identified and targeted for enforcement efforts. This implies enforcement under various legislation and by a variety of personnel including Alberta Fish and Wildlife Officers, Alberta Parks Conservation Officers, and Conservation, Forest and Lands Officers, as well as Alberta Environment and Sustainable Resource Development (*Water Act*), Fisheries and Oceans Canada (*Fisheries Act*) and National Park Wardens (*National Parks Act and National Parks Fishing Regulations*).

Strategy MR3. Stocking program rationalization

A30 Reduce the potential for illegal introductions and cease stocking of native or non-native species where they can negatively impact recovery or survival of westslope cutthroat trout.

Strategy MR4. Sportfishing regulations

A31 Continue to include genetically pure westslope cutthroat trout as a fish that can be angled under catch-and-release regulations. Evaluate and rationalize special circumstances where the species may be angled under catch-and-keep regulations. Under either scenario, it must be shown that no demonstrable harm to populations will occur as a result of angling.

A32 Monitor angling pressure where appropriate and recommend sportfishing regulation changes where necessary to protect all classes of populations.

Strategy MR5. Recover populations within historical range

A33 Contingent on the results of Strategy R5 – *Conduct feasibility studies of recovering populations within historical range* – implement findings with the goal of increasing population levels through threat elimination and mitigation and re-establishing populations in identified candidate areas. This will include waterbodies where genetic recovery may be feasible.

Strategy MR6. Intergovernmental cooperation

A34 Participate in westslope cutthroat trout recovery programs and share data with other agencies and jurisdictions to facilitate basin-wide recovery efforts. This should include information exchange with agencies (e.g., Alberta Agriculture) responsible for licensing privately stocked ponds. This agreement should also include agency-specific and joint reporting on progress of plan.

Strategy MR7. Data conservation and management

A35 Properly preserve and/or archive information on the species' genetic status, life history and habitat, such that changes can be tracked over time and the information can be re-visited. The development of a common database should be explored to improve access to information and the security of the data.

Strategy MR8. Manage and reduce footprint of human activities

A36 Apply management actions to the results of data collections, as identified in the strategies addressing research and assessment of threats, with an overall goal of reducing cumulative effects on land and water in westslope cutthroat trout habitat. Relate and include management actions in relevant land-use plan or framework.

A37 Classify streams in provincially managed waters with *Core* populations as Class A under the *Water Act - Codes of Practice.* As per the *Working Agreement: Class A Watercourses,* a joint federal-provincial protocol exists for the review of development applications for activities or works proposed in Class A watercourses. This designation is also consistent with what has been proposed to be critical habitat in the federal recovery strategy (see section 4.0). The determination was based primarily on the small number (of both individuals and populations) and the small size and limited distribution of areas still occupied by genetically pure-strain westslope cutthroat trout. As part of this action item, the recovery team recommends the following: specific locations for Class A designation on each stream will be refined as much as current knowledge permits to include only those areas deemed to meet the Class A definition; applications submitted under the Working Agreement should be considered as long as it can be shown that no negative impact will result on genetically pure populations. The basis of discussions would be to identify and address the threats specific to each situation. Considerations for application review should include an evaluation of such items as the: existence of baseline data, risk of failure, long-term monitoring commitment, cumulative effects, and effects on survival and recovery of the species. This is not meant to imply that future habitat gains for the species will automatically result in a Class A designation; rather each population would be examined on a stream or lake specific basis. As part of the submission process, proponents must recognize that any proposed work in a Class A area will require sufficient lead time to accommodate a more detailed data collection and review process.

A38 Utilize agency-specific mechanisms (e.g., notations, Operating Ground Rules, Range Management Plans) to flag watercourses with *Core* and *Conservation* populations to ensure a high level of protection and review of land-use applications to ensure all levels of governments and responsible departments within governments are acting in a manner consistent with this recovery plan.

8.5 Education and Outreach

Educating anglers, the general public, industry, and governments is essential to gain acceptance of, and compliance with, the overall recovery plan. Support can be gained through increased awareness of the westslope cutthroat trout and through involvement in stewardship programs. As the recovery activities involve multiple jurisdictions efforts should be coordinated where possible to provide uniform and timely messaging. The following strategies are recommended:

Strategy E1. Improve awareness of the species

A39 Identify target audiences (e.g., land owners, anglers, industry, contractors) and determine how each may contribute to and/or be impacted by recovery plan activities. Based on this information, define key messages and outreach options (e.g., social media, fact sheets, popular articles, podcasts, digital stories, information specific items in sportfishing regulations, GPS features, Bow Habitat Station) to target each group.

A40 Promote mandatory fish identification testing (e.g., for a harvest license for Eastern Slopes Region) for anglers to improve awareness of the species and better protection

from illegal harvest due to misidentification. Provide fish identification quiz online at AESRD website and good quality fish identification information in the Sportfishing Regulations.

A41 Provide training awareness of the species and its needs for government agencies with responsibility for managing land and water.

A42 Evaluate success of awareness efforts using appropriate means.

Strategy E2. Encourage stakeholder participation

A43 Create a plan and a process to engage stakeholders (e.g., Trout Unlimited Canada, Alberta Fish and Game Association (AFGA), municipal conservation partnerships, industry) and enlist their assistance in implementing action items and educational opportunities.

Strategy E3. Facilitate information exchange

A44 Disseminate information on the progress of the recovery plan through presentations and papers at conferences, professional meetings (e.g., Alberta Society of Professional Biologists, industry conferences or meetings such as with CAPP and Forestry, AFGA annual conference and zone meetings), and at educational facilities (e.g., Bow Habitat Station, schools), as well as through federal and provincial management agencies' Species at Risk websites. Information can also be exchanged in informal settings such as through interactions with the public and students (e.g., university field courses).

Strategy E4. Discourage species introductions

A45 To prevent species introductions – intentional or otherwise – education programs that heighten awareness of this issue should be supported. Communicate messages using a variety of forums (e.g., fact sheets, popular articles).

9.0 IMPLEMENTATION SCHEDULE

The following schedule (Table 2) outlines those activities identified as being important to westslope cutthroat trout recovery and their associated costs (cash and 'in-kind') depicted by years. It is anticipated that a variety of agencies will participate in the funding and implementation of these activities.

Table 2. Implementation schedule for the action plan for westslope cutthroat trout (WSCT).

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A1. Describe life history requirements and characteristics by life stage	R1	1,2	Urgent	AESRD PCA DFO	*Start 70*	*70*	*70*			Several of the actions, for example describing life history, habitat use, population structure and genetics can be collected in the field at the same time.
A2. Determine population structure and dynamics	R1	2	Urgent	AESRD PCA DFO	*Start*	*	*	*	*	Some data on abundance and size structure currently exist for comparison. This action will take more than one year to collect baseline data and will be recurrent to detect changes over time. Costs included in A1.
A3. Conduct paleolimnological investigations on populations where uncertainty exists concerning the origin of fish in a waterbody	R1	2	Urgent	PCA	*Start Year 1 or 2*	*21*				Where uncertainty exists, this item will be important to resolve in a timely manner. Approximate cost is $7 000/site so total will depend on number of sites to be tested.
A4. Describe habitat use by life stage	R2	1	Urgent	AESRD PCA DFO	*Start*	*	*	*	*	This action will take more than one year to collect baseline data and will be recurrent to detect changes over time. Costs included in A1.
A5. Conduct surveys to characterize genetic status of populations in native range	R3	2	Urgent	AESRD PCA DFO AP	*Start Year 1 to 3 In-kind*	*10*	*10*			This work would likely be part of ongoing field work started in year 1 or 2. Costs included in A1 but not cost of genetic analysis. Partners to include AP for field assistance within parks.

[1] Prioritization: Urgent = high priority for immediate species conservation, initiate as soon as possible; Necessary = medium priority for long term species conservation; Beneficial = lower priority, primarily directed at potential future activities.
[2] Designated in-kind costs are encompassed within the normal operating costs of government or provided by another organization.
[3] The actions and timelines are recommended to immediately begin the recovery process for westslope cutthroat trout. The success of this plan is contingent on the availability of sufficient staff and resources.
[4] * Denotes year of action and ongoing action in subsequent years
[5] Lead agencies: Alberta Environment and Sustainable Resource Development (AESRD), Fisheries and Oceans Canada (DFO), Parks Canada Agency (PCA), Alberta Parks (AP), and the proponents of development projects (Project proponent).

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A6. Conduct regular re-evaluations of genetic status of populations	R3	2	Urgent	AESRD PCA DFO	*Start Year 4 to 8*			*10*	*10*	Periodic evaluation recommended every one to two generations or four to eight years. Frequency may vary depending on monitoring required in populations under specific management plans. Although it is recommended that monitoring start in year 4, it would be staggered (i.e., not every population would be tested starting in year 4).
A7. Evaluate the feasibility of modelling population viability	R4	2	Necessary	AESRD PCA DFO	*In-kind*					This could start anytime.
A8. Prioritize populations by threats and work towards threat elimination and mitigation to increase population levels	R5	3	Urgent	AESRD PCA DFO AP	*Start In-kind*	*	*	*	*	Year 1 for prioritization of *Core* and *Conservation* populations; year 1 and ongoing for threat elimination and mitigation. Partners to include project proponents and industry such as TransAlta Corporation. Also, AP can implement measures to eliminate threats within parks (e.g., removing or installing barriers, specifying the need for riparian area fencing in grazing plans within parks, rerouting of trails to avoid critical habitat, etc.)
A9. Identify candidate sites for re-establishing populations and determine feasibility	R5	5	Necessary	AESRD PCA DFO	*In-kind*				*	Requires completion of other action items (e.g., A7, A9). Medium and longer-term action necessary for long-term survival of species. Could start earlier as opportunities arise.
A10. Map land-use activities overlaid on population distribution	R6	3	Urgent	AESRD PCA DFO	*In-kind*	*	*	*	*	This should start immediately and may be able to be conducted in-kind with partners such as Spray Lake Sawmills and CAPP as applicable. Could be updated annually as resources permit.
A11. Assess impacts of angling-related mortality and illegal mortality	R6	3	Urgent	AESRD PCA DFO	*Start In-kind*					Literature review initially (e.g., see Sullivan 2007) for analysis of local data. May be able to undertake through partnerships or in-kind.

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A12. Evaluate environmental and biological factors that promote or limit hybridization	R6	3	Necessary	AESRD PCA DFO	*In-kind*			*	*	Some of these mechanisms or factors may become apparent when undertaking other actions. A plan for this action should be developed in year 4 or 5 for subsequent implementation. Current related project conducted by grad student.
A13. Identify and classify barriers in WSCT habitat	R6	1,3	Urgent	AESRD PCA DFO AP	*Start In-kind*	*5*				This work could be undertaken during population work. Some of costs included in A1. Partners to include AP for field assistance within parks.
A14. Assess subset of watercourse crossings in WSCT habitat for stream siltation issues	R6	1,3	Necessary	AESRD PCA DFO		*Start In-kind 50*	*	*	*	This work could start anytime and would likely be ongoing. Could be completed via partnerships with Spray Lakes Sawmills and local oil and gas operators (e.g., equipment purchase).
A15. Assess impact of water impoundments on WSCT habitat	R6	1,3	Necessary	AESRD PCA DFO			*5*	*		Literature review initially – could start anytime but should be by year 3 or 4. Partner could include TransAlta Corporation.
A16. Investigate effects of forest harvest on WSCT habitat	R6	1,3	Necessary	AESRD PCA DFO	*In-kind*		*25*	*	*	This work could start anytime. Literature review initially (e.g., see Peterson 2011). Cost would be contribution to partnership agreement. Partners could include Spray Lake Sawmills, Trout Unlimited Canada, and universities.
A17. Assess impact of temporary diversion licenses on WSCT habitat	R6	1,3	Necessary	AESRD DFO	*Start Year 1 to 3 In-kind*					Investigate land tenure exemption as well as temporary diversion licenses.

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A18. Review current work on climate change specific to range of WSCT and determine how recommendations can be incorporated into future recovery efforts	R6	1,3	Necessary	AESRD PCA DFO					*10*	This work could start anytime. Possible graduate project. Other action items may tie in with this (e.g., monitoring water temperatures).
A19. Evaluate feasibility of modeling cumulative effects in WSCT habitat	R6	1,3	Necessary	AESRD DFO						Could start anytime. Could be done initially on a portion of the watershed.
A20. Conduct surveys of introduced populations within and outside of native range to determine genetic status, population structure and dynamics	R7	6	Necessary	AESRD PCA DFO	*In-kind*				*20*	This work could start anytime and might be based upon opportunity. If not should start by year 5.
A21. Conduct regular population monitoring	M1	2	Urgent	AESRD PCA DFO				*30*	*30*	Links and continues from A2 and A5. Generally is long-term initiative but is dependent on timing of initiatives undertaken in short-term and need for evaluation.
A22. Conduct Fish Sustainability Index (FSI) assessment on WSCT following Alberta protocol	M1	1,2,3	Urgent	AESRD	*Start 15*	*				This should start immediately.
A23. Conduct regular water quality and habitat monitoring	M2	1,3	Necessary	AESRD PCA DFO				*10*	*10*	Possible tie-in with CABIN monitoring which is ongoing in National Parks. Some habitat parameters will be monitored during other data collections. May create partnerships (e.g., WPACs).
A24. Monitor and report on effectiveness of mitigation and restoration measures	M3	1,2,3,5	Necessary	AESRD PCA DFO		*20*	*20*	*20*	*20*	Dependent on timing of initiatives undertaken in short-term but would not start before year 2. Partners could include various industries (e.g., Spray Lake Sawmills, local oil and gas operators).

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A25. Prioritize waterbodies where suppression or removal of non-natives or a genetic recovery may be feasible and conduct pilot projects on select waterbodies	MR1	3	Urgent	AESRD PCA DFO	*Start* *In-kind*	*30*	*30*	*30*	*30*	Ongoing Years 1 – 5 and > Year 5. Participation of conservation community such as Trout Unlimited Canada.
A26. Compile list of waterbodies where genetically pure populations exist in absence of barrier and evaluate threat of invasion; where necessary evaluate potential and consequences of installing man-made barrier	MR1	3	Urgent	AESRD PCA DFO	*Start* *In-kind*	*5*	*5*			This work could be undertaken with previous actions relating to life history, population, and barrier work. Does not include cost of installing barriers.
A27. Evaluate current practices and associated threats to ensure mitigation measures specific to WSCT are incorporated into practices	MR2	1,3	Necessary	AESRD PCA DFO AP	*Start* *Year 1* *In-kind*	*10*	*	*	*	Initially this would include a desktop exercise with possibility of field evaluation later. Will be ongoing throughout first 5 years and beyond. AP can specify recommended mitigations or best practices for park lands in management plans so they are recognized and adhered to over the long term.
A28. Develop a Public Land Use Zone in the Livingstone/Porcupine area to allow implementation of a range of management tools to mitigate threats	MR2	1	Urgent	AESRD	*Start* *In-kind*					Needs to be developed.
A29. Ensure priority waters for protection of WSCT populations are identified and targeted for enforcement efforts	MR2	3,4	Urgent	AESRD PCA DFO AP	*Start* *In-kind*	*	*	*	*	Currently being identified and targeted in Alberta waters. Ongoing yearly. This need can be specified in AP operational plans for the various districts.

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A30. Reduce potential for illegal introductions and cease stocking native or non-natives where they can negatively impact WSCT recovery	MR3	3	Urgent	AESRD PCA DFO	*Start In-kind*	*	*	*	*	This action is already being implemented to some extent via communication and regulatory tools. Specific tools for WSCT could be developed.
A31. Evaluate existing sportfishing regulations for effects on WSCT as well as opportunities to permit angling for this species	MR4	4,6	Necessary	AESRD PCA	*Start In-kind*	*				Regulations should state that it is primarily catch-and-release only for all *Core* populations and maybe some *Conservation* ones as well.
A32. Monitor angling pressure and recommend regulation changes as necessary	MR4	2,4	Necessary	AESRD	*Start*	*15*	*15*	*15*		Ongoing. Sportfishing regulations currently reviewed every two years and changes recommended.
A33. Contingent on feasibility study (A9), recover populations by increasing population levels and re-establishing populations in candidate areas	MR5	3,5	Necessary	AESRD PCA DFO			*	*	*	This action is dependant on several others so unlikely it could start before year 3. Costs will have to be developed at a later date.
A34. Participate in WSCT recovery programs and share data with other agencies to facilitate basin-wide recovery efforts	MR6	4	Necessary	AESRD PCA DFO	*Start In-kind*	*	*	*	*	This has already started and will be ongoing as further information or opportunities arise.
A35. Preserve and archive samples and data; explore development of common database to improve access to information	MR7	1,2,3	Necessary	AESRD PCA DFO	*In-kind*	*15*				Samples currently being archived. Development of database as soon as possible based on opportunity and preferably within first 5 years.
A36. Apply a management action to the results of data collections (re: research and threats) with overall goal of reducing cumulative effects on land and water in WSCT habitat	MR8	1,3,4	Necessary	AESRD PCA DFO	*In-kind*	*	*	*	*	This work could start anytime and the action itself is in-kind and ongoing. Since it will take time to complete other actions – new management action would likely be applied on an opportunistic and ongoing basis.

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A37. Classify streams in provincially managed waters with *Core* populations as Class A under the *Water Act - Codes of Practice*	MR8	1,3,4	Urgent	AESRD	*Start In-kind*					Process should start immediately.
A38. Utilize agency-specific mechanisms to flag watercourses with *Core* and *Conservation* populations to ensure a high level of protection and review of land-use applications	MR8	1,3,4	Urgent	AESRD DFO PCA	*Start In-kind*					This needs to start and be completed in year 1 since the recovery strategy is based upon understanding these concepts.
A39. Identify target audiences and determine how each may contribute to and/or be impacted by recovery plan activities. Define key messages and outreach options to target each group	E1	4	Urgent	AESRD PCA DFO	*Start In-kind*	*25*	*5*	*5*	*5*	This should accompany release of recovery strategy and be ongoing.
A40. Promote mandatory fish identification testing for anglers (e.g., East Slopes harvest license)	E1	3,4	Urgent	AESRD PCA DFO	*Start In-kind*	5	*	*	*	This is likely a recommendation that could occur immediately and would be ongoing.
A41. Provide training awareness of the species and its needs for government agencies with responsibility for managing land and water	E1	1,3,4	Urgent	AESRD DFO PCA	*Start In-kind*	*10*	*10*	*	*	Some aspects and tools for awareness are already produced so providing these tools to others would not take much effort and could be done immediately. Other aspects such as training may not be started until year 3.
A42. Evaluate success of awareness efforts using appropriate means	E1	4	Necessary	AESRD PCA DFO				*20*	*20*	This is required but may not start until year 3 or 4 – it should be ongoing after that following release of awareness projects and efforts.
A43. Engage stakeholders and enlist their assistance in implementing action items and educational opportunities	E2	1,3,4	Necessary	AESRD DFO PCA	*5*	*5*	*5*	*	*	Can occur in an opportunistic manner and at anytime. Partners could include Trout Unlimited Canada, Alberta Fish and Game Association, etc.

Action	Strategy	Objective	Priority[1]		Year and Associated Cost[2,3,4] (in thousands/year)					
				Lead/ Partners[5]	2012/ 13	2013/ 14	2014/ 15	2015 /16	2016/ 17	Comment
A44. Disseminate information on the progress of the recovery plan through a variety of means	E3	4	Necessary	AESRD DFO PCA	*Start*		*5*	*5*	*5*	Likely to occur to some extent each year. Need stakeholder/public support to maintain interest. Could include interpretive programs at campgrounds, articles in Kananaskis Country Explorer magazine, Currents newsletter, and environmental education programs for school kids.
A45. To prevent species introductions – intentional or otherwise – education programs that heighten awareness of this issue should be supported	E4	3,4	Necessary	AESRD DFO PCA AP	*Start Year 1 or 2*	*	*	*	*	Some materials such as fact sheets already developed and could be updated as appropriate. New material development should occur in year 1 or 2. Partners to include the Park Interpretation section within AP (e.g., educational materials in visitor resource centers, interpretive programs for park visitors during the summer months). Costs included in above.

10.0 SOCIO-ECONOMIC CONSIDERATIONS

There will be costs and benefits associated with the recovery actions proposed as part of this plan. It is likely this recovery plan will result in some modifications to land use practices and possibly restrictions on some human activities. It is anticipated that some restrictions will result in higher costs to industry. These may be associated (for example) with increased planning costs and the inability to utilize resources in some instances. Restrictions on human activities may also result from limited access to some types of recreational activities such as off-trail motorized recreation. However, it is important to recognize the benefits to Alberta that accrue by protecting and restoring this once widespread and abundant trout. The trout angling community is economically valuable and this activity is sustainable if properly managed. Angling for true native trout has a premium value to many anglers (Smith 1984; Trotter 1987). Cutthroat trout are the near-perfect reusable fly fishing trout because of their surface-feeding tendencies, willingness to take flies, and durability (Gresswell 1985; Schill *et al*. 1986). These traits could translate to increased angling and increased tourism.

Westslope cutthroat trout also have intrinsic value as they contribute to species biodiversity. In December 1992, with the support of the provinces and territories, Canada became the first industrialized country to ratify the United Nations Convention on Biological Diversity. As required by the Convention, Canada developed the Canadian Biodiversity Strategy (CBS) to guide the conservation of Canada's biodiversity and sustainable use of biological resources. The Alberta government actively participated in the development of the CBS and signed a Statement of Commitment supporting the strategy in November 1995. This recovery program is an opportunity to significantly improve and enhance this asset by restoring at least a portion of native populations to something close to their original state.

11.0 PLAN REVIEW AND AMENDMENT

The life of this plan is five years. The recovery team may conduct an annual review of the plan to monitor its implementation and to determine the effectiveness of conservation actions. Progress reports will be made available through various means (e.g., annual Species at Risk reports, on-line project report). Recovery action plans are considered “living” documents and conservation actions can be amended during these reviews as new information becomes available, conditions change, or as circumstances warrant. At the end of five years, and at the discretion of the team lead in consultation with the Provincial Species at Risk Specialist, the recovery team may be reconvened to determine what amendments are required, prior to the plan being renewed for another five years. Decisions regarding amendments shall be based on the comparison of specific performance measures to the stated recovery objectives.

12.0 LITERATURE CITED

Adams, S. B., C. A. Frissell, and B. E. Rieman. 2001. Geography of invasion in mountain streams: Consequences of headwater lake fish introductions. Ecosystems 4(4): 296-307.

Adams, S.B., C. A. Frissell, and B. E. Rieman. 2000. Movements of nonnative brook trout in relation to stream channel slope. Transactions of the American Fisheries Society 129: 623-638.

Adams, B. and L. Fitch. 1995. Caring for the green zone: riparian areas and grazing management. Alberta Cattle Commission; Trout Unlimited Canada; Canadian Cattlemen's Association; Alberta Agriculture, Food & Rural Development; Alberta Environmental Protection and Canada Department of Fisheries and Oceans. 36 p.

Aitken, G. 1997. Restoration of trout waters in the west: Blackfoot River of Montana. Pages 402-424 *In*: Watershed Restoration: Principles and Practices. American Fisheries Society, Bethesda, MD.

Alberta Environment and Olson + Olson Planning and Design. 1999. The southern Rockies landscape planning pilot study. Disturbance and pattern analysis. Alberta Environment, Land and Forest Service, Integrated Resource Management Division, Edmonton, AB. 195 p.

Alberta Sustainable Resource Development. 2008. Distribution and genetic status of native (not stocked) populations of westslope cutthroat trout sampled between 2000 and 2007. Map prepared by Alberta Fish and Wildlife Division, Calgary, AB, April 2008.

Alberta Sustainable Resource Development and Alberta Conservation Association (ASRD & ACA). 2006. Status of the westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in Alberta. Alberta Sustainable Resource Development, Wildlife Status Report No. 61. Edmonton, AB. 34 p.

Aldous, M. 1881. Extract from the report of the operations of the western section of the standard survey. Annual report of the Department of the Interior for the year 1880: 51-53.

Allendorf, F.W. and R.F. Leary. 1988. Conservation and distribution of genetic variation in a polytypic species, the cutthroat trout. Conservation Biology 2:170-184.

Allendorf, F.W., R.F. Leary, N.P. Hitt, K.L. Knudsen, M.C. Boyer, and P. Spruell. 2005. Cutthroat trout hybridization and the U.S. Endangered Species Act: One species, two policies. Conservation Biology 19:1326-1328.

Allendorf, F.W., R. F. Leary, P. Spruell, and J. K. Wenburg. 2001. The problems with hybrids setting conservation guidelines. Trends in Ecology and Evolution 16:613–622.

Anderson, P.G., D.A. Fernet, Z. Kovats and C.M. Gelowitz. 1996. The Lake Minnewanka aquatic resources investigation. A report for TransAlta Utilities and Banff National Park by Golder Associates Ltd., Calgary, AB. Report #942-2256. 160 p. + 4 appendices.

Armour, C., D. Duff, and W. Elmore. 1994. The effects of livestock grazing on western riparian and stream ecosystems. Fisheries 19: 9-12.

Beaudry, P.G. 1998. Effects of forest harvesting on streamflow and sediment concentrations of small streams in central British Columbia. Pages 80-89 in Mountain to sea: human interactions with the hydrologic cycle. Proceedings of the 51st annual conference of the Canadian Water Resources Association, 10-12 June, 1998, Victoria. Edited by B.C. Y. Alila. Canadian Water Resources Association, Cambridge, Ontario.

Behnke, R. J. 1992. Native trout of Western North America. American Fisheries Society Monograph 6, Bethesda, MD. 275 p.

Behnke, R.J. 2002. Trout and salmon of North America. Simon and Schuster, New York. 359 p.

Behnke, R.J. and M. Zarn. 1976. Biology and management of threatened and endangered western trout. US Department of Agriculture, Forest Services General Technical Report RM-28. 45 p.

Benjamin, J. R., J. B. Dunham and M. R. Dare. 2007. Invasion by nonnative brook trout in Panther Creek, Idaho: roles of local habitat quality, biotic resistance, and connectivity to source habitats. Transactions of the American Fisheries Society 136:875-888.

Bernatchez, L. 1999. Gene diversity analysis of cutthroat trout and rainbow populations from Banff National Park. Département de biologie, Université Laval, Québec, PQ. Report prepared for Banff National Park, Banff, AB. 12 p.

Beschta, R. L., C. A. Frissell, R. Gresswell, R. Hauer, J. R. Karr, G. W. Minshall, D. A. Perry and J. J. Rhodes. 1995. Wildfire and salvage logging: recommendations for ecologically sound post-fire treatments on federal lands in the west. Report published by the authors. Contact the lead author at Oregon State University, Corvallis, OR, 14 p.

Blank, M. and T. Clevenger. 2009. Improving the Ecological Function of the Upper Bow River: Bow Lake to Kananaskis Dam. Yellowstone to Yukon Conservation Initiative, Canmore, Alberta, Technical Report #7, April 2009.

Brewin, M.K., and D.M. Monita, technical coordinators. 1998. Forest-fish conference: land management practices affecting aquatic ecosystems. Proceedings of the Forest-Fish Conference, May 1-4, 1996, Calgary, Alberta. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta.

British Columbia Forest Practices Board. 2007. The effect of mountain pine beetle attack and salvage harvesting on streamflows. Special investigation. Report FPB/SIR/16, British Columbia Forest Practices Board, Victoria, BC. 27 p.

Brown, R.S., and W.C. Mackay. 1995. Fall and winter movements of and habitat use by cutthroat trout in the Ram River, Alberta. Transactions of the American Fisheries Society 124:873-885.

Campton, D. E., and L. R. Kaeding. 2005. Westslope cutthroat trout, Hybridization, and the U.S. Endangered Species Act. Conservation Biology 19: 1323 – 1325.

Carl, L. M. and J. D. Stelfox. 1989. A meristic, morphometric and electrophoretic analysis of cutthroat trout, *Salmo clarki*, from two mountain lakes in Alberta. Canadian Field-Naturalist 103:80-84.

Carlson, S. M., A. P. Hendry, and B. H. Letcher. 2007. Growth rate differences between resident native brook trout and non-native brown trout. Journal of Fish Biology 71(5): 1430-1447.

Chamberlin, T. W., R. D. Harr, and F. H. Everest. 1991. Timber Harvesting, Silviculture, and Watershed Processes. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication No. 19. pp. 181-205.

Clare, J. J., and M. L. Bothwell. 2003. The effects of logging and solar ultraviolet radiation on benthic invertebrates in Baptiste (B5) Creek. Pages 239-253 in Forestry impacts on fish habitat in the northern interior of British Columbia: a compendium of research from the Stuart-Takla Fish-Forestry Interaction Study. Edited by E. A. MacIsaac. Canadian Technical Report of Fisheries and Aquatic Sciences 2509: v + 266p.

Cleator, H., J. E. Earle, L. Fitch, S. Humphries, M. Koops, K.E. Martin, D. Mayhood, S Petry, C. J. Pacas, J. D. Stelfox, and D. Wig. 2009. Information relevant to a recovery potential assessment of pure native westslope cutthroat trout, Alberta population. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Research Document 2009036, iv+24 p.

COSEWIC. 2006a. Database. Committee on the Status of Endangered Wildlife in Canada.

COSEWIC. 2006b. COSEWIC assessment and status report on westslope cutthroat trout *Oncorhynchus clarkii lewisi*. Committee on the Status of Endangered Wildlife in Canada. Ottawa, On. iii+86 p.

Department of Marine and Fisheries. 1914. Annual report for the year 1913-14. Government of Canada, Ottawa, ON.

Donald, D. B., and D. J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71:238-247.

DuBey, R. J., C. A. Caldwell and W. R. Gould. 2007. Relative susceptibility and effects on performance of Rio Grande cutthroat trout and rainbow trout challenged with *Myxobolus cerebralis*. Transactions of the American Fisheries Society 136:1406-1414.

Dunnigan, J. L., D. H. Bennett and B. E. Rieman. 1998. Effects of forest management on westslope cutthroat trout distribution and abundance in the Coeur d'Alene River system, Idaho, USA. pp. 471-476. in Brewin, M. K. and D. M. A. Monita, editors. Forest-fish conference: land management practices affecting aquatic ecosystems. Proceedings of the Forest-Fish Conference, May 1-4, 1996, Calgary, AB. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Information Report NOR-X-356. xiv+533 p.

Eaglin, G. S. and W. A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13:844-846.

Earle, J.E., A.J. Paul and J.D. Stelfox. 2010a. Quirk Creek population estimates and one-pass electrofishing removal of Brook Trout – 2009. Unpublished report, Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta.

Earle, J.E., J.D. Stelfox and B.E. Meagher. 2010b. Quirk Creek Brook Trout suppression project – 2009. Unpublished report, Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta.

Fausch, K.D. 1989. Do gradient and temperature affect distributions of, and interaction between, brook charr (*Salvelinus fontinalis*) and other resident salmonids in streams? Physiology and Ecology Japan Special Volume 1:303-322.

Fausch, K. D. 2007. Introduction, establishment and effects of non-native salmonids: considering the risk of rainbow trout invasion in the United Kingdom. Journal of Fish Biology 71:1-32.

Fitch, L. A. 1977-1980. Stream survey reports, Castle and Crowsnest river drainages. Alberta Fish and Wildlife Division, Lethbridge, AB.

Furniss, M. J., T. D. Roelofs and C. S. Yee. 1991. Road construction and maintenance. pp. 297-323 *in* Meehan, W. R., editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. 751 p.

Gates, K. K., C. S. Guy and A. V. Zale. 2007. Movement of sediment by anglers and the implications for transporting aquatic nuisance species. pp. 275-277 *in* Carline, R. F. and

C. LoSapio, editors. Sustaining wild trout in a changing world. Proceedings of Wild Trout IX symposium, 2007 October 9-12, West Yellowstone, MT. 308 p. http://www.wildtroutsymposium.com

Gresswell, R. E. 1985. Saving the dumb gene in Yellowstone: there is more to preservation than granola. Paper presented at the 65th Annual Conference of the Western Association of Fish and Wildlife Agencies, 6 p.

Gresswell, R. E., B. A. Barton and J. L. Kershner. 1989. Practical approaches to riparian resource management: an educational workshop. U.S. Bureau of Land Management, Billings, MT. x+193 p.

Griffith, J. 1988. Review of competition between cutthroat trout and other salmonids. Pages 134-140 *in* Gresswell, R., editor. Status and management of interior stocks of cutthroat trout. American Fisheries Symposium 4. American Fisheries Society, Bethseda, MD. 216 p.

Griffith, J. S. and R. W. Smith. 1993. Use of concealment cover by juvenile cutthroat and brown trout in the South Fork of the Snake River, Idaho. North American Journal of Fisheries Management 13:823-830.

Hauer, F. R., G. C. Poole, J. T. Gangemi, and C. V. Baxter. 1999. Large woody debris in bull trout (*Salvelinus confluentus*) spawning streams of logged and wilderness watersheds in northwest Montana. Canadian Journal of Fisheries and Aquatic Science 56:915-924.

Hedrick, R. P., M. El-Matbouli, M. A. Adkison and E. MacConnell. 1998. Whirling disease: re-emergence among wild trout. Immunological Reviews 166:365-376.

Hepworth, D. K., M. J. Ottenbacher and C. B. Chamberlain. 2001. Occurrence of native Colorado river cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the Escalante River drainage, Utah. Western North American Naturalist 61:129-138.

Hitt, N., C. Frissel, C. Muhlfeld, and F.W. Allendorf. 2003. Spread of hybridization between native westslope cutthroat trout *Oncorhynchus clarkii lewisi*, and nonnative rainbow trout, *Oncorhynchus mykiss*. Canadian Journal of Fisheries and Aquatic Sciences 60:1440-1451.

Huntington, C. W. 1998. Streams and salmonid assemblages within roaded and unroaded landscapes in the Clearwater River sub-basin, Idaho. pp. 413-428 *in* Brewin, M. K. and D. M. A. Monita, editors. Forest-fish conference: land management practices affecting aquatic ecosystems. Proceedings of the Forest-Fish Conference, May 1-4, 1996, Calgary, AB. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Information Report NOR-X-356. xiv+533 p.

Irving, J. S., and T. C. Bjornn. 1984. Effects of substrate size composition on survival of kokanee salmon and cutthroat and rainbow trout. Idaho Cooperative Fish and Wildlife Research Unit, Technical Report 84-86, Moscow.

Janowicz, M. 2005. Genetic analysis of hybridization between native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and introduced rainbow trout (*O. mykiss*) in the eastern slopes of the Rocky Mountains in Alberta. Department of Biology and Environmental Science, Concordia University College of Alberta, Edmonton, AB. 65 p.

Karr, J. R., J. J. Rhodes, G. W. Minshall, F. R. Hauer, R. L. Beschta, C. A. Frissell and D. A. Perry. 2004. The effects of postfire salvage logging on aquatic ecosystems in the American West. Bioscience 54:1029-1033.

Kirkwood, A.E., T. Shea, L.J. Jackson, and E. McCauley. 2007. *Didymosphenia geminata* in two Alberta headwater rivers: an emerging invasive species that challenges conventional views on algal bloom development. Canadian Journal of Fisheries and Aquatic Sciences 64: 1703-1709.

Leathe, S. A. and M. D. Enk. 1985. Cumulative effects of micro-hydro development on the fisheries of the Swan River drainage, Montana. Volume 1: summary report. Bonneville Power Administration, Division of Fish and Wildlife, P. O. Box 3621, Portland, OR 97208. 114 p.

Lemmen, D. S., F. J. Warren, J. Lacroix, and E. Bush. 2008. From Impacts to Adaptation: Canada in a Changing Climate 2007. Government of Canada, Ottawa ON. 448 p.

Liknes, G. and P. Graham. 1988. Westslope cutthroat trout in Montana: life history, status and management. American Fisheries Society Symposium 4:53-60.

Macdonald, J. S., E. A. MacIsaac, and H. E. Herunter. 2003. The effect of variable retention riparian buffer zones on water temperatures in small headwater streams in sub-boreal forest ecosystems of British Columbia. Canadian Journal of Forest Research 33:1371-1382.

MacMillan, R. H. 1909. Annual report of the Department of the Interior for the year ending March 31, 1909. VII. Forestry and irrigation:40-42.

MacPhee, C. 1966. Influence of differential angling mortality and stream gradient on fish abundance in a trout-sculpin biotope. Transactions of the American Fisheries Society 95:381-387.

Marnell, L. F., R. J. Behnke and F. W. Allendorf. 1987. Genetic identification of cutthroat trout (*Salmo clarki*) in Glacier National Park, Montana. Canadian Journal of Fisheries and Aquatic Sciences 44:1830-1839.

Mayhood, D. W. 1992. Approaches to managing freshwater fishes in North American parks and reserves. Part 2 of a fish management plan for Jasper National Park. Report prepared by FWR Freshwater Research Limited for Canadian Parks Service, Jasper National Park, Jasper, AB. 118 p.

Mayhood, D. W. 1995. The fishes of the Central Canadian Rockies Ecosystem. FWR Freshwater Research Limited Report 950408 prepared for Parks Canada, Banff National Park, P.O. Box 900, Banff, AB T0L 0C0. 59 p.

Mayhood, D. W. 2000. Provisional evaluation of the status of westslope cutthroat trout in Canada. pp. 579-585 *in* L. M. Darling, editor. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, BC, February 15-19, 1999. BC Ministry of Environment, Lands and Parks, Victoria, BC and University College of the Cariboo, Kamloops, BC. 2 Volumes. 974 p.

Mayhood, D. W. 2009. Contributions to a recovery plan for westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in Alberta: threats and limiting factors. Report prepared for Alberta Fish and Wildlife, Cochrane, AB. FWR Freshwater Research Limited Technical Report No. 2009/05-2, Calgary, AB. ix+68 p.

Mayhood, D.W. and E.B. Taylor. 2011. Contributions to a recovery plan for westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in Alberta: Distribution, population size and trends. Report prepared for Alberta Fish and Wildlife, Cochrane, AB. FWR Freshwater Research Limited Technical Report No. 2011/06-1, Calgary, AB. 39 p. + appendices http://www.fwresearch.ca/Library.html

Mayhood, D. W., W. Haskins, and M. D. Sawyer. 1997. Cumulative effects on fish. pp. 173-187 *in* M. D. Sawyer, D. W. Mayhood, P. Paquet, R. Thomas, C. Wallis, and W. Haskins, editors. Southern East Slopes cumulative effects assessment. Hayduke and Associates Ltd., Calgary AB, funded by Morrison Petroleum Ltd., Calgary AB. 207p. + appendices.

McAllister, D. J., F. W. Allendorf and S. R. Phelps. 1981. An analysis of the native and resident cutthroat trout (*Salmo clarki*) in the Bow, Kootenay-Columbia and Waterton river systems. Report prepared by Techman Engineering Ltd. for Parks Canada, Calgary, AB. 98 p.

McCaffery, M., T. A. Switalski and L. Eby. 2007. Effects of road decommissioning on stream habitat characteristics in the South Fork Flathead River, Montana. Transactions of the American Fisheries Society 136:553-561.

McCleary, R., C. Sherburne, and C. Bambrick. 2004. Long-term effects of riparian harvest on fish habitat in three Rocky Mountain foothills watersheds. Pages 189-198 *in* Forest land-fish conference II – ecosystem stewardship through collaborations. G. J. Scrimgeour, G. Eisler, B. McCulloch, U. Silins, and M. Monita, editors. Proceedings of the Forest-Land-Fish Conference II, April 26-28, 2004, Edmonton, Alberta.

McGrath, C. C. and W. M. Lewis Jr. 2007. Competition and predation as mechanisms for displacement of greenback cutthroat trout by brook trout. Transactions of the American Fisheries Society 136:1381-1392.

McIllrie, J. H. and M. H. White-Fraser. 1983. Fishing in southern Alberta. Excerpts from reports by the authors dated 1890, Royal Canadian Mounted Police records RG-18 volume 44, file 814, Public Archives of Canada, Ottawa, ON. Published in Alberta History Magazine Spring 1983:36-38.

McIntyre, J. and B. Rieman. 1995. Westslope cutthroat trout. Pp. 1-15 *in* M. Yound, editor. Conservation assessment for inland cutthroat trout. Tech. Report RM-GTR-256. USDA Forest Service.

Meehan, W.R. Editor. 1991. Influences of forest and rangeland management on Salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, Maryland, USA.

Miles, C. F. 1890. DLS. pp. 73-76 *in* Department of the Interior, annual report for the year 1889. Ottawa, ON.

Miller, R.B. and W.H. MacDonald. 1949. Preliminary survey of Alberta watersheds, 1947-1949. Alberta Provincial Department of Lands and Forests. 139 p.

Miller, R. R., J. D. Williams, and J. E. Williams. 1989. Extinction of North American fishes during the past century. Fisheries 14:22-38.

Montana Cutthroat trout Steering Committee (MCTSC) and Montana Cutthroat trout Technical Committee (MCTTC). 2007. Memorandum of Understanding and Conservation Agreement for Westslope cutthroat trout and Yellowstone Cutthroat trout in Montana.

Muhlfeld, C.C., S.T. Kalinowski, T.E. McMahon, M.L. Taper, S. Painter, R.F. Leary and F.W. Allendorf. 2009a. Hybridization rapidly reduces fitness of a native trout in the wild. Biology Letters published online 18 March 2009:1-4.

Muhlfeld, C.C., T.E. McMahon, D. Belcer and J.L. Kershner. 2009b. Spatial and temporal spawning dynamics of native westslope cutthroat trout, *Oncorhynchus clarkii lewisi*, introduced rainbow trout, *Oncorhynchus mykiss*, and their hybrids. Canadian Journal of Fisheries and Aquatic Sciences 66:1153-1168.

Muhlfeld, C.C., T.E. McMahon, M.C. Boyer and R.E. Gresswell. 2009c. Local habitat, watershed, and biotic factors influencing the spread of hybridization between native westslope cutthroat trout and introduced rainbow trout. Transactions of the American Fisheries Society 138:1036-1051.

Nelson, J. S. 1965. Effects of fish introductions and hydroelectric development on fishes in the Kananaskis River system, Alberta. Journal of the Fisheries Research Board of Canada 22:721-753.

Nelson, J. S. and M. J. Paetz. 1992. The fishes of Alberta. Second edition. University of Alberta Press, Edmonton, and University of Calgary Press, Calgary, AB, xxvi + 437 p.

Pacas, C. and B. Hunt. 2004. Results of creel surveys on Lake Minnewanka with emphasis on 2000. Parks Canada, Banff National Park. 67 p.

Paul, A. J. and T. D. Boag. 2003. Cumulative effects of human activities on aquatic ecosystems within Devon Canada Corporation's Livingstone coalbed methane exploration area, SW Alberta. Applied Aquatic Research Ltd. report prepared for TERA Environmental Consultants, Calgary, AB. xi+95 p.

Paul, A.J. and J.R. Post. 2001. Spatial distribution of native and nonnative salmonids in streams of the eastern slopes of the Canadian Rocky Mountains. Transactions of the American Fisheries Society 130:417-430.

Paul, A.J. and J.R. Post. 1996. A quantitative assessment of the recovery of bull trout populations in Alberta and development of models of sustainable yield: the first year of investigation (1995). University of Calgary, Calgary, Alberta. 57 p.

Paul, A. J., J. R. Post and J. D. Stelfox. 2003. Can anglers influence the abundance of native and nonnative salmonids in a stream from the Canadian Rocky Mountains? North American Journal of Fisheries Management 23:109-119.

Peterson, L. 2011. Forestry-Fish: A Literature review. Prepared by Trout Unlimited Canada, Calgary, Alberta.

Peterson, D. P., and K. D. Fausch. 2003. Upstream movement by nonnative brook trout (*Salvelinus fontinalis*) promotes invasion of native cutthroat trout (*Oncorhynchus clarki*) habitat. Canadian Journal of Fisheries and Aquatic Sciences 60:1502–1516.

Peterson, D. P., K. D. Fausch, J. Watmough, and R. A. Cunjak. 2008. When eradication is not an option: Modeling strategies for electrofishing suppression of nonnative Brook Trout to foster persistence of sympatric native Cutthroat trout in small streams. North American Journal of Fisheries Management 28 (6): 1847-1867.

Peterson, D. P., K. D. Fausch, G. C. White. 2004. Population Ecology of an invasion: effects of Brook Trout on native Cutthroat trout. Ecological Applications 14 (3):754-772.

Platts, W. S. 1991. Livestock grazing. Pages 289–423 *in* W. R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Bethesda, MD. Spec. Publ. 19.

Potvin, C., C. Landry, C. Pacas and L. Bernatchez. 2003. Genetic population structure of cutthroat (*Oncorhynchus clarkii*) and rainbow (*Oncorhynchus mykiss*) trout in Banff and Waterton Lakes National Parks, Alberta. Final report presented to Parks Canada, Banff and Waterton Lakes National Parks. Département de Biologie, Université Laval, Québec.

Prince, E. E., T. H. McGuire and E. Sisley. 1912. Dominion Alberta and Saskatchewan Fisheries Commission 1910-11. Report and recommendations with appendices. Government Printing Bureau, Ottawa, ON. 71 p.

Radford, D. S. 1977. A report on biological inventories of 17 streams in the Livingstone drainage district. Alberta Fish and Wildlife Division report, Lethbrdge, AB. 82 p.

Radford, D. S. 1975. Oldman River flow regulation: a preliminary study of the fish resources. Alberta Fish and Wildlife Division, Lethbridge, AB. 85 p.

Range-wide YCT Conservation Team (RYCTCT). 2009. Conservation strategy for Yellowstone Cutthroat trout (*Oncorhynchus clarkii bouvieri*) in the States of Idaho, Montana, Nevada, Utah, and Wyoming. Montana Fish, Wildlife, and Parks, Helena. Conservation Agreement.

Rasmussen, J.B., M.D. Robinson, D.D Heath. 2010. Ecological consequences of hybridization between native Westslope Cutthroat (*Oncorhynchus clarkii lewisi*) and introduced Rainbow Trout (*Oncorhynchus mykiss*): effects on life history and habitat use. Canadian Journal of Fisheries and Aquatic Sciences 67: 357-370.

Rhodes, J. J. 2007. The watershed impacts of forest treatments to reduce fuels and modify fire behavior. Report prepared for Pacific Rivers Council, Eugene, OR. 94 p.

Rhymer, J. M. and D. Simberloff. 1996. Extinction by hybridization and introgression. Annual Review of Ecology and Systematics 27:83-109.

Rinne, J. N. and B. Calamusso. 2007. Native southwestern trouts: conservation with reference to physiography, hydrology, distribution, and threats. pp. 175-189 *in* Brouder, M. J. and J. A. Scheurer, editors. Status, distribution, and conservation of native freshwater fishes of western North America: a symposium proceedings. American Fisheries Society Symposium 53. xii+207

Robins, G. L. 2009. Spatial distributions of 33 fish species in the mainstem rivers of the South Saskatchewan River basin under changing thermal regimes. M.Sc. thesis, Department of Biological Sciences, University of Calgary, Calgary, AB. xxix+357 p.

Robinson, M. D. 2008. Remnant westslope cutthroat trout population inventory for southern Alberta, 2007. Interior Reforestation Co Ltd, Cranbrook, BC, report prepared for Alberta Sustainable Resource Development, Cochrane, AB. 534 p.

Robinson, M.D. 2007. The ecological consequences of hybridization between native westslope cutthroat (*Oncorhynchus clarkii lewisi*) and introduced rainbow trout (*O. mykiss*) in southwestern Alberta. M.Sc. thesis, Biological Sciences Department, University of Lethbridge. Lethbridge, Alberta, Canada.

Rosenfeld, J. S., S. Macdonald, D. Foster, S. Amrhein, B. Bales, T. Williams, F. Race, T. Livingstone. 2002. Importance of small streams as rearing habitat for coastal cutthroat trout. North American Journal of Fisheries Management 22 (1): 177-187.

Rosenfeld, J. S., M. S. Porter and E. A. Parkinson. 2000. Habitat associations of juvenile cutthroat trout: implications for forestry impacts. pp. 587-593 *in* Darling, L. M., editor. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, BC, February 15-19, 1999. BC Ministry of Environment, Lands and Parks, Victoria, BC and University College of the Cariboo, Kamloops, BC. 2 Volumes. 974 p.

Rubidge, E. M. and E. B. Taylor. 2005. An analysis of spatial and environmental factors influencing hybridization between native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and introduced rainbow trout (*O. mykiss*) in the upper Kootenay River drainage, British Columbia. Conservation Genetics 6:369-384.

Rubidge, E. M. Corbett, and E. Taylor. 2001. A molecular analysis of hybridization between native westslope cutthroat trout and introduced rainbow trout in southeastern British Columbia, Canada. Journal of Fish Biology 59:42-54.

Sauchyn, D. and S. Kulshreshtha. 2008. Prairies. pp. 278-328 *in* Lemmen, D. S., S. J. Warren, J. Lacroix and E. Bush, editors. From impacts to adaptation: Canada in a changing climate 2007. Government of Canada, Ottawa, ON. 448 p.

Sawyer, M.D. and Mayhood, D.W. 1998. Cumulative Effects Analysis of Land-Use in the Carbondale River Catchment: Implications for Fish Management. Pages 429-444 *in* M.K. Brewin and D.M.A. Monita, tech. coords. Forest-fish conference: land management practices affecting aquatic ecosystems. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta. Natural Resources Canada, Canadian Forest Service, Edmonton, Alberta. Inf. Rep. NOR-X-356.

Schill, D. J., J. S. Griffith, and R. E. Gresswell. 1986. Hooking mortality of cutthroat trout in a catch-and-release segment of the Yellowstone River, Yellowstone National Park. North American Journal of Fisheries Management 6 (2):22-232.

Schindler, D. W. and W. F. Donahue. 2006. An impending water crisis in Canada's western prairie provinces. Proceedings of the National Academy of Sciences of the United States of America 103: 7210-7216.

Schindler, D.W. and C. Pacas. 1996. Cumulative effects of human activity on aquatic ecosystems in the Bow Valley of Banff National Park. Chapter 5 in: Green, J., C. Pacas, L. Cornwell

and S. Bayley (eds). Ecological Outlooks Project. A Cumulative Effects Assessment and Futures Outlook of the Banff Bow Valley. Prepared for the Banff Bow Valley Study. Department of Canadian Heritage, Ottawa, ON. 59 p.

Schmetterling, D. 2001 Seasonal movements of fluvial westslope cutthroat trout in the Blackfoot River drainage, Montana. North American Journal of Fisheries Management 21:507-520.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pp.

Seiler, S. M., and E. R. Keeley. 2007a. A comparison of aggressive and foraging behaviour between juvenile cutthroat trout, rainbow trout and F1 hybrids. Animal Behaviour 74(6):1805-1812.

Seiler, S.M., and E.R. Keeley. 2007b. Morphological and swimming stamina differences between Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*), rainbow trout (*Oncorhynchus mykiss*), and their hybrids. Canadian Journal of Fisheries and Aquatic Sciences 64: 127-135.

Seiler, S. M., and E. R. Keeley. 2009. Competition between native and introduced salmonid fishes: cutthroat trout have lower growth rate in the presence of cutthroat-rainbow trout hybrids. Canadian Journal of Fisheries and Aquatic Sciences 66 (1):133-141.

Shaw, G. L. and D. Thompson. 1986. Water quality management and timber operations in southwest Alberta. Report prepared for the Alberta Environmental Research Trust Fund, Grant #T0953, by the Faculty of Environmental Design, University of Calgary, Calgary, AB. 75 p.

Shepard, B. B. 2004. Factors that may be influencing nonnative brook trout invasion and their displacement of native westslope cutthroat trout in three adjacent southwestern Montana streams. North American Journal of Fisheries Management 24:1088-1100.

Shepard, B., B. May and W. Urie. 2003. Status of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the United States: 2002. USDA Forest Service, Bozeman, MT. 100 p.

Shepard, B. B., R. Spoon and L. Nelson. 2002. A native westslope cutthroat trout population responds positively after brook trout removal and habitat restoration. Intermountain Journal of Sciences 8:191-211.

Shepard, B., K. Pratt, and P. Graham. 1984. Life histories of westslope cutthroat trout and bull trout in the upper Flathead River Basin, Montana. Montana Department of Fish, Wildlife, and Parks, Helena, MO.

Sisley, E. 1911. Fish of the eastern slopes of the Rockies. Canadian Alpine Journal 3:113-116.

Smith, R. H. 1984. Native trout of North America. Frank Amato Publications, Portland, OR 97202. 144 p.

Stelfox, J. D., D. M. Baayens, A. J. Paul, G. Shumaker. 2001. Quirk Creek brook trout suppression project. *In*: Brewin M. K., A. J. Paul, and M. Monita, editors, Bull Trout II Conference Proceedings. Trout Unlimited Canada. Calgary, AB. Pp. 37-46.

Strobeck, C. 1994. Survey of cutthroat trout in Banff National Park. Department of Biology, University of Alberta. Report prepared for Parks Canada, Banff National Park, Banff, AB. 12 p.

Sullivan, M. 2007. Modelling potential effects of angling on recovery of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in Alberta. Alberta Fish and Wildlife Division, Edmonton, AB. 22 p.

Taylor, E. B. and J. L. Gow. 2007. An analysis of hybridization between native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and introduced Yellowstone cutthroat trout (*O. c. bouvieri*) and rainbow trout (*O. mykiss*) in Canada's mountain parks and adjacent watersheds in Alberta. Report prepared for Parks Canada and Alberta Fish and Wildlife by Department of Zoology, Biodiversity Research Centre, and Native Fishes Research Group, University of British Columbia, Vancouver, BC. 46 p. + appendices.

Taylor, E. B. and J. L. Gow. 2009. An analysis of hybridization between native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and introduced Yellowstone cutthroat trout (*O. c. bouvieri*) and rainbow trout (*O. mykiss*) in Canada's mountain parks and adjacent watersheds in Alberta: Summer 2007 data. Addendum to 2007 report. Report prepared for Parks Canada and Alberta Fish and Wildlife by Department of Zoology, Biodiversity Research Centre, and Native Fishes Research Group, University of British Columbia, Vancouver, BC. 4 p. + appendices.

Taylor, M and S. Helms. 2008. Road-Stream crossing assessment report for Banff, Glacier, Kootenay, Mount Revelstoke, Waterton Lakes and Yoho National Parks. 59 p + appendices.

Trotter, P. C. 1987. Cutthroat: native trout of the west. Colorado Associated University Press, Boulder, CO. 219 p.

Valdal, E.J. and M.S. Quinn. 2010. Spatial analysis of forestry related disturbance on westslope cutthroat trout (*Oncorhynchus clarkii lewisi*): Implications for policy and management. Applied Spatial Analysis and Policy 4(2):95-111.

Varley, J.D. and R. Gresswell. 1988. Status, ecology and management of the Yellowstone cutthroat trout. American Fisheries Society Symposium 4:13-24.

Vick, S.C. 1913. Classified guide to fish and their habitat in the Rocky Mountains Park. Dominion Parks Branch, Department of the Interior, Ottawa.

Wagner, E., R. Arndt, M. Brough and D. W. Roberts. 2002. Comparison of susceptibility of five cutthroat trout strains to *Myxobolus cerebralis* infection. Journal of Aquatic Animal Health 14:84-91.

Wang, L., and R. J. White. 1994. Competition between wild Brown Trout and hatchery greenback Cutthroat trout of largely wild parentage. North American Journal of Fisheries Management 14 (3):475-487.

Weaver, T. M and J. J. Fraley. 1993. A method to measure emergency success of westslope cutthroat trout fry from varying substrate compositions in a natural stream channel. North American Journal of Fisheries Management 13 (4): 817-822.

Wohl, N. E., and R. F. Carline. 1996. Relations among riparian grazing, sediment loads, macroinvertebrates, and fishes in three central Pennsylvania streams. Canadian Journal of Fisheries and Aquatic Sciences 53: 260-266.

Personal Communications

Shelley Humphries. 2011. Aquatics Specialist, Banff, Yoho and Kootenay, Parks Canada.

Barb Johnston. 2011. Aquatics Specialist. Waterton Lakes National Park, Parks Canada.

Charlie Pacas. 2011. Aquatics Specialist, Banff National Park, Parks Canada.

13.0 GLOSSARY

Adfluvial – fish that live in lakes and migrate into rivers or streams to spawn.

Endangered Species – a species facing imminent extirpation or extinction.

Endemic – a species or taxonomic group that is restricted to a particular geographic region because of restrictive factors such as isolation or habitat characteristics.

Extinction – when a species dies out or ceases to exist.

Extirpation – localized removal or extinction.

F_1 hybrid – A first-generation offspring of two closely related species or strains.

Fish habitat – areas which fish depend on (directly or indirectly) in order to carry out life processes.

Fluvial – fish that inhabit a river or stream.

Habitat Loss – the process in which natural habitat is rendered functionally unable to support the species present, this can represent complete disappearance, a decrease in amount, or degradation of habitat which does remain so that it can not support as many individuals as previously.

Hybridization – the act of mixing different species to produce hybrids.

Indigenous – a species that occurs naturally in an area; a synonym for native.

Introduced species – a species that has been transported by human activities, either intentionally or unintentionally, into a region in which it did not occur in historical time which is now reproducing in the wild; a synonym for non-native species.

Introgression – the transfer of genetic information from one species to another as a result of hybridization between them and repeated back crossing.

Introgressive hybridization – the spreading of genes of a species into the gene complex of another due to hybridization and extensive backcrossing. Introgression.

Invasive species – Species that spread beyond their native range or species introduced to a new range that establish themselves and spread (not necessarily harmful), alternately, species that displace native species and have the ability to dominate an ecosystem, or a species that enters an ecosystem beyond its natural range and causes economic or environmental harm.

Iteroparous – a life history adaptation where an organism is capable of breeding or reproducing multiple times over the course of a lifetime.

Lacustrine – of, relating to, or pertaining to lakes.

Lentic – of, pertaining to, or living in still fresh water.

Lotic – of, pertaining to, or living in moving fresh water.

Native – a species with respect to a particular ecosystem that historically occurred or currently occurs in that ecosystem rather than as a result of an introduction**;** synonym for indigenous.

Redd – a spawning nest made by a fish, especially a salmon or trout.

Rescue effect – the process whereby individuals from a different population emigrate to a small population, thereby preventing localized extirpation or extinction.

Resident – an individual who resides in a particular place permanently or for an extended period.

Riparian Zone – the part of a watershed immediately adjacent to a stream; i.e. the interface between land and water.

Subpopulation – a part or subdivision of a population, with common, distinguishing characteristics.

Threatened Species – a species likely to become endangered if limiting factors are not reversed.

Trout – any of various freshwater or anadromous food and game fishes of the family Salmonidae, usually having a streamlined, speckled body with small scales.

Viable – able to maintain an independent existence.

APPENDIX A

Threat Assessment Analysis

Knowledge of the threats to a species and potential to mitigate those threats is fundamental to a species' recovery.

The assessment of each potential threat was qualitative rather than quantitative, with each factor being rated as "low", "moderate" or "high". These assessments were based on the best professional judgement of the recovery team, and determined by consensus following discussions. For each potential threat the following factors were considered:

- **Likelihood of Occurrence** - The probability of a threat occurring. Those that presently affect the species were rated "high".

- **Extent of Occurrence** - The spatial range of each identified threat. Those that affect most or all of the area occupied by the species were rated "high".

- **Severity of Impact** - The severity of the direct or indirect impact of a threat on the survival or recovery of the species. Impacts with the potential to extirpate the species were rated "high".

- **Immediacy of Impact** - The immediacy of the anticipated impact from a threat was denoted with a "P" for past impacts; "C" for current, ongoing impacts; and an "F" for possible future impacts.

- **Threat Significance** - The risk of damage to the westslope cutthroat trout population from a particular threat, based on its likelihood and extent of occurrence and on the severity and immediacy of its impacts.

- **Mitigation Potential** - The biological and technical feasibility of mitigating a threat. Where there are no biological impediments and proven technology exists to successfully mitigate threats, the mitigation feasibility was rated "high".

In the tables, questions marks (?) denote uncertainty, and the need for research. Comments provide background on each threat or its assessment.