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Information Relevant to a Recovery Potential Assessment of Pure Native Westslope Cutthroat Trout, Alberta Population

Information à l'appui de l'évaluation du potentiel de rétablissement de la truite fardée pure et indigène du versant occidental (populations de l'Alberta)

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ABSTRACT

In November 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Alberta population of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) as Threatened because the pure native populations[1] had been reduced by almost 80% as a result of overexploitation, habitat degradation and hybridization/competition with introduced non-indigenous trout (COSEWIC 2006). Remaining pure native Westslope Cutthroat Trout persist mainly as severely fragmented, remnant headwater populations. They are now being considered for legal listing under the *Species at Risk Act* (SARA). In advance of making a listing decision, DFO Science was asked to undertake a Recovery Potential Assessment (RPA); this Research Document supports the RPA. It describes the current state of knowledge of pure native Westslope Cutthroat Trout in Alberta in terms of their biology, ecology, abundance, distribution and trends, habitat requirements and threats. A recovery goal, mitigation measures and alternatives to threats and the potential for allowable harm are presented, as is information relevant to critical habitat and residence. The information contained in the RPA and this document may be used to inform both scientific and socio-economic elements of the listing decision and, if listed, development of recovery documents and for assessing SARA Section 73 permits.

RÉSUMÉ

En novembre 2006, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a désigné la population de truite fardée (*Oncorhynchus clarkii lewisi*) versant de l'ouest de l'Alberta en tant que population menacée du fait que les populations indigènes de lignée pure[1] ont été réduites d'environ 80 % par la surexploitation, la dégradation de l'habitat et l'hybridation/concurrence découlant de l'introduction d'espèces de truites non indigènes (COSEPAC, 2006). La truite fardée versant de l'ouest de lignée pure ne subsiste principalement que sous la forme de populations fortement fragmentées dans les eaux d'amont de cours d'eau. On envisage actuellement l'inscription de ces populations à la liste de la *Loi sur les espèces en péril* (LEP). Avant de prendre une décision quant à cette inscription, on a demandé au secteur des Sciences du MPO de procéder à une évaluation du potentiel de rétablissement (EPR), laquelle est appuyée par le présent document de recherche. Celui-ci résume notre compréhension actuelle de la biologie, de l'écologie, de l'abondance et de la répartition de la truite fardée versant de l'ouest indigène de lignée pure (population de l'Alberta) ainsi que des tendances affichées par cette sous-espèce, de ses besoins en matière d'habitat ainsi que des menaces pesant sur elle. Le présent document expose un objectif de rétablissement, des mesures d'atténuation des menaces et des solutions de rechange, les dommages admissibles ainsi que l'information relative à l'habitat essentiel et à la résidence. L'information contenue dans l'EPR et dans le présent document peut être utilisée pour orienter les volets scientifiques et socio-économiques des processus décisionnels relatifs à l'inscription et, si la population est inscrite, l'élaboration des documents relatifs au rétablissement ainsi que l'évaluation des permis délivrés en vertu de l'article 73 de la LEP.

[*] Revised February 2010

[1] In this document, pure native populations are assumed to be non-stocked populations.

[1] Dans le présent document, les populations indigènes de lignée pure sont considérées comme des populations non ensemencées.

INTRODUCTION

The Westslope Cutthroat Trout is a subspecies of native salmonid whose distribution in Canada straddles the Continental Divide. Over the past century, pure native Westslope Cutthroat Trout have undergone a dramatic decline in number and distribution of populations in southwestern Alberta and elsewhere. They are viewed as an indicator species of general ecosystem health because of their restricted habitat needs. Frequently they are the only native trout throughout much of their range in western Canada. This subspecies is a popular recreational sport fish which contributes to local economies. Westslope Cutthroat Trout are prized by the local angling community because they are a wild native trout, easy to catch, ideal for fly fishing because they are surface feeders, have the potential to grow larger than some introduced non-indigenous salmonids and are resilient to catch-and-release. Maintaining populations in Alberta is important for the re-establishment of extirpated populations and the long-term survival and recovery of this valuable fish.

<u>Species Biology and Ecology</u>

The Alberta population of Westslope Cutthroat Trout occurs in southwestern Alberta, primarily in the upper South Saskatchewan River drainage (Bow and Oldman rivers). Westslope Cutthroat Trout have dark spots on a lighter background and bright orange-red slashes beneath the lower jaw, which give the species its name. Often spawning fish develop bright red colouration over the entire body. Their fork length is typically 150-230 mm and rarely exceeds 410-460 mm (Behnke 2002).

Westslope Cutthroat Trout have distinct life history forms: nonmigratory (i.e., resident in streams) and migratory (fluvial, which live in rivers and migrate elsewhere in the mainstem (Prince and Morris 2003) or to tributary streams to spawn, and adfluvial which reside in lakes and migrate up- or down-stream into rivers or streams to spawn). The distances fish travel to spawning or feeding areas, or in response to changing water levels and stream temperatures, appears to be determined by its place of residence or life history type (Brown and Mackay 1995a). In Montana, resident fish in headwater streams may move less than 1 km (Jakober *et al.* 1997), while fluvial and adfluvial fish may migrate over distances in excess of 100 km (Schmetterling 2001; Prince and Morris 2002). Resident and fluvial populations were once common in Alberta, while adfluvial populations were less so (historically in Crowsnest Lake, Waterton Lakes, Lake Minnewanka, Lower Kananaskis Lake, Spray Lakes, and possibly Bow and Hector lakes). Fluvial and adfluvial populations have largely disappeared from Alberta; resident populations are now primarily the only remaining form. The migratory forms of Westslope Cutthroat Trout may be getting rarer than the resident form because of fragmentation and migration barriers (McIntyre and Rieman 1995). The fluvial and adfluvial forms typically attain larger sizes and weights (e.g., often exceed 300 mm) than the stream-resident form (e.g., seldom exceed 250-300 mm) (Shepard *et al*., 1984; McIntyre and Rieman 1995).

Individual fish undertake movements to find feeding habitat and overwintering habitat, to spawn and in response to other shifts in life-history regime. Seasonally, Westslope Cutthroat Trout often move in early- to mid-summer in search of suitable feeding habitat. In late summer and early fall, they begin to seek deep pools and/or groundwater discharge areas for overwintering in response to decreasing water temperatures and ice formation. In late winter-early spring they move to spawning areas in response to increasing water temperatures and lengthening days. After spawning they return to their summer habitat.

Overwintering habitat usually consists of deep pools, groundwater discharge areas, or both (Boag and McCart 1993; Brown and Mackay 1995b; Brown and Stanislawski 1996). These features are frequently limited in distribution in many stream networks. As a result, they are frequently limiting to populations and disproportionately important habitat for survival and recovery.

The mating system of Westslope Cutthroat Trout is typical of salmonids in which spawners migrate to or are resident in small, low gradient, natal streams where males compete for access to females. Females reach sexual maturity at 150-280 mm fork length (FL), between 3 and 5 years of age, and males at 110-210 mm FL, between 2 and 4 years of age (Radford 1975; Downs *et al.* 1997). Spawning usually occurs in May and June in Alberta, often during short moderate- to high-flow events (Radford 1975, 1977; Boag and McCart 1993; Brown and Mackay 1995a), and usually when water temperatures approach 10°C (Radford 1975, 1977; Nelson and Paetz 1992; Brown and Mackay 1995a). Sex ratio on the spawning grounds generally favours males in resident headwater populations and females in migratory populations where males may be more susceptible to angling (Downs *et al.* 1997). Females may contain between about 200 and 1500 eggs (Liknes and Graham 1988) depending on their size, and larger females also produce larger eggs, which improves their survivability (Downs *et al.* 1997[*]). Though Westslope Cutthroat Trout are iteroparous (i.e., capable of having many reproductive cycles over the course of their lives) there appear to be very few repeat spawners and post-mating mortality may be significant for males (Liknes and Graham 1988; McIntyre and Rieman 1995; Schmetterling 2001).

Eggs usually incubate in the spawning gravels for 6-7 weeks before hatching. The alevins remain in the substrate. The fry emerge from the streambed in early July to late August, at about 20 mm in length, and quickly move to slower-moving waters with cover, commonly in shallows near banks and side channels (Boag and McCart 1993). Depending on the productivity of the stream and life-history form of the individual fish, juveniles remain in their natal streams from 1 to 4 years. They may be relatively sedentary during this period or range in response to water levels, stream temperatures or the availability of food. Migratory life-history forms typically leave their natal streams at 2-3 years of age (McIntyre and Rieman 1995). Survival is likely lowest from the egg to juvenile stage when they are sensitive to environmental degradation, especially sedimentation and dewatering, and predation by piscivorous fishes. When riparian cover is lacking, adults are vulnerable to raptors, mustelids and other predators. Westslope Cutthroat Trout seldom attain 10 years of age (Scott and Crossman 1973).

The diet is comprised of chironomid larvae for young-of-the-year fry and mostly terrestrial and aquatic invertebrates for older juveniles and adults. Zooplankton can also be an important food source for adfluvial fish during winter (Shepard *et al.* 1984), or certain populations of lake-resident fish in the open-water season (Mayhood 1983). Even when forage fish are available, Westslope Cutthroat Trout are not highly piscivorous.

Resident Westslope Cutthroat Trout show some spawning fidelity to natal streams (Miller 1957). Genetic evidence suggests that genetic differentiation among pure Westslope Cutthroat Trout populations in Alberta is substantial at the level of streams and lakes rather than between major watersheds (e.g., Bow and Oldman rivers), with little gene flow even in adjacent populations (Potvin *et al.* 2003; Taylor *et al.* 2003; Taylor and Gow 2007). This genetic independence suggests these populations may have differing responses to environmental changes or management regimes (Taylor *et al.* 2003; Taylor and Gow 2007). The degree to which migratory populations home to natal streams or particular spawning locations has been little studied, however it is possibly in the order of 70% (Huston *et al*. 1984, cited by Shepard *et al*. 1984).

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Hatchery-reared Cutthroat Trout have been stocked in about 250 waterbodies in several major drainages within their original native range (e.g., Oldman and Bow rivers), as well as outside of it (e.g., North Saskatchewan, Peace and Athabasca drainages). Many of these introductions were made in headwater lakes, above impassable barriers, which previously did not have fish. While widespread, most introduced populations appear to be small and localized. Several non-indigenous salmonid species, and hybrids, including Rainbow Trout (*Oncorhynchus mykiss*) and Yellowstone Cutthroat Trout (*O. c. bouiveri*), have also been introduced widely throughout the native range of the Westslope Cutthroat Trout. These stocking activities have affected the genetic integrity of pure populations of Westslope Cutthroat Trout as a result of hybridization. Introgressive hybridization with Rainbow Trout is most pervasive. Rainbow Trout and Westslope Cutthroat Trout appear to have evolved in relative reproductive isolation (Behnke 2002) and, therefore, did not develop strong isolating mechanisms, though in drainages where the species do occur in natural sympatry, hybridization is limited and stable (Behnke 1992; Kozfkay *et al.* 2007). The relative similarity in chromosome number between Rainbow Trout and Westslope Cutthroat Trout allows for fertile crosses (Thorgaard 1983; Allendorf and Leary 1988). At least some hybrids survive and reproduce in the wild. Many of the remaining genetically pure Westslope Cutthroat Trout populations are found in small, isolated headwater populations (Donald 1987; Hilderbrand and Kershner 2000; Potvin *et al*. 2003; Taylor and Gow 2007). Introduced Yellowstone X Westslope hybrids have been found in the Bow, Waterton and Crowsnest drainages (Nelson and Paetz 1992; Taylor and Gow 2007). Golden Trout (*O. m. aguabonita*) may have the potential to hybridize with Westslope Cutthroat Trout though there are no known cases in Alberta.

COSEWIC assessed the status of only genetically pure (i.e., ≤ 1% introgression) populations of Westslope Cutthroat Trout that occur within their native range in Alberta. They did not assess populations that were known to be hybridized with other trout species or those that had been introduced into a waterbody in which native Westslope Cutthroat Trout populations were previously absent.

ASSESSMENT

Historic and Current Abundance and Trends

According to numerous historical accounts (Mayhood *et al.* 1997), Westslope Cutthroat Trout likely occurred in abundant numbers in about 274 streams/rivers from the Bow River to the Alberta-Montana border. Numbers of fish began to decline following the arrival of the Canadian Pacific Railway in 1883 (Prince *et al.* 1912), primarily as a result of overexploitation and later displacement and hybridization with stocked non-indigenous salmonids.

By 2006, when COSEWIC assessed Westslope Cutthroat Tout, only 61 streams (22% of the original 274) were known or suspected to still contain pure strains (COSEWIC 2006). Most of the remaining streams that contained pure Westslope Cutthroat Trout averaged about 8 km in length and contained an average of 100 adults (range: 30-200), therefore the 61 remaining known or suspected wild, native populations in Alberta were estimated to contain no more than 6,100 mature individuals in total (COSEWIC 2006).

More recently, some of the populations previously suspected of being genetically pure have been identified as hybrid populations. Only 50 streams (18% of the original 274) are now known or suspected to contain pure strains of Westslope Cutthroat Trout (data sources shown in Table 1), totaling probably no more than 5,000 adults. Given the limited sample sizes that have been used for genetic testing to date, it is possible that as sample sizes increase in the future some of the remaining "pure strain" populations will be identified as hybrid populations. To date, at least 63 populations have been lost in the Bow River basin and 49 populations from the Oldman River basin. It is likely that the genetically pure fluvial and adfluvial forms have been lost from both drainages and essentially only small stream-resident populations now remain.

Some of the remaining populations are likely stable, but available information suggests that many others are smaller than historic levels or have become extirpated. Some contain only 30 or fewer mature fish. Eight (16%) of the extant populations are currently thought to have a low chance of recovery (Table 1).

Historic and Current Distribution and Trends

The native range of this subspecies is thought to have been the Bow and Oldman drainages of the South Saskatchewan River, from the headwaters downstream to the plains. They may also have occurred in the headwaters of the Milk River (Sisley 1911; Prince *et al.* 1912; Willock 1969). In response to overexploitation, hybridization and competition with non-indigenous salmonid species, and habitat damage and loss over the past century, Westslope Cutthroat Trout have been lost from most of their native range in Alberta. Pure populations now occur almost exclusively in headwater streams and lakes and the uppermost reaches of rivers. It is estimated that the total proportion of the historical distribution that remains occupied is at most 20% (ASRD/ACA (Alberta Sustainable Resource Development and Alberta Conservation Association) 2006), with an area of occupancy of less than 2,000 km^2 (COSEWIC 2006).

Populations in the Bow drainage today are generally small and restricted to the extreme headwaters of a few major tributaries and upper mainstem. They are estimated to now occupy less than 5% of their native range in the Bow drainage (Mayhood 1995) except in Banff National Park where they occupy about 20-30% (Parks Canada Agency, unpubl. data). Based on genetic analysis available as of July 2009, pure strains are present only above Lake Louise, in the extreme headwaters of the Spray (Potvin *et al.* 2003) and Cascade rivers, in one small tributary of the Kananaskis River, in the upper reaches and two tributaries of the Ghost River, in three tributaries to the upper part of the Elbow River and the upper part of one tributary to the Sheep River (Mayhood 1995, 2000; Taylor and Gow 2007, 2009). They are also found in several small tributaries and two lakes in the Highwood River drainage upstream of High River.

In the Oldman River drainage, pure Westslope Cutthroat Trout still occur in the upper basin but not in the mainstem east of the mountain front or in most accessible tributaries (Radford 1977; Mayhood *et al.* 1997). Relatively large populations are present in the upper Oldman, Livingstone and Castle basins and small populations are present in the Crowsnest River basin, and may be present in the upper Belly drainage and the upper Willow Creek drainage. Their current status in the Milk River is unknown: only a single specimen has ever been reported, and a more recent survey failed to find any specimens (Clayton and Ash 1980).

By any account, the current distribution of pure native Westslope Cutthroat Trout in Alberta is severely fragmented.

Information to Support Identification of Critical Habitat

This subspecies thrives in cold, clean streams with abundant pool habitat and cover, containing features such as undercut banks, pool-riffle habitat and riparian vegetation. Westslope Cutthroat Trout prefer stream temperatures of 9-12°C (Behnke and Zarn 1976). Recent work identified the upper incipient lethal temperature as just 19.6°C (Bear *et* al. 2007). Historically, this subspecies was abundant throughout most of its native range in Alberta in mainstem rivers, and a few mainstem lakes and their accessible tributaries, at lower elevations (Mayhood *et al.* 1997). Today they are typically restricted to smaller, less productive waterbodies with lower energy discharges (e.g., headwater streams and lakes, upper reaches of mainstem rivers), though they are able to handle times of rising or peak flows that allow them to negotiate seasonal barriers within systems. Westslope Cutthroat Trout have very strict habitat requirements for various life history stages. Life history type also influences habitat use. Stream-resident forms typically remain in their natal stream throughout their lives. In contrast, individuals that exhibit one of the migratory life-history forms leave their small natal streams for larger systems, where fluvial adults seek out slow pools with adjacent fast water and plenty of cover and adfluvial adults seek out lentic habitat with cooler temperatures (< 16°C) (McIntyre and Rieman 1995). Westslope Cutthroat Trout prefer to spawn in small, low-gradient streams with cold well-oxygenated water and clean unsilted gravels in close proximity to good cover, such as large woody debris, boulders or bedrock. Spawning females seek out the downstream edge of deep pools. Juvenile rearing habitat consists of small streams that remain wet during low flow and have a diversity of cover (McIntyre and Rieman 1995). Young fish prefer shallow riffles or backwater habitat, often right at the land-water boundary. The presence and quantity of groundwater influx, deep pools and the absence of anchor ice are important components of overwintering habitat (Brown and Mackay 1995b). Fluvial adults congregate in slow deep pools while adfluvial adults overwinter in lakes. Juveniles use sheltered waters with cover provided by boulders and other instream structures, or sloughs and beaver ponds. Availability of pool habitat may limit juvenile productivity, as well as adult population density. Riparian cover often serves as an important source of terrestrial invertebrates, for food, in summer.

In summary, survival and recovery of Westslope Cutthroat Trout depends on the availability of habitat for key components of the life cycle: overwintering, spawning, juvenile rearing and summer feeding. Cold clean water with varied instream structure and riparian cover, which provide both complexity and areas of refuge, clean gravel for spawning, shallow low-velocity areas for juvenile rearing, pools for adult holding, and deep pools and/or groundwater discharge areas for overwintering, all connected by passable migration routes (because these habitat features are rarely found in the same locations), are all essential characteristics of their habitat. The availability, quality, quantity and distribution of overwintering habitat is frequently limited and, therefore, disproportionately important habitat for survival and recovery.

In streams with high (0.3 fish/m) cutthroat trout abundance, and incorporating a population loss rate of 10%, it has been estimated that about 9 km of stream is required to maintain a population (Hilderbrand and Kershner 2000). In streams with low (0.1 fish/m) abundance, the length of stream needed was estimated to be about 28 km. In Alberta (not including the national parks), most remaining streams containing pure Westslope cutthroat Trout average about 8 km in length and contain an average of 100 adults (ASRD/ASA 2006).

Given that the current distribution of pure native Westslope Cutthroat Trout is severely fragmented and the remaining fragments are very small, it is reasonable to assume that all the geographic areas where they are currently found may be critical for their survival or recovery. Efforts to recover the Alberta population may require rehabilitation of whole watersheds, including streams or parts of streams, within the historic range so that Westslope Cutthroat Trout populations can recolonize former, now-abandoned range. The value of these geospatial areas depends on their ability to provide the functional attributes necessary for overwintering, spawning, juvenile rearing, summer feeding and migration/movements, which is only possible by retaining or reinstating the natural hydrological regime at the watershed scale, in association with riparian areas. Removal of barriers to re-establish connectivity that historically existed within drainage systems would be counterproductive in some cases, as it would further facilitate hybridization and competition with invasive non-indigenous salmonid species, which already pose a serious threat to pure strains.

Residence

SARA defines a *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”.

During the spawning season, female Westslope Cutthroat Trout dig redds at least 305 mm in diameter and 102-127 mm in depth (Scott and Crossman 1973) in clean gravel. A female develops a redd by lying on her side and rapidly fanning her caudal fin up and down to create a depression in the gravel. The female then settles in the nest. When a male swims to her side, they release their eggs and sperm, and the fertilized eggs fall into the spaces in the graveled depression.

Most redds are found in lower-order tributaries in clean substrates, in close proximity to undercut banks or large woody debris, comprised of gravels, cobbles and/or pebbles, which are relatively unconsolidated and easily moved by spawning females. Overhead cover enhances the suitability of an area by providing cover and protection during redd construction and spawning, though Westslope Cutthroat Trout will also spawn in open sections of creeks. Areas of freshly deposited small and large gravels and cobbles may be critical for spawning, but it is likely that no single attribute is essential to redd site selection. Probably a combination of factors, including water velocity, water depth, temperature, cover, substrate permeability and substrate size, determines their locations. Despite differences in stream characteristics, redd attributes have been found to be remarkably similar among streams.

Most redds are abandoned by spawning adults within 48 hours (Schmetterling 2000) though the eggs, and later the alevins, remain in the substrate until the fry emerge sometime between early July and late August. Redds can be reliably identified only on the basis of where fish are seen spawning. If water flows are high and turbid during the spawning season, or scouring of the substrate occurs after spawning, this hampers detection.

Redds are created and used by Westslope Cutthroat Trout for spawning and development up until the fry emerge. Eggs, alevins and fry are critical components in the life cycle, therefore redds meet the SARA definition of residence.

Recovery targets

The recovery goal is to protect and maintain all remaining pure native, non-stocked, populations of Westslope Cutthroat Trout in Alberta, each containing at least their current number of fish, with their historical degree of connectivity within drainage systems (except where it would permit invasive non-indigenous species to establish) throughout their current range to ensure their persistence until at least 2020. The aim over the long term is to recover populations within their historic range, where possible.

A reasonable way forward to achieve this recovery goal might to be to prioritize recovery efforts for all remaining pure native populations based on their current size, importance and a realistic evaluation of their prognosis for survival and recovery (i.e., a triage approach) (Table 1). Some populations, such as those found in the upper Carbondale basin and the upper Oldman-Livingstone basin, are relatively large and will likely survive over the long term with minimal protection. Other populations that are more at risk of extinction may require more aggressive recovery efforts such as removing non-indigenous species. For populations with < 50 adults, which are on the brink of extinction, such as those found in Iron Creek and Corral Creek, recovery efforts might be undertaken only if a useful approach can be developed and funding is available. Waters where populations that have already gone extinct could be re-stocked, but that ignores the loss of genetic diversity.

The populations listed in Table 1 are those in which the average of all fish tested was ≥ 0.99 proportion of WSCT genome. Some of these populations may contain one or more individual fish with a slightly lower proportion of WSCT genome. Regardless, the conservation value of all these populations is high and protection and recovery efforts should be afforded to all of them.

One significant problem faced by many very small populations (i.e., 20-30 adults) of Westslope Cutthroat Trout is that they are already at carrying capacity for the available habitat. A major review of viability analysis conducted on numerous vertebrate populations suggested that approximately 7,000 adults (fits with the 99% goal) are needed in a population to ensure a 99% probability of its long-term persistence over 40 generations (Reed *et al.* 2003). Using data in Reed *et al*. (2003), Mayhood (in prep.) estimated that a Westslope Cutthroat Trout population must have about 470 adults to have a 50% probability of persistence for at least 40 generations (i.e., 120 – 200 years), and more than 4,600 adults to have a 90% probability of long-term persistence. For many, if not most, very small populations, it seems unlikely that it will be possible to facilitate population growth to a level that would ensure their long-term persistence.

Populations with only 100 adults have only a 23% probability of persisting over 40 generations, which means that most currently-remaining populations have little chance of surviving over the long term given their current status (Mayhood, in prep.). Small headwater populations in Alberta have persisted historically which suggests they may have gone extinct repeatedly in the past, but were subsequently replenished by downstream populations (Mayhood, in prep.). This hypothesis highlights the importance of re-forming metapopulations within connected systems in Alberta, which would allow persistence despite disturbance or changing environments (Rieman and Clayton 1997), as long as it does not allow invasive non-indigenous species to enter systems where they do not already exist.

<u>Threats to Survival and Recovery</u>

Four general types of threats of anthropogenic origin (Table 2) have led to the decline in numbers of Westslope Cutthroat Trout in Alberta over the past 125 years: initially overexploitation, then the introduction of non-indigenous species and/or genotypes, and more recently habitat damage and loss and climate change.

The introduction of salmonids is the greatest current threat to native Westslope Cutthroat Trout populations in Canada because it can cause both genetic (e.g., hybridization) and/or ecological impacts (e.g., displacement and competition) and predation of alevins, fry and subadults depending on the introduced species. Beginning in 1913, non-indigenous salmonids were widely introduced into most waterbodies along the eastern slopes of Alberta within the native range of Westslope Cutthroat Trout.

The extent of hybridization, especially with Rainbow Trout and to a much lesser degree with Yellowstone Cutthroat Trout and possibly Golden Trout (*Oncorhynchus mykiss aguabonita*), is widespread in Alberta (Janowicz 2005, Taylor and Gow 2007). For example, pure Westslope Cutthroat Trout populations now exist in only 23% of stream kilometres surveyed in the upper Oldman River watershed (Robinson 2007). Many populations exhibit highly mixed genotypes. Of 54 populations sampled within the native range in Alberta, 59% provided evidence of hybridization at a mean frequency of 34% (COSEWIC status report 2006, modified from Janowicz 2005). Even small amounts of hybridization with Rainbow Trout (e.g., a 20% admixture) can reduce reproductive success in Westslope Cutthroat Trout by about 50% (Muhlfeld *et al.* 2009). Yet, hybridization may spread, threatening the persistence of pure native Westslope Cutthroat Trout, because it appears that first-generation hybrids and a few males with high levels of admixture have relatively high reproductive success. Recent studies which examined hybridization of Westslope Cutthroat Trout with Rainbow Trout in Alberta and British Columbia revealed that the vast majority of hybrids were post-F_1 or backcross hybrids (Potvin *et al.* 2003; Janowicz 2005; Taylor and Gow 2007). Increasing land use, degradation of habitat, and increasing water temperature resulting from climate change, will likely lead to increased hybridization in Westslope Cutthroat Trout and reduce the opportunity for rescue effect (i.e., immigration from an outside source). Habitat disruption has been associated with both increased hybridization and increased invasiveness by Brook Trout (*Salvelinus fontinalis*).

Stocking of non-indigenous salmonids (e.g., Rainbow Trout, Brook Trout, Brown Trout (*Salmo trutta*) and Lake Trout (*Salvelinus namaycush*)) in Alberta has also led to displacement and predation of Westslope Cutthroat Trout and might also pose other threats such as parasites and disease (Mayhood, in prep.). An evaluation of the efficacy of a selective harvest by anglers to reduce Brook Trout and restore native Westslope Cutthroat Trout in Quirk Creek, a small stream in Alberta, initially revealed that the lower catchability of Brook Trout coupled with their early maturity and fast population growth made them relatively resilient to angling exploitation (Paul *et al.* 2003). However, further study showed that angling may be able to suppress Brook Trout, provided that a stream is readily accessible by road, that anglers can identify the fish species in it and that sufficient angling pressure can be exerted over multiple years (Earle *et al.* 2008). Following a decade of suppression efforts in Quirk Creek (i.e., removal of Brook Trout by angling in the lower and/or upper reaches in 1998-2008 and removal of Brook Trout by electrofishing in the upper reach in 2004-08), Brook Trout declined from 92% of the catch in 1995 to 30% in the lower reach and 50% of the upper reach in 2008, while Westslope Cutthroat Trout climbed to 68% and 48%, respectively (Earle *et al.* 2009).[*]

In Alberta, resource extraction (forestry, mining and oil and gas exploration/development), and the associated construction of roads, culverted crossings, and railways have caused the loss and degradation of habitat and decline of some populations. Cumulative effects assessments of basins in the upper Oldman, Crowsnest and Carbondale, for example, revealed that two-thirds of those watersheds were at moderate risk and the rest at high risk of damage from effects related to extensive clearcutting and road development (Mayhood *et al.* 1997, Mayhood 2000). Bank armouring is also increasing in use, thereby removing undercut banks, sweepers and log jams that provide summer feeding habitat. Streamside livestock grazing, off-highway vehicle use and other recreational activities, and urbanization have also destroyed preferred habitat. Hydroelectric developments and agricultural irrigation have contributed to habitat perturbations through flooding of and blockage of access to spawning areas (Miller and MacDonald 1949; Miller 1954), changes in flow regimes and, in the case of agriculture, the removal of riparian habitat. For example, more than 40% of the running waters of the Banff-Bow valley have already been regulated, obstructed or impounded in some way (Schindler and Pacas 1996). The effect of prescribed burns, as well as wildfires and forest beetle kills, has not been fully studied, though burns have been known to cause the melt freshet to occur earlier in spring and reduced flows in summer, and salvage logging has been shown to increase total suspended sediments, phosphorus and nitrogen (Silins *et al.* 2009). A loss of vegetation could shift the competitive advantage to non-indigenous competitors. All these

[*] Revised February 2010

anthropogenic activities have reduced population densities and have caused habitat damage and loss, thereby reducing the carrying capacity of the habitat available to this subspecies.

Current scenarios and models for climate change within the native range of Westslope Cutthroat Trout predict a rise in temperatures that will intensify with time and a small increase in precipitation that will increase in the southern part of the range by the 2080s (Mayhood, in prep.). The hydrological implications of climate change are likely to include substantial changes in basin hydrology, channel morphology, riparian physical structure and streamflows within the native range, especially from the 2050s to 2080s and beyond. As water temperatures increase, Westslope Cutthroat Trout will likely become increasingly excluded from more productive lower-elevation waters within its historic range. The amount and quality of habitat will shrink, especially during summer, as lower seasonal flows may reduce near-bank rearing habitat and the number and size of pools available to adults. Overwintering conditions may improve if higher temperatures, and possibly precipitation in winter and spring, increase base flows. The effects of changes in peak spring runoff will probably cause deterioration of the watershed resulting from deposition of fine sediments in the spawning gravels, infilling of critical pool habitat with coarser sediments and channel widening (producing shallower waters). Westslope Cutthroat Trout appear to be well-adapted to physical changes in habitat provided that local refuges or open corridors for movement are available to allow escape and recolonization (Liknes and Graham 1988; Brown and Mackay 1995b; Prince and Morris 2003). However, as water temperatures increase in response to climate change, it is likely the physiology of Westslope Cutthroat Trout will be affected which, in turn, will affect their biology and ecology (e.g., behaviour, competitive ability, habitat use and vulnerability to hybridization, predators, parasites and disease).

Overharvest in the late 1800s and early 1900s contributed significantly to the decline of native stocks of Westslope Cutthroat Trout in Alberta. Catchability of Westslope Cutthroat Trout is 2.5 times higher than for non-indigenous salmonids like Brook Trout (Paul *et al.* 2003). Higher catchability combined with later maturity and slower population growth makes Westslope Cutthroat Trout extremely sensitive to overexploitation. Over the past 20 years, fishing regulations have become increasingly more restrictive, including closure to harvest of some streams in the Bow and Oldman drainages and to angling during vulnerable overwintering periods and spawning migrations (November to June). Starting in 1998, angling regulations have prohibited the harvest of any fish in many of the waters that contain Westslope Cutthroat Trout. In waters where harvest is still permitted, the implementation of large minimum-size limits (e.g., 30 or 35 cm) has greatly reduced the proportion of the population that is vulnerable to harvest. Bait bans have further reduced the effects of hooking mortality. Fishing pressure is probably very light on many of the smaller streams that contain pure remnant populations, because of the small size of the streams, very small size of the fish and difficulty of access. Several intensive Westslope Cutthroat Trout fisheries remain where conditions allow fish numbers and/or biomass to be maintained or increased while sustaining relatively high levels of fishing pressure (e.g., Oldman and Livingstone rivers) and in some cases harvest (e.g., Picklejar Lakes, Castle and Carbondale rivers). While the threat from angling has been significantly reduced, mortality can occur as a result of intentional (poaching) and unintentional (misidentification) illegal harvest. Overall, overexploitation is currently a relatively minor threat to this subspecies.

Local extirpation of beaver populations within the historic range of Westslope Cutthroat Trout has permanently changed flowing streams to ephemeral streams. This has led to the loss of some pure strain populations.

Limiting Factors for Population Recovery

Westslope Cutthroat Trout possess several intrinsic or evolved biological characteristics that may naturally influence or limit their potential for recovery: (1) preference for cold water with limited productivity, (2) requirement for watersheds that have suitable spawning areas, deep pools and/or groundwater discharge areas for overwintering and that don't have high sediment loads, and (3) small population sizes with variable numbers of spawners which makes them subject to stochastic events (e.g., epidemic disease, drought).

Mitigation and Alternatives

Many threats to Westslope Cutthroat Trout are related to habitat loss or damage. DFO developed generic mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Ontario Great lakes Area (DFO, in prep.), which would also be appropriate for this subspecies. Additional mitigation and alternative measures specific to Westslope Cutthroat Trout are outlined below.

Invasive non-indigenous species: hybridization, competition and predation

Mitigation

- Prohibit stocking non-indigenous salmonids in waterbodies where pure native populations of Westslope Cutthroat Trout remain and no non-indigenous species occur.
- Carefully evaluate the costs and benefits before removing an existing control structure or barrier (e.g., culvert) in a waterbody containing a pure native population of Westslope Cutthroat Trout. Removing a structure may allow non-indigenous salmonids, especially Rainbow Trout, to move upstream and hybridize with Westslope Cutthroat Trout.

Alternatives

- Archive selected genetically pure stocks of Westslope Cutthroat Trout in appropriate waters with suitable habitat.
- Restore pure native Westslope Cutthroat Trout in some headwater areas where non-indigenous and hybridized fish also occur (stocking is not always necessary), if appropriate.
- Introduce barriers to isolate and protect pure populations above them when there is a threat of invasive non-indigenous species moving upstream. (This strategy may increase potential extinction risks due to stochastic environmental and demographic processes.)
- Educate the public about the risks to pure populations of Westslope Cutthroat Trout associated with hybridization and/or competition from non-indigenous salmonids, what measures they can take to help prevent it and the value of this trout species.

Habitat damage and loss: hydroelectric barriers and impoundments

Mitigation

- Mitigate habitat loss and changes in flow regimes resulting from hydroelectric dams and impoundments through changes to current operating conditions.
- Provide fish passage for Westslope Cutthroat Trout where appropriate.
- Incrementally restore habitat for pure Westslope Cutthroat Trout. In areas where a pure native population and an artificial or natural barrier downstream already exists, and suitable habitat is available below the barrier, a second barrier could be installed several kilometres downstream of the first, all non-indigenous and hybridized fishes cleared in that stretch of water and then the first barrier removed so that the pure Westslope Cutthroat Trout could extend their range downstream. Or, if removal of the first barrier is not possible, some fish could be transferred

downstream from above the first barrier to between the two barriers. In areas where no pure native population currently exists, a barrier could be installed, the water cleared of non-indigenous and hybridized fishes and then conservation stocking undertaken with pure Westslope Cutthroat Trout.

Alternatives

- Remove dams not in use that are barriers to connectivity within Westslope Cutthroat Trout metapopulations, unless it would allow invasive non-indigenous species to enter systems where they do not already have access.
- Prohibit the construction of new dams to prevent further loss of connectivity in areas where pure native Westslope Cutthroat Trout are known to occur, except where there is a threat of invasive non-indigenous species moving upstream.

Habitat damage and loss: oil and gas, forestry, mining, agriculture, urbanization, road and rail infrastructure and recreation

Mitigation

- Selectively remove, re-contour and re-vegetate roads that are not needed from watersheds, restore natural drainage, remove culverts and prevent access while the rights-of-way recover.
- In areas where pure native Westslope Cutthroat Trout are known to occur, prohibit activities that cause, or have the potential to cause, the following:
    - removal of riparian vegetation
    - removal of instream structure (e.g., woody debris and boulders)
    - significant sedimentation, especially during winter or spring
    - significant changes in water flow, especially during spring (when spawning and rearing occur) and winter (for holding habitat)
    - release of contaminants
    - significant changes in water temperature, total gas pressure, salinity or nutrient concentrations
- Educate the public about the risks to Westslope Cutthroat Trout associated with environmental destruction or degradation and what measures they can take to help prevent it.

Fishing

Mitigation

- Institute a program of severe fines for poaching of suspected and known pure native Westslope Cutthroat Trout, extensive advertising of the fines, enhanced officer presence at streams and strongly worded enforcement messages to reduce intentional illegal harvest, recognizing that differences exist between how national parks and areas outside national parks are managed (under Parks Canada and Alberta Government jurisdiction, respectively).
- Increase angler awareness of fish identification by distributing educational materials. In areas outside national parks, move toward requiring anglers to pass a mandatory test before they are permitted to harvest fish from eastern slopes waters in the South Saskatchewan River watershed that contain fish species, other than pure native Westslope Cutthroat Trout, that can be harvested.
- Regulate or encourage fishing practices that improve fish survival for catch-and-release fisheries, such as cutting lines of deeply-hooked fish and tight-line fishing.

Alternatives

- Encourage fish watching as an alternative to fishing.

Allowable Harm

Decisions about whether harm from human-induced mortality and habitat modifications is allowable are informed by the potential for recovery and the impact of human activities as well as alternate and mitigation measures to those activities. The potential for recovery of the remaining pure native populations of Westslope Cutthroat Trout in Alberta ranges from high to low (Table 1) depending on the status of the population and current and anticipated threats. Invasive non-indigenous species, habitat damage and loss resulting from human land uses, climate change and overexploitation pose threats to the survival and/or recovery of many of these populations.

Activities that have a moderate to high probability of jeopardizing the survival or recovery of pure native Westslope Cutthroat Trout in Alberta are not recommended. Preliminary stage-based modelling indicates that population growth in this subspecies is equally sensitive to changes in demographic parameters (e.g., survival) for young-of-the-year, juvenile and adult fish (M. Koops, DFO, unpubl. data). This means that threats that target all three life stages are particularly harmful. Introductions of invasive non-indigenous species pose severe consequences to pure-strain populations, by negatively affecting all life stages through hybridization, competition and predation and thus are a high risk to survival or recovery where pure remnant Westslope Cutthroat Trout populations remain. Land-use activities also have the potential to indiscriminately affect all three life stages making them more likely to jeopardize survival or recovery of a population. Those land-use activities that damage or destroy the functional components of habitat or negatively affect key life components of the life cycle (e.g., spawning, recruitment and survival) have a high risk to negatively impact Westslope Cutthroat Trout populations.

Recreational angling is a common activity within the native range of this subspecies in Alberta. Fishing effort can be controlled by location, timing, severity (e.g., by bag limits and bait bans) and segment of the population affected (e.g., size limits), therefore it has the potential to target only one portion of the population thereby reducing its potential for harm. Some populations have the capacity to accommodate some catch-and-release or harvest of fish, thus allowable harm from controlled recreational angling (catch-and-release or harvest) may be considered. For example, Picklejar Lakes have sustained relatively high levels of fishing effort since 1986 yet maintained acceptable numbers of fish (J. Stelfox, Alberta Sustainable Resource Development, unpubl. data). In cases where harvest is allowed, fishing effort and population status should be monitored regularly and any necessary corrective measures undertaken to ensure the population is not being negatively affected at the population level.

Research activities should be allowed if they are beneficial to the subspecies and will not jeopardize the survival or recovery of a population.

Data and Knowledge Gaps

Completion of surveys to identify all remaining pure native populations and hybridized populations in Alberta is urgently needed. The possibility of using remnant pure native stocks to aid in recovery needs to be evaluated. Obtaining information on abundance, trends and life-history parameters (e.g., recruitment and mortality) for, and current threats to, the remaining populations of pure native Westslope Cutthroat Trout is a high priority. Understanding how they currently use habitat and what anthropogenic stressors they can and cannot accommodate, including prescribed burns or wild fires, is essential to assessing the potential impacts of habitat manipulation. Surveys are needed to identify where spawning and overwintering occurs. It would be helpful to undertake a comprehensive inventory of remaining “pristine”, unoccupied habitat that could serve as potential refuge sites for imperiled populations. Surveys of Cutthroat Trout introduced outside of the native range in Alberta could be useful, as those populations may contain the only remaining migratory life-history types.

Sources of Uncertainty

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, evolving genetics methods and uncertainty about whether natural polymorphisms exist in some populations have contributed to this problem. There has been debate in the literature about what threshold should be used for deciding that an individual fish or population is pure versus hybridized. Also, advanced-generation backcross hybrids with introgression levels greater than 1% can look indistinguishable from pure Westslope Cutthroat Trout, and past estimates of introgression levels are “snapshots” and can change with time.

Maintaining natural genetic integrity and diversity is critical for the survival and recovery of pure native Westslope Cutthroat Trout in Alberta, yet powerful selective forces have already been at work on the remnant stocks. Populations subjected to such stresses can evolve very rapidly. However, it is unknown whether Westslope Cutthroat Trout can evolve reproductive, behavioural or other isolating mechanisms, with or without assistance, that would reduce or prevent hybridization and/or increase competitiveness with invasive non-indigenous salmonids.

CONCLUSION

In Alberta, pure native Westslope Cutthroat Trout have declined in numbers over the past century, though the rate of decline is unknown. Of the 50 extant populations currently identified as pure strain, eight (16%) are currently thought to have a low chance of recovery. It is estimated that most streams contain between 30 and 200 adults (mean: approximately 100), for a total of less than 5,000 mature individuals. Most, if not all, current populations are restricted to the extreme headwaters of a few major tributaries and upper mainstem of the Bow River drainage, and the upper basin of the Oldman River drainage but not in the mainstem east of the mountain front or in most accessible tributaries.

All the geographic areas where they are currently found may be critical for their long-term survival and recovery. Redds created by spawning females for spawning and the initial development of the eggs and alevins meet the SARA definition of residence. Areas or places that provide essential habitat during key components of the life cycle (i.e., rearing, holding/staging, overwintering and feeding) could also be considered “a dwelling-place” under the SARA definition.

The recovery goal is to protect and maintain all remaining pure native, non-stocked, populations of Westslope Cutthroat Trout in Alberta, each containing at least their current number of fish, with their historical degree of connectivity within drainage systems (except where it would permit invasive non-indigenous species to establish) throughout their current range to ensure their persistence until at least 2020. The aim over the long term is to recover populations within their historic range, where possible.

Invasive non-indigenous species, habitat damage and loss, and climate change pose significant threats to the long-term survival and recovery of pure Westslope Cutthroat Trout. Non-indigenous species introductions pose threats to Westslope Cutthroat Trout through hybridization, competition for resources, predation and possibly the introduction of transferable parasites and disease. Activities related to hydroelectric barriers and impoundments, oil and gas, forestry, mining, agriculture, urbanization, road and rail infrastructure and recreation can damage or destroy habitat and reduce population densities. Climate change may play an important role in limiting the distribution of Westslope Cutthroat Trout in the future through changes in water temperature, patterns of precipitation, stream morphology and hydrology. Overexploitation was an important threat historically, but now is relatively minor.

Important mitigation measures that would improve the current likelihood of survival and recovery of this subspecies include protection of pure native populations from hybridization and competition with non-indigenous species, protection, restoration and enhancement of their habitat, especially by restoring watershed ecological function, and public education (in decreasing order of importance). Recovery efforts for all remaining populations should be prioritized based on current size, importance and a realistic evaluation of prognosis for survival and recovery (i.e., a triage approach).

Activities that have a moderate or higher probability of jeopardizing the survival or recovery of pure native Westslope Cutthroat Trout in Alberta are not recommended. Introductions of invasive non-indigenous species pose severe consequences to pure-strain populations through hybridization, competition and predation and thus are a high risk to survival or recovery where pure remnant Westslope Cutthroat Trout populations remain. Land-use activities that damage or destroy the functional components of habitat or negatively affect key life components of the life cycle (e.g., spawning, recruitment and survival) also have a high risk to negatively impact Westslope Cutthroat Trout populations. Some populations have the capacity to accommodate some catch-and-release or harvest of fish, thus allowable harm from controlled recreational angling (catch-and-release or harvest) may be considered, so long as fishing effort and population status are monitored regularly and any necessary corrective measures undertaken to ensure the population is not being negatively affected at the population level. Research activities should be allowed if they are beneficial to the subspecies and will not jeopardize the survival or recovery of a population.

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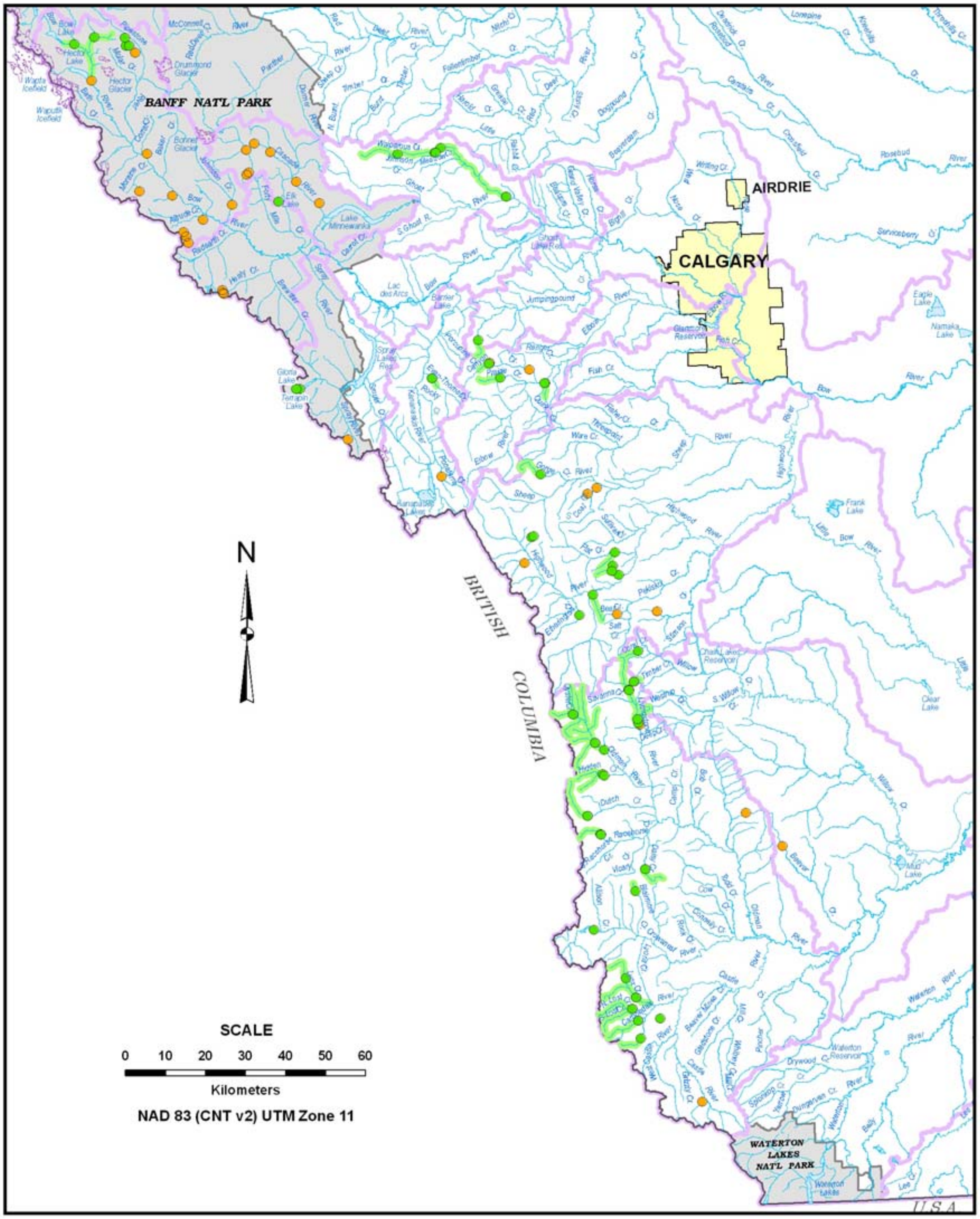

Figure 1. The distribution of pure native (non-stocked) populations of Westslope Cutthroat Trout in Alberta sampled between 2000 and 2008 based on genetic analysis (as of July 2009). Green circles and lines indicate pure strain populations and the potential extent of pure strains, respectively. Orange circles indicate that genetic analysis results are pending. The tertiary watershed boundaries are shown in purple. (©2009 Government of Alberta. All rights reserved. Base Data provided by Spatial Data Warehouse Ltd. The information as depicted is subject to change therefore the Government of Alberta assumes no responsibility for discrepancies at time of use. Alberta Sustainable Resource Development, Southern Rockies Area, Resource Information Unit - Calgary, July 2009)

Table 1. The distribution of known and suspected pure native Westslope Cutthroat Trout (WSCT) populations in Alberta (as of July 2009) based on genetic testing. A pure population is defined as one in which the average of all fish tested was ≥ 0.99 proportion of WSCT genome. Populations marked with an asterisk (*) are those in which pure WSCT were introduced into a waterbody that already contained pure native WSCT. *Sample sizes for most populations are relatively small which reduces the degree of confidence about whether the population is pure. Current population (popn) status (see Appendix 1) is defined in terms of the relative size of the population and its distribution, and degree of connectivity. Recovery potential (see Appendix 1) is based on a combination of current population status and current threats status (Table 2). Data sources: McAllister et al. 1981 (a), Carl and Stelfox 1989 (b), Potvin et al., 2003 (c), Janowicz 2005 (d), Robinson 2007 (e), Taylor and Gow 2007 (f), Taylor and Gow 2009 (g). (Note: The methods used to test for genetic purity evolved over time.)*

Watershed	Suspected and known pure native WSCT populations	Number of fish tested [data source]	Current popn status	Recovery potential: 2009-2039
Bow/upper Bow River (within Banff National Park, above falls at Banff)	Elk Lake Fish Lake (Upper, Big) Little Fish Lake (Lower) Deer Lake (Pipestone Lake)* Moose Lake Bow River, upstream of Hector Lake* Bow River, downstream of Hector Lake* Mosquito Creek Outlet Creek Taylor Creek Mystic Lake Cuthead Creek Sawback Lake Sawback Creek[1]	14 [a], 23 [f] 30 [c] 31 [c] 53 [c] 25 [c] 17 [f, g] pending 23 [f, g] pending pending 11 [a], 23 [f] 21 [c], 17 [f] 17 [f] 29 [f]	High High High High High Low Low Low Moderate Low High Moderate Low Moderate	High Secure Secure Secure Secure Moderate Low Moderate Moderate Low High Moderate Low Moderate
Bow/lower Bow River	None			
Bow/Sheep	Gorge Creek, upper*[†]	30 [g]	Moderate	Moderate
Bow/Jumpingpound	Tributary to upper Jumpingpound Creek*[†]	15 [d]	Low	Low
Bow/Elbow	Silvester Creek Tributary to upper Canyon Creek*[†] Prairie Creek*[†]	23 [d] , 27 [g] 19 [d] 27 [g]	Moderate Moderate Moderate	Moderate Moderate Moderate
Bow/Highwood	Tributary to Flat Creek (Cutthroat Creek) Picklejar Lake #4 Picklejar Lake #2	18 [d], 26 [g] 26 [b], 29 [g] 26 [g]	Moderate High High	Moderate Secure Secure

[1] Sampled fish were from Sawback Creek but mislabeled in Potvin *et al.* 2003.
[†] Revised February 2010

Watershed	Suspected and known pure native WSCT populations	Number of fish tested [data source]	Current popn status	Recovery potential: 2009-2039
Bow/Highwood (cont.)	Tributary to Flat Creek Deep Creek Zephyr Creek Etherington Creek, below seasonal barrier*†	30 [g] 29 [g] 30 [g] 30 [g]	Low Low Low Moderate	Moderate Moderate Moderate Moderate
Bow/Kananaskis	Evan-Thomas Creek*†	55 [d]	Low	Low
Bow/Ghost	Waiparous Creek*† Johnson Creek	11 [d], 29 [g] 17 [g]	Moderate Moderate	Moderate Moderate
Bow/Spray	None			
Oldman/upper Oldman	Oldman River, above falls*‡† Oldman River, immediately below falls*‡† Oyster Creek Honeymoon Creek Hidden Creek, above falls*‡† North Racehorse Creek, above falls Dutch Creek*† Daisy Creek, above falls*‡†	25 [g], 59 [e] 21 [g] 17 [d] 56 [e] 27 [g] 28 [g], 30 [e] 14 [d, e] 20 [d]	Moderate Moderate Moderate Low Moderate Moderate Moderate Moderate	High Moderate High Moderate Moderate Moderate Moderate Moderate
Oldman/mid Oldman	None			
Oldman/Livingstone	Livingstone River, above falls*‡† Livingstone River, below falls*‡† North Twin Creek Beaver Creek	58 [e], 27 [g] 63 [e] 19 [d] 60 [e]	Moderate Moderate Low Moderate	Moderate Moderate Moderate Moderate
Oldman/Crowsnest	Blairmore Creek, upper above falls*‡† Tributary to Crowsnest River	20 [d] 30 [g]	Moderate Low	Moderate Low
Oldman/Castle	Lost Creek*† Carbondale River*† Lynx Creek, above falls*‡† O'Hagen Creek Gardiner Creek*†	28 [g] 22 [g] 14 [f], 15 [d] 30 [g] 29 [g]	High High High Moderate Low	Moderate Moderate Moderate Moderate Moderate
Oldman /lower mainstem	None			
Oldman/Willow	Corral Creek Iron Creek*†	30 [g] 2 [g]	Low Low	Low Low
Oldman/St Mary	None			
Oldman/Belly	None			

† Revised February 2010
‡ Stocking location is unknown; may have been above or below the falls.

Table 2. Current status of threats (see Appendix 1) to pure native Westslope Cutthroat Trout by population, defined in terms of the likelihood of occurrence and level of severity, based on current knowledge of the populations and the areas in which they occur. (L = low, M = moderate, H = high, U = unknown)

THREATS

	Invasive non-indigenous species	**Habitat loss or degradation**								**Climate**	**Consumptive use**
POPULATIONS	Introduced salmonid species[1]	Hydroelectric barriers/ impoundments and activities[2]	Oil and gas exploration/ extraction[2]	Forestry exploration/ extraction[2]	Mining exploration/extraction[2]	Agricultural activities[2]	Urban development[2]	Road and Rail Infrastructure[2]	Recreation[3]	Climate change[4]	Over-exploitation[5]
Elk Lake	L	L	L	L	L	L	L	L	L	U	L
Fish Lake (Upper, Big)	L	L	L	L	L	L	L	L	L	U	L
Little Fish Lake (Lower)	L	L	L	L	L	L	L	L	L	U	L
Deer Lake (Pipestone Lake)	L	L	L	L	L	L	L	L	L	U	L
Moose Lake	L	L	L	L	L	L	L	L	L	U	L
Bow River (upstream Hector Lake)	M	L	L	L	L	L	L	L	L	U	L
Bow River (downstream Hector Lake)	H	L	L	L	L	L	L	L	L	U	L
Mosquito Creek	M	L	L	L	L	L	L	L	L	U	L
Outlet Creek	L	L	L	L	L	L	L	L	L	U	L

[1] Threats include predation by, and competition for resources with, Rainbow Trout, Brook Trout, Brown Trout, Lake Trout, Yellowstone Cutthroat Trout and hatchery-raised Westslope Cutthroat Trout (WSCT). Hybridization of pure native WSCT with some of these species is also resulting in the loss of pure WSCT strains.

[2] Threats include changes in flow regime, frazil and anchor ice, water temperature, concentrations of sediments, nutrients and contaminants, habitat structure and cover, food supply and migration/access to habitat, surface hardening and pollution.

[3] Threats include off-highway vehicle use causing riparian disturbance, stream sedimentation, channel damage, etc.

[4] Threats include changes in water temperature, patterns of precipitation, stream morphology and hydrology.

[5] Illegal harvest - intentional (e.g., poaching) and unintentional (e.g., misidentification) - and hooking mortality (bycatch) in waterbodies closed to harvest of pure native WSCT.

POPULATIONS	Introduced salmonid species	Hydroelectric barriers/ impoundments and activities	Oil and gas exploration/ extraction	Forestry exploration/ extraction	Mining exploration/extraction	Agricultural activities	Urban development	Road and Rail Infrastructure	Recreation	Climate change	Over-exploitation
Taylor Creek	H	L	L	L	L	L	L	L	L	U	L
Mystic Lake	L	L	L	L	L	L	L	L	L	U	L
Cuthead Creek	U	L	L	L	L	L	L	L	L	U	L
Sawback Lake	L	L	L	L	L	L	L	L	L	U	M
Sawback Creek	H	L	L	L	L	L	L	L	L	U	L
Gorge Creek, upper	H	L	L	M	L	L	L	L	L	U	L
Tributary to upper Jumpingpound Creek	H	L	L	M	L	L	L	L	L	U	L
Silvester Creek	M	L	M	M	L	M	L	M	M	U	L
Tributary to upper Canyon Creek	M	L	L	M	L	L	L	M	L	U	M
Prairie Creek	M	L	L	L	L	M	L	M	L	U	M
Tributary to Flat Creek (Cutthroat Creek)	M	L	M	L	L	M	L	L	L	U	L
Picklejar Lake #4	L	L	L	L	L	L	L	L	L	U	M
Picklejar Lake #2	L	L	L	L	L	L	L	L	L	U	M
Tributary to Flat Creek	M	L	L	L	L	M	L	L	L	U	L
Deep Creek	M	L	M	L	L	M	L	L	L	U	L
Zephyr Creek	M	L	L	L	L	M	L	L	L	U	L
Etherington Creek, below seasonal barrier	H	L	L	M	L	L	L	L	L	U	L
Evan-Thomas Creek	H	L	L	L	L	L	L	L	L	U	L
Waiparous Creek	H	L	L	L	L	L	L	M	M	U	M
Johnson Creek	H	L	L	L	L	L	L	M	M	U	L
Oldman River, above falls	M	L	M	M	L	M	L	H	H	U	L
Oldman River, immediately below falls	H	L	M	M	L	M	L	H	H	U	L
Oyster Creek	M	L	M	M	L	M	L	H	H	U	L
Honeymoon Creek	H	L	M	M	L	M	L	M	H	U	L

POPULATIONS	Introduced salmonid species	Hydroelectric barriers/ impoundments and activities	Oil and gas exploration/ extraction	Forestry exploration/ extraction	Mining exploration/extraction	Agricultural activities	Urban development	Road and Rail Infrastructure	Recreation	Climate change	Over-exploitation
Hidden Creek, above falls	H	L	M	M	L	M	L	H	H	U	L
North Racehorse Creek, above falls	H	L	M	M	L	M	L	H	H	U	L
Dutch Creek	H	L	M	M	L	M	L	H	H	U	L
Daisy Creek, above falls	H	L	M	M	L	M	L	H	H	U	L
Livingstone River, above falls	M	L	M	M	L	M	L	H	H	U	L
Livingstone River, below falls	H	L	M	M	L	M	L	H	H	U	L
North Twin Creek	H	L	M	M	L	M	L	H	H	U	L
Beaver Creek	M	L	M	M	L	M	L	L	H	U	L
Blairmore Creek, upper above falls	H	L	M	M	L	M	L	H	H	U	L
Tributary to Crowsnest River	M	L	L	L	L	M	L	L	L	U	L
Lost Creek	H	L	M	M	L	M	L	H	H	U	L
Carbondale River	H	L	M	M	L	M	L	H	H	U	L
Lynx Creek, above falls	M	L	M	M	L	M	L	H	H	U	L
O'Hagen Creek	L	L	L	M	M	M	L	M	M	U	L
Gardiner Creek	H	L	M	M	L	M	L	L	H	U	L
Corral Creek	H	L	M	M	L	M	L	L	M	U	L
Iron Creek	H	L	M	M	L	M	L	L	M	U	L

Appendix 1. Matrix developed and applied to pure native Westslope Cutthroat Trout (Alberta population) to determine population status, threats status and the resulting recovery potential for each population identified in Table 1.

Step 1 Fill in fourth column of Table 1 by determining the population status level for each population identified in the second column in Table 1 that best fits the criteria by considering population size, distribution and connectivity in decreasing order of importance.

POPULATION STATUS

	Criteria		
Population status	Population size based on estimate or expert opinion)	Distribution (based on estimate or expert opinion)	Connectivity (based on knowledge or expert opinion)
LOW	< 50 adults	< 4 km	no
MODERATE	between 50 and 200 adults	between 4 and 10 km	not likely
HIGH	> 200 adults	> 10 km	perhaps or yes
UNKNOWN	Unknown	Unknown	Unknown

Step 2 Fill in Table 2 by determine the status of each threat category for each population based on the criteria and examples provided.

CURRENT THREATS STATUS

	Severity of threat (see examples)			
Likelihood of occurrence of threat	Minor impact on population	Moderate impact on population	Large population-level impact	Unknown
Never or occasionally a threat	LOW	MODERATE	MODERATE	UNKNOWN
Often a threat	MODERATE	MODERATE	HIGH	UNKNOWN
Always a threat	MODERATE	HIGH	HIGH	UNKNOWN
Unknown	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN

Examples of different levels of severity for various categories of threats to be used to determine current threats status.

	Minor impact on population	Moderate impact on population	Large population-level impact
Examples for Introduced Salmonid Species	No introduced salmonid species in the area.	Barrier downstream preventing introduced salmonid species from moving upstream but could be intentionally transferred by disgruntled fisher.	No barrier present to prevent introduced salmonid species from moving upstream.
Examples for Habitat Loss or Degradation threats, and Climate Change	Threat is either not occurring, or if occurring is very localized and/or of short duration.	Threat is affecting larger area and/or of longer duration.	Threat is affecting significant portion of population's range and/or of significant duration.
Examples for Overexploitation (resulting from poaching or misidentification)	No fishing is allowed or is likely to occur (e.g., remote location), or catch-and-release regulations are in effect, or minimum-size limit is larger than the Westslope Cutthroat Trout present, or stunting is evident, indicating that overexploitation is not occurring.*	Fishing may or may not be allowed but waterbody is accessible or with little or no control.	Fishing may or may not be allowed but waterbody is accessible, multiple species are present, some of which can be legally harvested, which increases potential for angler harvest of misidentified fish.

Step 3 Fill in the fifth column of Table 1 by determining the recovery potential status for each population based on the criteria provided. Population status is derived from Step 1. Threats status is based on expert opinion of overall impacts of all threats to the population derived from Step 2.

RECOVERY POTENTIAL STATUS

	Threats status			
Population status	Low	Moderate	High	Unknown
Low[1]	MODERATE	LOW	LOW	LOW
Moderate[2]	MODERATE	MODERATE	LOW	UNKNOWN
High[3]	HIGH	MODERATE	LOW	UNKNOWN
Unknown	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN

[1] High risk of extinction

[2] Moderate risk of extinction

[3] Low risk of extinction

* Revised February 2010