Fish & Wildlife Division

RESOURCE DATA AND SPECIES AT RISK SECTION

Status of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisii*) in Alberta

Alberta Wildlife Status Report No. 61

Alberta Conservation Association

Alberta

Status of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisii*) in Alberta

Prepared for:
Alberta Sustainable Resource Development (SRD)
Alberta Conservation Association (ACA)

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PREFACE

Every five years, the Fish and Wildlife Division of Alberta Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*) and 2000 (*The General Status of Alberta Wild Species 2000*), assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

Cutthroat trout (*Oncorhynchus clarkii*) is a polytypic (having many forms) species of trout endemic to western North America. The species is highly variable in terms of phenotypic traits (physical features) and life history characteristics but has strict habitat requirements, requiring cold clean water and varied forms of cover to maintain populations. Although the original distribution of cutthroat trout was likely greater than any other form of North American trout or salmon (with the exception of lake trout, *Salvelinus namaycush*), the various cutthroat subspecies (of which there are four main types and 10 further derivatives) have undergone dramatic declines in their numbers and distribution since European settlement; some have disappeared from as much as 90% of the native range. The only subspecies native to Alberta, and the focus of this review, is the westslope cutthroat trout (*O. clarkii lewisii*), whose current global distribution has become extremely fragmented into isolated, high elevation headwater areas. Westslope cutthroat trout are native to the Bow and Oldman drainages of the South Saskatchewan River and were originally found from the extreme headwaters of these systems throughout mainstem stretches and down onto the grassland plains. Today, populations are largely restricted to the Rocky Mountain Natural Region and the Parkland Natural Region (Foothills Subregion) in the uppermost reaches of mainstem rivers and the extreme headwaters of a few major tributaries.

Although introduced hatchery populations of westslope cutthroat trout populations are widespread in Alberta, only 60–70 streams are believed to contain genetically pure native strains (the total Alberta population size of wild, native westslope cutthroat trout is likely much smaller than 7000 mature individuals). Many of the native river migratory populations are believed to be severely depressed, if not already extirpated; some disappeared following the construction of dams early in the last century, whereas others have declined as a consequence of habitat degradation and the stocking of non-native species. The greatest threats to westslope cutthroat trout in Alberta continue to be the human-caused manipulation and degradation of the environment in which they live. Introgressive hybridization (permanent incorporation of foreign genetic material) between native westslope cutthroat trout and introduced species (primarily rainbow trout) is believed to be widespread, and the continued presence of non-native species threatens the genetic integrity of remaining westslope cutthroat trout populations. In November 2006, the Committee on the Status of Endangered Wildlife in Canada designated the remaining genetically pure populations inhabiting the native range in Alberta as *Threatened* (i.e., likely to become endangered if limiting factors are not reversed). A comprehensive assessment of the genetic integrity of the remaining populations and thorough review of the current stocking program in Alberta seem necessary if native populations of westslope cutthroat trout are to be maintained in the province.

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INTRODUCTION

Westslope cutthroat trout (*Oncorhynchus clarkii lewisii*) is a unique and important component of Canada's freshwater fish fauna. Historically, this species was one of the first fish to recolonize western Canada postglacially and in many areas is the only native trout species present. Populations in British Columbia and Alberta exist on the northern periphery of the subspecies' range, which extends over both sides of the Continental Divide as far south as Montana, Idaho, Washington, Oregon and Wyoming. Although historically a widespread species, westslope cutthroat trout has shown dramatic global declines in the number and distribution of populations. Habitat degradation, overharvesting and the introduction of nonnative species (through increased competition and hybridization) have all contributed to the decline. In November 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) formalized two designatable units of westslope cutthroat trout in Canada: a British Columbia population and an Alberta population. Whereas the British Columbia population was designated *Special Concern**, the Alberta population was designated as *Threatened* (i.e., likely to become endangered if limiting factors are not reversed). Note that the COSEWIC process only considers the remaining genetically pure native populations in Canada; there are a large number of hybridized or introduced hatchery populations that were not assessed. As in the United States, pure, native populations of westslope cutthroat trout in Alberta have become severely fragmented and isolated in headwater stream areas. This report is intended to compile and summarize up-to-date information on the status of wild, native westslope cutthroat trout in Alberta to assist in that process.

* See Appendix 1 for definitions of selected status designations.

SPECIES INFORMATION

Westslope cutthroat trout (*Oncorhynchus clarkii lewisii*, formerly *Salmo clarki lewisi*) is a popular sport fish in Alberta. The subspecies is known by a number of different names where it is found, including cutthroat, interior cutthroat, mountain cutthroat, cutty, spotted trout, (Montana) black-spotted trout, black spots, red-throated trout, Lewis' trout, or *truite fardée* (Fr.). It has the streamlined body typical of salmonids and is generally trout-like in appearance, with dark spots on a lighter background. The spots are small and irregularly shaped, forming a characteristic arc from the base of the anal fin forward to the pectoral fin (more numerous toward the tail and concentrated above the lateral line). Body colouration ranges from silver to yellowish-green with red on the front and sides of the head. Spawning fish often develop a bright red colouration over the entire body. The field identification of westslope cutthroat trout, however, can be difficult in areas of natural sympatry (co-occurrence) with closely related species or where nonnative forms have been stocked. Many of the interior cutthroat trout subspecies appear to be of fairly recent origin (i.e., since the most recent glaciation) so that no one phenotypic or meristic character (i.e., those pertaining to body shape, size, coloration, etc.) clearly differentiates them. As well, considerable overlap exists between cutthroat trout and its sister species, rainbow trout (*Oncorhynchus mykiss*). Cutthroat trout generally tend to have a larger mouth than rainbow trout with a longer maxillary (lower jaw bone), which extends past the hind portion of the eye. As well, a series of small tooth-like structures at the back of the throat are generally considered to be diagnostic of pure cutthroat trout throughout much of their range (Behnke 1992, Leary et al. 1996, Weigel et al. 2002). The most conspicuous character distinguishing cutthroat trout from similar species, however, is the presence of orange-red slashes beneath the lower jaw, which give the species its name.

The occurrence of introgressive hybridization (permanent incorporation of foreign genetic material) between westslope cutthroat and rainbow trout, however, usually leads to a host of alternate spotting patterns in westslope cutthroat trout and the appearance of spots on top of the head and anterior portion of the body. Hybrids may also lack the slash beneath the lower jaw, and have a larger head-tail length ratio (Behnke 1992, Weigel et al. 2002).

HABITAT

1. Habitat Description – As with other salmonids, four main types of habitat are required for the westslope cutthroat trout to complete its life cycle:

a) Spawning – Spawning takes place in small, low gradient streams with cold, well-oxygenated water and clean, unsilted gravels; it often occurs at the downstream edge of deep pools at moderate to high flow events, which are often of short duration (Brown and Mackay 1995a, Schmetterling 2001). Shoal spawning (on shallow beaches or gravel bars in lakes) has been observed (e.g., Carl and Stelfox 1989), but does not appear to be common. Proximity to cover is important for spawners; while residing in spawning tributaries, spawners are located almost exclusively in habitat units formed by large woody debris, boulders or bedrock. This instream structure creates the necessary pool habitat to catch and retain spawning gravels and provides cover from predation. High mortality often results when suitable cover is lacking (Behnke 1992, Brown and Mackay 1995b).

b) Rearing – Small streams (first- to third-order) that remain permanently wetted during low flows and have a diversity of cover are required juvenile-rearing habitat (McIntyre and Rieman 1995). Young-of-the-year fry migrate to low energy lateral habitat (i.e., shallow riffle or backwater habitat) with protective cover and low water velocities, whereas some populations may rear in lakes. Larger juveniles move into pools where they establish social dominance based on size. Juveniles require large territories and the availability of pool habitat often limits their productivity even in productive streams (Schmetterling 2001).

c) Adult/feeding – Adult habitat is quite varied, depending on the particular life history type involved (see *Conservation Biology* section in this report). Individuals making up the resident component of populations may remain in the natal stream for their entire lives. Migratory forms will undergo a niche shift and leave small natal streams for larger systems or mainstem habitat where the potential for increased growth may be greater. For fluvial (riverine) forms, slow pools formed by boulders or large woody debris with fast adjacent water and plenty of cover (undercut banks, riparian vegetation, instream structure) are required. Adfluvial (migrating between lakes and rivers) and lacustrine (lake-resident) adults will spend summer months feeding in lakes and reservoirs with temperatures less than 16°C (McIntyre and Rieman 1995).

d) Overwintering – Overwintering habitat suitability appears to be largely determined by groundwater influx and the absence of anchor ice (Brown and Mackay 1995a). During winter months, fluvial adults will congregate in slow deep pools sheltered from high flows. Juveniles often overwinter in cover provided by boulders and other large instream structures or in off-channel habitat such as sloughs or beaver ponds. Adfluvial fish will often overwinter in lakes.

Stream temperature is likely an important habitat parameter affecting cold-water salmonids like westslope cutthroat trout. Cutthroat trout are sensitive to changes in water temperature and are not usually found in waters where maximum stream temperature repeatedly exceeds 22°C (Behnke and Zarn 1976). Their preferred temperatures likely range from 9°C to 12°C. Their preference for cooler water temperatures

appears to make westslope cutthroat trout a superior competitor at higher elevation stream reaches (Griffith 1988, Fausch 1989, Paul and Post 2001). Riparian cover and varied instream structure are also essential elements of westslope cutthroat trout habitat. Riparian vegetation (e.g., alders, willow, poplar) serves to stabilize stream banks, reduce predation and keep stream temperatures low by reducing insolation (reviewed by Reeves et al. 1997). As well, the riparian input of terrestrial insects is often a significant food source for westslope cutthroat trout during summer months (Behnke 1992). Undercut banks, root wads and boulders are also important in partitioning stream habitats and in creating areas of refuge. Bedrock outcroppings are perhaps of more importance in areas where trees are smaller and debris jams are less frequent.

2. Trends – Historically, westslope cutthroat trout could be found in a range of habitats in Alberta, from headwater streams and tributaries to mainstem river sections extending down onto the grassland plains. They are now predominately restricted to headwater streams and lakes, and the uppermost reaches of mainstem rivers, where they appear to have a competitive advantage over other fish species (Griffith 1988, Fausch 1989, Paul and Post 2001). Resource development, urbanization and water diversion have negatively affected the amount and quality of westslope cutthroat trout habitat in Alberta. First, resource exploration has led to a dramatic increase in road density in Alberta, translating into an explosion of wilderness access points (e.g., roads, cutlines). Increasingly, off-road vehicle traffic is leading to increased stream bank erosion and sedimentation, as well as increased angling pressure. Cumulative impact assessments conducted on 98 fourth-order or higher watersheds in the upper Oldman, Crowsnest and Carbondale (Castle River drainage) basins, for example, found that approximately two-thirds of the watersheds in those systems were at moderate risk, and the remainder at high risk of degradation from increased peak flows and surface erosion caused by extensive clearcutting and road development (Mayhood et al. 1997, Mayhood 2000).

Second, the human population in the South Saskatchewan River basin has grown dramatically and is expected to reach approximately 2 million by 2021 (from 1.3 million in 1996); accompanying this population growth is a projected increase in domestic water demand of 29%–66% (Alberta Environment 2003). Presently, 41.5% of the running waters of the Bow River valley watershed in Banff have already been regulated, obstructed or otherwise impounded (Schindler and Pacas 1996). There are four TransAlta hydroelectric plants on the Bow River mainstem alone (11 in total on the Kananaskis/Bow River system) and the health of the aquatic environment downstream on the Bow and Oldman rivers appears to be declining (Golder and Associates Ltd. 2003). While the major withdrawals occur in the lower parts of these systems and below existing westslope cutthroat trout populations, it is likely that such withdrawals have contributed to the extirpation of local populations in the past (see *Distribution*).

CONSERVATION BIOLOGY

1. Life History Diversity – Cutthroat trout are arguably the most diverse salmonids in North America and show extensive variation in the size, colouration and life history characteristics typical of populations (reviewed by Trotter 1987, Behnke 1992). Several different life history types are present throughout the Canadian range of westslope cutthroat trout; fluvial and resident populations are common throughout British Columbia and Alberta (adfluvial perhaps less so) and mixed strategies may often be present within the same population. These different life history strategies expose westslope cutthroat trout to different resource environments that vary in what opportunity they provide for growth and development.

This variety has a direct influence on typical size at maturity; stream-resident westslope cutthroat trout seldom exceed a fork length of 250–300 mm, whereas fluvial and adfluvial fish often attain sizes of greater than 300 mm and 0.9–1.4 kg in weight (Shepard et al. 1984, McIntyre and Rieman 1995). Age composition or size structure in westslope cutthroat trout populations may therefore be quite complex.

2. Reproduction – Cutthroat trout exhibit a mating system typical of other salmonids (reviewed by Fleming and Reynolds 2004). Spawners return or "home" to small natal streams where females compete for preferred spawning areas (usually in the tailouts of deep pools) and males compete for access to females (although alternate "sneaking" strategies are employed by small stream-resident males). Downs et al. (1997) found that males in isolated headwater populations from Montana first reached maturity at age two and were all mature by four years of age. The youngest female found to be mature was three years old whereas most were mature by the age of five years. Spawning generally takes place between May and July (depending on location) and is likely stimulated by rising water temperatures (approximately 5–6.5°C). Eggs generally incubate in the spawning gravels for between six and seven weeks, depending on water temperature, and newly emerged fry quickly migrate to low-energy lateral habitats. Cutthroat trout are iteroparous (repeat-spawning) and some fish may reproduce every year or every alternate year. Post-mating mortality may be significant, however, especially for males. There appear to be very few repeat spawners in the Blackfoot River, Montana (0.7%–2.9%; Schmetterling 2001) although higher values have been reported elsewhere (Shepard et al. 1984, McIntyre and Rieman 1995). As female fecundity is known to increase with size, the importance of maintaining these repeat spawners is particularly relevant for small populations that are subject to habitat degradation. Not only do larger females produce more eggs, but the eggs are larger and produce larger fry, increasing their chances for survival (Downs et al. 1997).

3. Survival – 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. Eggs and newly hatched alevins (newborns with egg sac intact) are highly sensitive to environmental degradation, particularly sedimentation and dewatering. Physical injury and competition for rearing habitat is likely significant where such habitat is limited. For fry and larger juveniles, competition with each other and sympatric species for food and areas of refuge may be significant. As well, they may be heavily preyed upon by piscivorous fishes (e.g., cottids, bull trout [*Salvelinus confluentus*], northern pikeminnow [*Ptychocheilus oregonensis*] and introduced species). Adults are susceptible to a number of riparian predators (raptors, mustelids, etc.) where sufficient cover is lacking. Recreational harvesting may also represent a significant source of mortality for adults, even where fisheries restrictions have been implemented (see *Limiting Factors*). Given that the age at first reproduction is 2 to 5 years and that very few repeat spawners exist (see *Reproduction*, above), few adults likely live beyond 5 years. Some fish from unproductive high elevation lakes may live to 8 or possibly 12 years in rare cases (A. Costello pers. comm. 2006).

4. Movements and Dispersal – Westslope cutthroat trout undertake several types of movement during their lifetime, including those associated with life history shifts, movements to and from feeding and overwintering habitats, and those associated with reproduction. During their first year of life, fry disperse from areas of high density to low density, generally into lateral habitats with sufficient cover. Juveniles rear in natal streams between one and four years, depending on stream productivity and the particular life history type involved.

During this time, individuals may be relatively sedentary, remaining in the vicinity of the same stream reach or pool. Older juveniles and subadults may range further in response to changing water levels, stream temperatures or the availability of food. Individuals from headwater streams in Montana, for example, have been observed to move less than 1 km (Jakober et al. 1997), whereas fluvial and adfluvial westslope cutthroat trout may migrate over large distances (in excess of 100 km) to find suitable feeding grounds or overwintering habitat (Schmetterling 2001, Prince and Morris 2002). Movement during the summer will often cease once suitable feeding habitat has been found. In late summer and early fall, westslope cutthroat trout begin to seek suitable overwintering sites in response to decreasing water temperatures and ice formation. In streams with dynamic ice conditions, movement can continue throughout the winter (Brown and Mackay 1995a, Schmetterling 2001, Prince and Morris 2002). In response to lengthening days and increasing water temperatures, westslope cutthroat trout will often rapidly leave their overwintering habitat to return to small natal tributaries to spawn. This shift may occur between March and July, but most typically between May and June. Following spawning, there may or may not be a sudden movement to summer habitat (again depending on its location/availability), followed by little subsequent movement during the summer.

Although feeding/overwintering movements may extend for many kilometres, actual inter-population straying or dispersal appears to be minimal. Like other salmonids, westslope cutthroat trout are characterized by well-developed natal philopatry (i.e., a propensity to return to the natal stream), which tends to limit dispersal potential. Genetic evidence, for example, suggests that distinct breeding units for westslope cutthroat trout are structured over small geographic distances and that even adjacent populations may exhibit little gene flow (i.e., less than one migrant per generation; Potvin et al. 2003, Taylor et al. 2003). Migration barriers are obviously a significant factor in structuring the opportunity for dispersal (see *Limiting Factors*). Significant divergence among populations lacking obvious migration barriers, however, suggests reproductive isolation and a high degree of demographic independence among even mainstem river populations (e.g., Taylor et al. 2003).

5. Nutrition – Westslope cutthroat trout tend to specialize as invertebrate feeders, even where forage fish are abundant (Shepard et al. 1984). For young-of-the-year fry, chironomid larvae in lateral habitats are an important food source. Older juveniles and adults feed both on terrestrial and planktivorous insects; dipterans (crane flies, fruit flies, etc.) and ephemeropterans (mayflies) are the most important dietary components. Trichopterans (caddisflies) are important for fish that are 110 mm long or longer and the diversity of food items increases with increasing size (reviewed by Liknes and Graham 1988). For adfluvial forms, zooplankton is an important food source, particularly during winter months (Shepard et al. 1984).

6. Interspecific Interactions and Hybridization – Cutthroat trout possess traits that appear to reduce their interspecific interactions with other salmonids. First, their relatively small size at maturity allows them to use smaller streams than those typically inhabited by larger salmonids. Platts (1974) found that westslope cutthroat trout densities peaked at a channel gradient of about 10%, which was higher than that for peak densities of bull trout, rainbow trout or brook trout (*Salvelinus fontinalis*). These densities may indicate that such habitats are less optimal for other salmonids, not necessarily that they are preferred by westslope cutthroat trout. It appears that cutthroat trout populations are less likely to coexist with introduced brook trout than with other native salmonids (Griffith 1988). In Yellowstone National Park, the

introduction of brook trout has nearly always resulted in the disappearance of cutthroat trout (Varley and Gresswell 1988). Brook trout mature earlier in life than westslope cutthroat trout and may have a competitive advantage at warmer temperatures (e.g., DeStraso and Rahel 1994). It may be that westslope cutthroat trout are marginalized by other mechanisms such as habitat degradation or overfishing, and are then replaced by brook trout. Once a westslope cutthroat trout population is replaced by another salmonid species, it is unlikely that the habitat will ever be recolonized.

As noted, westslope cutthroat trout are further subjected to introgressive hybridization when closely related species (i.e., rainbow trout, other cutthroat subspecies) are introduced into their range (Allendorf and Leary 1988, Rubidge et al. 2001, Scribner et al. 2001). Although the relative fitness of these hybrid fish remains uncertain, the ongoing spread of introgression in the wild (e.g., Hitt et al. 2003, Rubidge and Taylor 2005) suggests that at least some hybrids do survive and are capable of successful reproduction. The apparent absence of selection against hybrids also suggests that introgressed genotypes can persist in wild populations and have the potential to ultimately lead to the formation of hybrid swarms (Forbes and Allendorf 1991). Hybrid swarms present a significant threat to the persistence of native species and have been perceived as a "genomic extinction" or "extinction in progress" because the unique genotypes characteristic of the pure parental species are lost once randomly mating hybrid swarms are formed (Rhymer and Simberloff 1996, Allendorf et al. 2003).

DISTRIBUTION

1. Alberta – Alberta contains a small portion of the current global range of native westslope cutthroat trout (now centered on the upper Kootenay River in British Columbia). Although the area of occupancy is unknown (predominately restricted to headwater reaches), the extent of occurrence in Alberta is roughly 20 000 km² and limited to the Rocky Mountain Natural Region and the Parkland Natural Region (Foothills subregion; Figure 1). The historical range was likely limited to the Bow and Oldman drainages of the South Saskatchewan River and possibly the headwaters of the Milk River on the eastern slopes of the Rocky Mountains (Willock 1969). In the Bow drainage, westslope cutthroat trout were originally found from the extreme headwaters above Bow Lake in Banff National Park (BNP), downstream to the plains below Calgary and in all of its major tributaries: the Spray, Cascade, Kananaskis, Ghost, Elbow and Highwood rivers, as well as Jumpingpound and Fish creeks (Prince and McGuire 1912, Behnke 1992, Mayhood 2000).

Today, populations in the Bow drainage (which represent about half of the historical range) are generally small, occupying less than 5% of the historical native range outside BNP (Mayhood 2000). Over the last 100 years, the species is known to have disappeared from an estimated 30% of its historical range within park boundaries (Schindler and Pacas 1996) and is now present only in streams above Lake Louise, in the uppermost headwaters of the Spray and Cascade rivers, in three small tributaries of the Kananaskis River, the upper reaches of the Ghost River and a few small tributaries, and in the upper parts of five Elbow River tributaries (Table 1). There do appear to be westslope cutthroat trout populations in the Highwood River below the Forest Reserve boundary in a few, short, highly isolated tributary reaches. The Jumpingpound Creek population is similarly present below the Forest Reserve boundary (Mayhood 2000). Although a small portion of lacustrine populations in BNP appears to be stable (westslope were stocked into as many as 64 lakes), fluvial populations are believed to no longer exist in the area. Surveys of the Bow River mainstem through the park during the 1990s found very few westslope cutthroat trout between Redearth Creek and Forty Mile Creek;

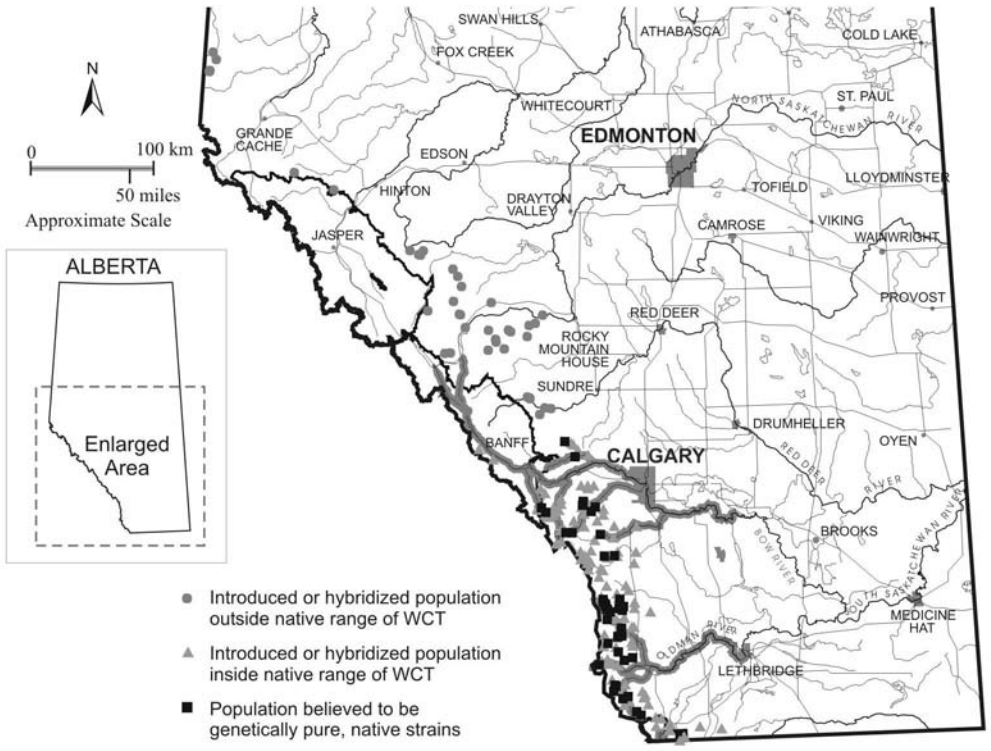

Figure 1. Current distribution of native and introduced westslope cutthroat trout (WCT) populations in Alberta (Alberta Sustainable Resource Development and Alberta Conservation Association 2004). The approximate historical range has been highlighted (primarily from Mayhood 1995).

brook trout are now common in the area and the few westslope cutthroat trout that were seen appeared to be westslope cutthroat/rainbow trout hybrids (C. Pacas pers. comm. 2003).

In the Oldman River drainage, westslope cutthroat trout were present from the headwater falls below Cache Creek downstream to the plains and in all of the Oldman River's major tributaries: the Livingstone, Crowsnest, Castle and Belly rivers, as well as Willow Creek (Mayhood 2000). Westslope cutthroat trout still occupy most of the native range in the upper Oldman basin, but are no longer found in the mainstem east of the mountain front or in most of its accessible tributaries (Mayhood et al. 1997). Although populations in the upper Oldman, Livingstone and Castle river basins appear to be reasonably large, populations in the St. Mary and Belly drainages appear small and are not common; those in the Crowsnest drainage are believed to have been extirpated (Mayhood et al. 1997). Finally, the Milk River, which flows north into Alberta from Montana before turning south to join the Missouri River, is one of only a few Canadian tributaries of that system. Although native westslope cutthroat trout were recorded to have been collected there in the past (e.g., Willock 1969), their status there is unknown and there are no recent records of westslope cutthroat trout in the Milk River. Overall, it appears that the total proportion of the historical distribution in Alberta that remains occupied is at most 20% (A. Costello pers. comm. 2006).

It is clear that habitat degradation and the stocking of nonnative species have led to the displacement/replacement of native westslope cutthroat trout from large areas of the Alberta

Table 1. Status of selected westslope cutthroat trout populations in eight large drainages of the Bow River subbasin and Banff National Park. Introduced westslope cutthroat trout populations are labelled with an asterix (*). Sources include Thompson 1976, Wiebe 1978, Stelfox and Konnynenbelt 1980, Monenco Consultants Ltd 1982, Stelfox and Ladd 1982, Potvin et al. 2003 and J. Stelfox pers. comm. 2003. RBT = rainbow trout; BRT = Eastern brook trout; BT = brown trout; LT = lake trout.

Drainage	Pure westslope cutthroat trout populations	Suspected/Confirmed westslope cutthroat trout x RBT hybrid populations	Populations dominated by introduced RBT, BRT, BT or LT
Highwood	Cutthroat Creek Picklejar Lakes Upper Flat Creek	Etherington Creek Lower Flat Creek Upper Sullivan Creek Head Creek Fitzsimmons Creek Carnarvon Creek McPhail Creek Loomis Creek	Sullivan Creek Cataract Creek Pekisko Creek Lower Highwood mainstem
Sheep	*Lower Junction Creek *Upper Sheep River	Gorge Creek Upper Fisher Creek	Ware Creek (spawning area for RBT) Threepoint Creek Lower Fisher Creek Lower Sheep and tributaries Coal Creek
Elbow	*Cougar Creek *Ford Lake Canyon Creek Prairie Creek Silvester Creek	(Little available data)	Quirk Creek Bragg Creek Ranger Creek Lower Elbow and tributaries
Jumpingpound Creek	extreme headwaters	(RBT are established, hybridization likely in lower reaches)	Lower mainstem and tributaries Sibbald Creek
Kananaskis River	Upper Evan-Thomas Creek Porcupine Creek	Rocky Creek Spotted Wolf Creek	Lower Evan-Thomas Creek Muskeg Creek Kananaskis River Boulton Creek Wasotch Creek Lower Kananaskis Lake
Spray River	*Watridge Creek	Hogarth Creek Smuts Creek	Lower Spray River Spray Lakes Reservoir
Ghost River	Margaret Creek	Johnson Creek Waiparous Creek	Leseur Creek Meadow Creek
Fish Creek			Fish Creek and tributaries

Table 1 cont'd.

Banff National Park	Deer Lake Fish Lake #2 Little Fish Lake Upper Spray River Moose Lake Sawback Lake Mystic Lake *Luellen Lake *Boom Lake *Marvel Lake	Leman Lake Bow River Morraine Lake	(Data not available)
Waterton Lakes National Park	*Lone Lake *Carthew Lake *Crypt Lake *Goat Lake *Lineham Lake	Sofa Creek Dungarvan Creek	(Data not available)

range and the hybridization of many remaining populations. Water impoundment and hydroelectric development have negatively affected some populations and contributed to extirpations in parts of the Highwood, Bow and Oldman rivers. The disappearance of these populations came soon after the development of the dams and the stocking of rainbow trout into the reservoirs (Nelson 1965). Dams appear to have been a major factor in the decline of the lower Spray and Cascade westslope cutthroat trout populations as well. Although abundant in Spray Lake before the reservoir was filled, westslope cutthroat trout no longer exist in the Spray Lakes Reservoir (Stelfox 1987). Before dam construction in 1913, westslope cutthroat trout were notably present throughout the Kananaskis River system below Twin Falls (between the Upper and Lower Kananaskis lakes, in Lower Kananaskis Lake and in the Kananaskis River). Today, they are virtually absent from Lower Kananaskis Lake, the Kananaskis River mainstem and the upper reaches of all but three of its small tributaries (Rocky, Evan-Thomas and Porcupine). Similarly, no westslope cutthroat trout were found between the Ghost Dam on the Bow River and the Bearspaw Reservoir (RL&L Environmental Services Ltd. 1998) or from the TransAlta Pocaterra Power plant to Pocaterra Creek (Kananaskis River drainage; Golder and Associates Ltd. 1999). Both areas historically supported native westslope cutthroat trout populations.

It is important to note that hatchery-reared westslope cutthroat trout have been widely introduced throughout several major drainages in Alberta, most commonly into previously fishless headwater lakes located above impassable barriers, but not strictly so. They have been introduced into several streams in the Oldman and Bow river systems (Mayhood 2000) and into many lakes in Banff and Waterton Lakes national parks (Landry et al. 2000). In the upper North Saskatchewan River, they have been stocked into small headwater lakes above the Clearwater junction and the upper half of Brazeau River (Lake of the Falls, Landslide Lake and some tributaries of the Nordegg River). Recently, they have been introduced into the Bighorn River and Ram River above David Thompson Canyon, to the Athabasca River, Mowitch Creek (Jasper National Park), and into tributaries of the Peace River (Smoky, Wapiti, Simonette, Little Smoky, Pine and the

Narraway watersheds; Nelson and Paetz 1992). Although transplanted westslope cutthroat trout populations in Alberta are widespread, individual populations appear to be small and localized, with the exception of the Ram River population in the North Saskatchewan River drainage (Mayhood 2000). Their hatchery origin, however, makes them somewhat less relevant when discussing the conservation of *locally adapted **native** trout biodiversity*, and their presence tends to obscure the status of native populations (see *Limiting Factors*).

2. Other Areas – Although the original distribution of westslope cutthroat trout is not known with certainty, the species' known native range straddles the Continental Divide (Figure 2). West of the Rocky Mountains, this range includes the Salmon, Clearwater, Coeur d'Alene, St. Joe and Spokane river drainages in Idaho, and the Clark Fork and Kootenai (spelled "Kootenay" in Canada) drainages in Idaho and Montana. Westslope cutthroat trout are native above barriers in the upper Kootenay and Columbia drainages, as well as in the extreme headwaters of the Fraser River (South Thompson drainage) in British Columbia. To the immediate southeast, westslope cutthroat trout are present throughout the headwaters of the upper Flathead River, which flows south out of B.C. into Flathead Lake before joining the Clark Fork River drainage near Plains, Montana. On the eastern slopes of the Rocky Mountains, westslope cutthroat trout are native to the upper South Saskatchewan River drainage in Alberta (Bow and Oldman rivers), and also to the upper Missouri River drainage in southern Alberta, northwestern Wyoming and Montana (including the headwaters of the Judith, Milk and Marias rivers) to approximately 60 km downstream of Great Falls, Montana (Willock 1969, Behnke 1992). The current global distribution of westslope cutthroat trout populations has become extremely fragmented. Throughout its range in the United States, westslope cutthroat trout is believed to currently occupy approximately 59% of the 91 000 river km historically occupied *circa* 1800 (Shepard et al. 2003). Recent genetic testing suggests that westslope cutthroat trout populations may be genetically unaltered in as little as 8% of this historical range (Shepard et al. 2003). Dispersal barriers (e.g., falls, dams) on the upper Columbia and Kootenay rivers (as well as the formidable Rocky Mountains) currently preclude any significant dispersal between major watersheds.

POPULATION SIZE AND TRENDS

Because the species tends to occupy colder, less productive habitats, population sizes for westslope cutthroat trout are expected to be smaller than for many other salmonids. Exact numbers are likely a function of stream size but are typically on the order of tens to hundreds in even the largest systems (Trotter 1987, Behnke 1992, Brown and Mackay 1995b, Shepard et al. 2003). This estimate is in keeping with stream census data from Alberta that indicate that the majority of westslope cutthroat trout streams average about 8 km in length and contain from 30 to 200 adults (mean = 100; Jim Stelfox, unpublished data). Most are probably closer to 30 than to 100, but a few larger streams result in the higher mean. As a rough approximation, the mean of 100 adults per population will therefore be used as an upper limit to estimate total population size in the province.

1. Alberta – In total, 274 streams in Alberta are believed to have historically contained native populations of cutthroat trout; only 60–70 of these are now known or suspected to still have pure, native strains of westslope cutthroat trout (Alberta Sustainable Resource Development and Alberta Conservation Association 2004; J. Stelfox pers. comm. 2006). Applying the average number of 100 mature individuals per stream, the total Alberta population size of wild, native westslope cutthroat trout is likely much smaller than 7000 mature individuals. Furthermore, of the 60–70 native populations, nearly half (29) are deemed to be

Figure 2. Global/Canadian ranges of native coastal and westslope cutthroat trout (modified from Behnke 2002).

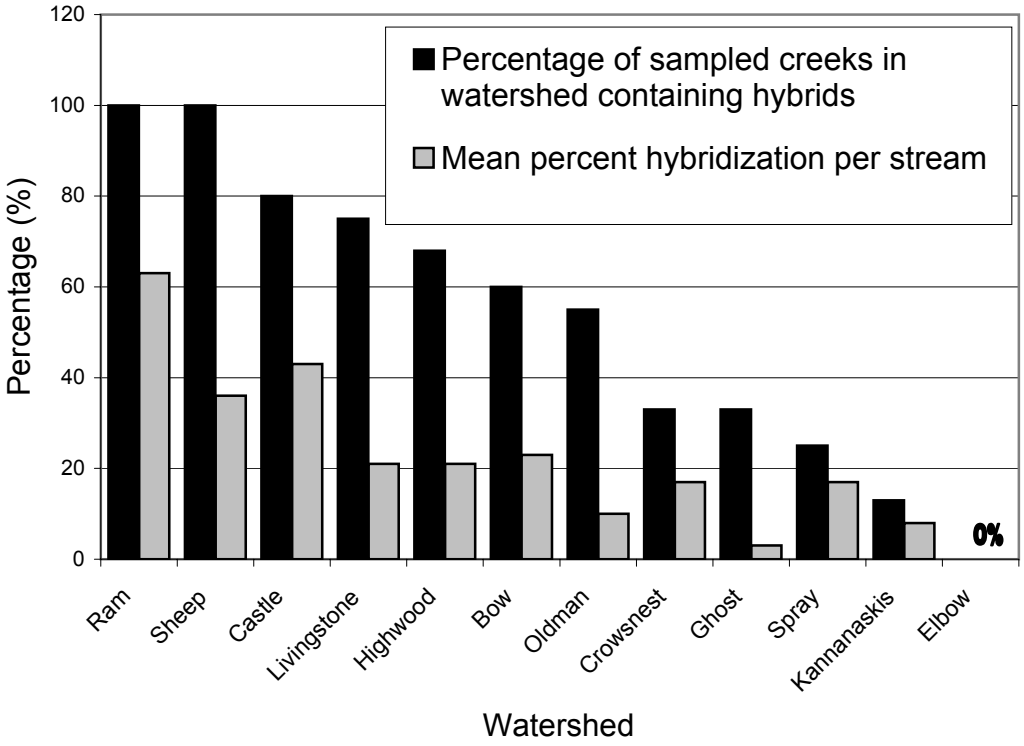

Figure 3. Summary of levels of hybridization in watersheds and individual creeks for selected Alberta drainages (modified from Janowicz 2004). Note that the high mean percent hybridization for hybridized streams for the Kananaskis system is based on only one hybridized site (see Appendix 2).

at considerable risk of extirpation, primarily due to hybridization and/or competition with exotic salmonids. Recent rates of decline (since the 1990s) are not known, but the story has been one of progressive decline since the early decades of the twentieth century. Initially the declines were largely due to exploitation, but more recently they are a result of competition and introgressive hybridization with introduced species, particularly rainbow trout. Although two studies of hybridization in Alberta found limited evidence for hybridization between native westslope cutthroat trout and introduced species (McAllister et al. 1981, Potvin et al. 2003), the morphological comparisons and genetic markers used in these studies appear to have had limited resolution to detect rainbow trout introgression. Furthermore, the majority of samples were chosen with the expectation that they would contain pure westslope cutthroat trout populations. More recent genetic testing suggests that hybridization between westslope cutthroat trout and rainbow trout may, in fact, be widespread on the eastern slopes of the Rocky Mountains.

Janowicz (2004) detected hybridized populations in 13 of 14 watersheds sampled (Figure 3; see also Appendix 2), with the degree of hybridization within watersheds ranging from 100% of sampled creeks (in the Ram and Sheep rivers, North Saskatchewan drainage) to 22% in the Kananaskis River. The severity of hybridization within individual streams varied considerably from one or a few hybrid individuals to those where in excess of 80% of all individuals appeared to be of hybrid origin. It should be noted that the low number of reference westslope cutthroat trout populations (i.e., populations known to be genetically pure westslope cutthroat trout, n =3) in the study may have led to overestimation of the number of hybrids observed in the sample as the number of diagnostic westslope cutthroat trout alleles was low. In other words, westslope cutthroat trout alleles not present in reference populations

may have been misidentified as rainbow trout alleles. Countering this potential upwards bias is the fact that many of the sampled streams were not chosen randomly, but with the belief that they contained pure westslope cutthroat trout populations. A standardized, comprehensive analysis of hybridization levels in the province is urgently required to determine the genetic purity of remaining Alberta westslope cutthroat trout populations and prioritize populations for conservation (see *Limiting Factors*). Wherever cutthroat trout and rainbow trout co-exist, it is only a matter of time before pure cutthroat trout are extirpated (J. Stelfox pers. comm. 2006).

Actual trend data are scarce, but several current populations (e.g., Quirk, Bragg, Leseur, Meadow, Sullivan, Loomis, Flat, Odlum, McPhail, Carnarvon, Pekisko, Ware, Threepoint, Fisher, Fish and Jumpingpound creeks) are considered to be severely depressed or already extirpated, largely as a result of widespread habitat degradation and the stocking of nonnative species (J. Stelfox pers. comm. 2004). Consider Quirk Creek as an example: it is a small system in the Elbow River drainage (Bow River tributary) that was the subject of a westslope cutthroat trout population study between 1995 and 2002 (reviewed by Stelfox et al. 2001). This creek supported only native bull trout and westslope cutthroat trout prior to the introduction of brook trout to the Elbow River watershed in 1940. A fisheries survey in 1948 found no brook trout in Quirk Creek, but by 1978, they had managed to colonize the lower 3 km of the creek and constituted 35% of the fish population. Electrofishing surveys in 1987 showed catches were still dominated by native westslope cutthroat trout and bull trout, but by 1995, brook trout had spread throughout the entire creek and represented approximately 92% of the fish population. The relative composition of fishes in Quirk Creek has remained stable over the past several years with a relative composition of 83% brook trout, 15% westslope cutthroat trout and 2% bull trout (Paul et al. 2003).

A similar trend is evident in Fish Creek (also in Bow River drainage). Historically, Fish Creek supported a significant westslope cutthroat trout fishery; in 1915, the Department of Naval Science reported that the value of Fish Creek's native trout fishery was nearly eight times that of the Bow River fishery (reported in Baayens and Brewin 1999). More recent surveys, however, reveal that the westslope cutthroat trout population has declined greatly since that time. Baayens and Brewin (1999) reported maximum likelihood population estimates for introduced brook trout at 211 fish/km, introduced rainbow trout at 59 fish/km and native westslope cutthroat trout at only 4 fish/km in the spring of 1993. This is a pattern common throughout the region.

2. Other Areas – The number and status of pure, unstocked westslope cutthroat trout streams in B.C. are not known with certainty. As many as 928 water bodies (including creeks, rivers and lakes) are reported to have contained native westslope cutthroat trout in that province (S. Pollard pers. comm. 2006); the majority of these systems are in the Kootenay River and Flathead watersheds, but a small number of disjunct systems also occur in the Upper Columbia and South Thompson (Fraser River tributary) watersheds. These numbers, however, may include many nonnative populations and those known to be introgressed with rainbow trout genetic material, and probably overestimate the number of native, genetically pure populations. Fluvial populations in large rivers appear to be stable based on creel surveys (J. Baxter pers. comm. 2004), but are clearly subject to increasing fishing pressure and hybridization (B. Westover pers. comm. 2003, Rubidge and Taylor 2005). Increasingly, introgression appears to be spreading throughout the lower reaches of systems nearest the Koocanusa Reservoir, where a rainbow trout stocking program existed from 1986 to 1998; evidence of hybridization with introduced rainbow trout has been reported in 78% of the streams genetically tested in the area (Rubidge and Taylor 2005).

As in Alberta, genetically pure populations in the area may be becoming increasingly restricted to isolated headwater streams, where they are subject to stochastic extinction events such as rockslides or drought. Unfortunately, the status of these headwater populations is largely unknown. Similarly, a recent status review in the United States identified a total of 563 "conservation populations" of westslope cutthroat trout (Shepard et al. 2003). These populations represent the remaining genetically pure native strains (as well as those of particular ecological or fisheries value) and occupy over 39 000 river kilometres of habitat in Montana, Idaho and Washington; the John Day basin in Oregon; and the Methow and Lake Chelan basins in Washington. Most (457 or 81%), however, are believed to be fragmented or isolated populations inhabiting headwater areas and are of significant conservation concern (Shepard et al. 2003).

LIMITING FACTORS

Westslope cutthroat trout possess biological characteristics that make them naturally susceptible to a host of limiting factors. The habitat requirements of the subspecies are such that populations typically inhabit coldwater habitat with limited productivity (Behnke 1992). Populations appear to be small and supported by a variable numbers of spawners, and so may be subject to stochastic events such as epidemic disease or catastrophic environmental change (e.g., drought, landslides). The dramatic declines in westslope cutthroat trout populations over the last century, however, clearly indicate that the greatest threats to cutthroat trout are the human-caused manipulation and degradation of the environment in which they live (Allendorf and Leary 1988, Liknes and Graham 1988, Shepard et al. 2003). Throughout the species' global range, the number and distribution of populations have steadily declined in response to the cumulative effects of habitat loss and degradation, overexploitation and detrimental interactions with introduced species (i.e., competition, predation, hybridization).

1. Habitat Loss – As noted, the range of westslope cutthroat trout in Canada is limited to Alberta and British Columbia, where provincial economies rely heavily on revenues generated from resource extraction and related industries. Timber extraction, mining and hydroelectrical developments have been responsible for substantial losses of westslope cutthroat trout habitat and the decline of several populations. The effects of water impoundment and changes to natural flow regimes have been shown to have a significant impact on stream-dwelling salmonids. Eggs and alevins are sensitive to the infiltration of fine sediments into spawning gravels. In laboratory studies, embryo survival was less than 50% when the concentration of fine sediments exceeded 20% (Shepard et al. 1984). Adequate riffle coverage and flow velocities are required to maintain levels of habitat diversity, insect production and insect delivery to juveniles rearing in pools. Low base flows can lead to substantial losses of marginal rearing habitat and elevated stream temperatures, potentially allowing nonnative salmonids a foothold in westslope cutthroat trout habitats. As well, the road networks associated with primary resource extraction have encroached upon an untold number of streams, through the installation of culverts and other alterations that have led to an explosion of access points for angling and recreational activities (i.e., off-roading, ATV use which further serve to degrade sensitive habitats).

Protected areas exist within the range of westslope cutthroat trout in Alberta, but they are often small and do not necessarily encompass all the habitats required by the various life history forms, particularly migratory forms, within one area. Although the exact nature of their movements is poorly described for many populations, westslope cutthroat trout are adapted to move during moderate- to high-flow events, which allow them to negotiate seasonal barriers to movement in accessing required habitats (Brown and Mackay 1995a, Schmetterling 2001). Even though westslope

cutthroat trout can and do move significant distances to required habitat, such migration is dependent on the preservation of suitable migration corridors between habitat types. Unfortunately, many dams, culverts, and other obstructions are not designed to accommodate fish passage at particularly high or low flows (but see *Recent Management in Alberta*). It is believed that migratory fluvial populations no longer exist in BNP, and it may be that native fluvial populations are severely depressed or already extirpated throughout most of Alberta. The loss of these migratory forms may be particularly regrettable, as their loss tends to limit the recolonization potential of areas with locally extirpated resident populations. Current populations are limited to headwater reaches and upper mainstems, where they retain a competitive advantage over other salmonids. As such, populations are highly fragmented and isolated above "warm" water habitats dominated by other salmonids such as introduced brook trout or brown trout, or species such as walleye (*Stizostedion vitreum*) and pike (*Esox lucius*). This fragmentation, of course, has obvious implications for long-term population viability (e.g., Hilderbrand and Kershner 2000).

It is likely that climate change brought on by global warming may play an important role in further limiting the distribution of westslope cutthroat trout in the future. Westslope cutthroat trout are associated with water temperatures less than 16°C at all life history stages (Behnke 1992, McIntyre and Rieman 1995), and the critical thermal maximum for westslope cutthroat trout has been reported to be lower than those estimated for brook trout and rainbow trout: 27.1°C versus 29.8°C and 31.6°C, respectively (McIntyre and Rieman 1995). Therefore, increasing water temperatures resulting from global warming may give nonnative fish a competitive advantage over westslope cutthroat trout in marginal habitats. A summary of available climate change models suggests that mean air temperatures in the Pacific Northwest could increase by 2°C to 5°C in the next 50–100 years (Neitzel et al. 1991). In the Rocky Mountain region, one study estimated that an increase of as little as 1°C in mean July air temperatures would reduce the geographic area of suitable salmonid habitat by 16.8%, and a 5°C increase in mean air temperature would reduce the amount of habitat by 71.8% (Keleher and Rahel 1996).

Finally, as management of fish and fisheries is a shared responsibility between federal and provincial agencies, resource managers are often limited in their ability to avoid or mitigate developmental impacts on private land. The majority of westslope cutthroat trout habitat in Canada, however, lies on public land and falls under the protection of provincial and federal legislation, and the federal government's fish habitat management policy and its "No Net Loss" (NNL) principle for aquatic habitats (Department of Fisheries and Oceans 1986). Rarely, however, is the NNL principle met (Harper and Quigley 2005, 2006). Fisheries and Oceans Canada has agreed to implement its fish habitat management program in accordance with fish management objectives set by Alberta. The NNL principle is accepted as a working guideline by Alberta. It is apparent that, in Alberta, more rigorous protection by both levels of government would help to ensure that fish population connectivity and fish habitat are maintained.

2. Overharvesting – A popular sport fish in western Canada, cutthroat trout is perhaps second only to rainbow trout in terms of angler interest. As is the case with many other sport fish in Canada, angling pressure is likely a significant factor limiting natural production (reviewed by Post et al. 2002). Compared to other parts of Canada, Alberta has a relatively small number of fish-bearing water bodies and fishing pressure is high (the ratio of anglers per lake is the third highest in Canada; Alberta Sustainable Resource Development 2005b). An estimated 300 000 recreational

anglers are active in the province and show a strong preference for trout. This may be in part because trout are more easily caught than other species (MacPhee 1966, Paul et al. 2003). Their sometimes voracious feeding habits and accessibility in small streams and lakes make westslope cutthroat trout subject to overharvesting. In a recent creel survey in the Elk River, B.C., westslope cutthroat trout made up 94.5% of the total catch of 98 031 fish (Heidt 2002). Although this could simply suggest greater relative abundance, it is likely that fish can be caught numerous times in a season and often more than once on the same day. In Yellowstone National Park, for example, studies have shown that individual cutthroat trout were caught an average of 9.7 times in a heavily fished catch-and-release section of the Yellowstone River during one 3.5-month fishing season (Schill et al. 1986). Even though catch-and-release fisheries have been implemented in particularly sensitive areas and have stemmed declines in some cases, hooking mortality following release may have a significant impact on populations that have already been marginalized by habitat loss or the introduction of nonnative fishes (Marnell and Hunsaker 1970, Mongillo 1984, Gresswell and Harding 1997).

3. Nonnative Introductions – Perhaps the most pressing and insidious threat facing native populations of westslope cutthroat trout in Alberta is the suite of harmful effects associated with the introduction of nonnative fish. The natural fecundity of fish (and the relative ease with which their reproductive cycle can be manipulated) has made the hatchery production of salmonids a common response to declining fish populations. Supplementation does not necessarily translate to increased population viability in the wild, however, because often the primary causes for population decline (i.e., habitat loss, overharvesting, etc.) go unaddressed. It is also becoming apparent that hatchery fish have been often stocked without an understanding of the effectiveness of the transfer, the fate of the released fish, or their impacts on wild populations (reviewed by Flagg et al. 2000, Scribner et al. 2001). In the United States, the introduction of nonnative species is believed to be the primary cause for the declines of several inland species of cutthroat trout (Allendorf and Leary 1988, Deeds et al. 1999, Shepard et al. 2003). The introduction of nonnative brook trout has typically resulted in range constriction or elimination of cutthroat trout from large portions of their native habitat (Donald 1987, Griffith 1988, Fausch 1989). The introduction of other planktivorous species such as kokanee (*Oncorhynchus nerka*) or lake whitefish (*Coregonus clupeaformis*) has typically led to dramatic declines in lacustrine/adfluvial populations of westslope cutthroat trout (by as much as 90%; Behnke 2002). Rainbow trout and Yellowstone cutthroat trout (*O. clarkii bouvieri*) introductions have resulted in significant levels of introgressive hybridization throughout the historical range of westslope cutthroat trout (Leary et al. 1984, Leary et al. 1987, Allendorf and Leary 1988, Hitt et al. 2003, Janowicz 2004, Rubidge and Taylor 2005).

Although the majority of current stocking is limited to lakes and not stream systems inhabited by westslope cutthroat trout, the majority are not "closed" in the sense that introduced nonnative fish are often able to access inlet and outlet streams through which they spread to other systems (Hitt et al. 2003, Rubidge and Taylor 2005). The continued presence of nonnative species within the native range of westslope cutthroat trout in Alberta suggests that populations remain at high risk for displacement/replacement and genetic extirpation, especially given that the factors influencing the spread of this introgressive hybridization are poorly understood at this time. Simply stated, hybridization appears to spread outwards from the site of stocking, and given the widespread history of stocking in the past (nearly 23 million rainbow trout have been stocked in Alberta during the last seven years

Table 2. Relative numbers of trout stocked throughout Alberta for the period 1998 to 2004 (Alberta Sustainable Resource Development 2005a).

	Trout Species Stocked			
Year	**Westslope cutthroat trout**	**Brook trout**	**Brown trout**	**Rainbow trout**
1998	104 000	277 000	80 400	3 738 000
1999		309 000	89 000	3 350 000
2000	134 000	291 000	90 200	3 620 000
2001		337 000	131 000	3 050 000
2002	107 000	258 000	88 600	3 310 000
2003	4 000	237 000	26 100	3 360 000
2004	90 400	205 000	92 600	2 540 000
TOTALS	439 400	1 914 000	597 900	22 968 000

alone; Table 2, Appendix 3), it seems likely that the number of genetically pure native populations of westslope cutthroat trout will be limited. A standardized, comprehensive analysis of hybridization levels in the province is urgently required to determine the genetic purity of remaining Alberta westslope cutthroat trout populations and prioritize populations for conservation. Every effort should be made to determine the conservation status of the remaining pure populations in Alberta and to halt the spread of any further hybridization. Importantly, although they may be of some importance in terms of fisheries opportunities, extensively hybridized populations are of little value to efforts to conserve native westslope cutthroat trout. Neither Canada nor the United States currently has an official policy regarding the inclusion of hybrid populations under their respective endangered species legislation, and the issues surrounding the ecological, taxonomic and legal status of hybridized populations remain largely unresolved (e.g., Allendorf et al. 2003).

STATUS DESIGNATIONS*

1. Alberta – The status of westslope cutthroat trout has not been formally evaluated in Alberta. The general status of cutthroat trout (the species) was assessed as *Secure* in 2000 (Alberta Sustainable Resource Development 2001) with native strains of the westslope subspecies recognized as *May Be At Risk* (MacKay 2001). In 2005, the general status of native westslope cutthroat trout was again ranked as *May Be At Risk*, and introduced cutthroat trout remained *Secure* (L. Matthias pers. comm. 2006). The Alberta Natural Heritage Information Centre (ANHIC) lists cutthroat trout (again, the species) as S4 in Alberta. Note that the S ranks for cutthroat trout reflect the inferred status for the entire population, not just pure native populations.

* See Appendix 1 for definitions of selected status designations.

2. Other Areas – The status of westslope cutthroat trout in Canada was reviewed by COSEWIC in November 2006. Two designatable units (DUs) were formalized: a British Columbia population and an Alberta population (COSEWIC 2006a, 2006b). Aside from their markedly different conservation status, recognition of the two DUs is supported by the distinct biogeographic ecozones inhabited by the two groups and the lack of current dispersal opportunities between them (separated by the Rocky Mountains). Alberta populations inhabit National Freshwater Ecological Area 4 (Saskatchewan-Nelson), whereas populations in British Columbia inhabit National Freshwater Ecological Area 11 (Pacific).

a) British Columbia population – This population was listed as *Special Concern* because populations are stressed by habitat loss and degradation resulting from agricultural and industrial activities, as well as competition and hybridization with introduced species (COSEWIC 2006a, 2006b).

b) Alberta population – This population received a *Threatened* designation. The review considered only the remaining genetically pure populations within the native range in Alberta (COSEWIC 2006a, 2006b). Such populations have become severely isolated and depressed as a result of habitat loss and degradation, exploitation, and especially hybridization with introduced species. The rate of hybridization indicates that this population could be at greater risk (i.e., *Endangered*); however, there was not enough genetic information available at the time to make that assessment (COSEWIC 2006a, 2006b).

The British Columbia Conservation Data Centre "blue" lists the B.C. population of westslope cutthroat trout as S3 ("having characteristics that make them particularly sensitive or vulnerable to human activities or natural events; at risk, but are not *Extirpated*, *Endangered* or *Threatened*"; B.C. Conservation Data Centre 2005).

Globally, westslope cutthroat trout are listed as G4T3 by the Nature Conservancy (last reviewed October 1999; NatureServe 2005). The T3 ranking refers to a taxonomic subunit (in this case, subspecies). Nationally in the United States, westslope cutthroat trout are listed as N2. At the state level, westslope cutthroat trout are listed as S2 in Idaho and Montana, S3 in Oregon, S1 in Wyoming, and are of uncertain rank in Washington and Colorado.

RECENT MANAGEMENT IN ALBERTA

As a popular sport fish in Alberta, the primary level of management for westslope cutthroat trout in the province is through sportfishing regulations. Current fishing regulations have become increasingly restrictive over the past 20 years to protect wild spawning fish. In the Bow and Oldman systems, there are now select stream closures in most areas during spawning migrations (November to June) and catch-and-release only fisheries from September to October. A daily limit of two fish over 35 cm is allowed in most areas during the summer (June to August) and there may or may not be a restriction on the use of bait. Some of the pertinent habitat issues for westslope cutthroat trout have recently been addressed by a number of collaborative initiatives focused on improving stream crossing management. Alberta Sustainable Resource Development has, for example, been developing an access management program, a long-term collaborative strategy to bring together various public, government and industry stakeholders to develop sustainable landscape management practices. As part of this program, efforts have been made to quantify the total number of stream crossings and their permeability in priority areas, quantify their effects on stream habitat communities, and suggest remedial measures where habitats have been adversely affected (Scrimgeour et al. 2004). That being said, habitat restoration or enhancement directly targeting westslope cutthroat trout has been limited and only marginally successful.

Instead, much effort has been placed into the development of hatchery programs for westslope cutthroat trout (and a variety of nonnative sport fish). From 1998 to 2004, over 400 000 cutthroat trout were stocked throughout the province (compared to nearly 23 million rainbow trout during the same period; Table 2). Several cursory analyses of hybridization have been funded by the province. Many were not designed to specifically investigate hybridization, but were preliminary assays into genetic structuring and population subdivision in the province. A more rigorous approach is urgently needed to determine the relative genetic purity of remaining westslope cutthroat trout populations and to prioritize populations for conservation.

SYNTHESIS

Once a fish of mainstem rivers, the westslope cutthroat trout is now largely confined to headwater areas through the cumulative effects of habitat loss (through urbanization, water diversion and resource extraction) and the introduction of nonnative species in Alberta. Native migratory populations are believed to be extirpated in Banff National Park and may be severely depressed or already extirpated throughout much of the Alberta range. Many of the remaining populations show signs of genetic introgression with nonnative species that have been introduced (Carl and Stelfox 1989, Mayhood 2000, Potvin et al. 2003, Janowicz 2004). Genetically pure populations of native westslope cutthroat trout are now rare in Alberta and have a highly fragmented distribution; total population size for pure populations within the native range in Alberta is estimated to be fewer than 7000 mature individuals. Populations remain subject to a number of anthropogenic threats, including the continued stocking of nonnative salmonids (particularly rainbow trout). Since the late 1990s, most rainbow trout stocking has been done into lakes and not rivers, although most lake complexes are not expected to be closed systems so that hybridization is still able to spread outwards from the point of stocking. A thorough, comprehensive review of the Alberta stocking program should also be considered given the impact on native fish biodiversity (similar problems have been addressed in the past for the stocking of brook trout into bull trout systems). To prevent further spread of hybridization, it may be necessary to attempt the difficult removal of nonnative species from particularly sensitive areas or to limit new stocking to demonstrably closed systems. Most needed, as a first step toward conservation, is a thorough examination of hybridization in the province. As Mayhood (2000) notes, population level inventories and genetic surveys are required to prioritize populations for conservation measures based on the degree of genetic purity. Pure, unstocked native westslope cutthroat trout populations should receive the highest priority for inventory and conservation, followed by native populations augmented by hatchery introductions, and finally populations showing evidence of introgression with rainbow trout or other cutthroat subspecies. As more genetic data become available, it may be useful to further delineate distinct population segments within drainages (e.g., conservation populations, sport fish populations) based on habitat structuring and population subdivision, or to prioritize conservation units on the basis of genetic integrity (i.e., genetically pure vs. mildly introgressed vs. extensively introgressed).

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Appendix 1. Definitions of selected legal and protective designations.

A. The General Status of Alberta Wild Species 2000 (after Alberta Sustainable Resource Development 2001)

2000 Rank	**1996 Rank**	**Definitions**
At Risk	Red	Any species known to be *At Risk* after formal detailed status assessment and designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Green	Any species that is not *At Risk*, *May Be At Risk* or *Sensitive*.
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species known or believed to be present but which has not yet been evaluated.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	Any species no longer thought to be present in Alberta (*Extirpated*) or no longer believed to be present anywhere in the world (*Extinct*).
Accidental/Vagrant	n/a	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Wildlife Act/Regulation

Species designated as Endangered under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation.

Endangered	A species whose present existence in Alberta is in danger of extinction within the next decade.
Threatened	A species that is likely to become endangered if the factors causing its vulnerability are not reversed.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2006a)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if limiting factors are not reversed.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk given current circumstances.
Data Deficient	A species for which there is inadequate information to make a direct, or indirect, assessment of its risk of extinction.

Appendix 1 continued.

D. Heritage Status Ranks: Global (G), National (N), Sub-National (S) (after Alberta Natural Heritage Information Centre 2004b, NatureServe 2005)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6 to 20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21 to 100 occurrences, may be rare and local throughout its range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically > 100 occurrences. Apparently secure.
G5/N5/S5	Typically > 100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated, historical records only.
GH/NH/SH	Historically known, may be relocated in the future.
GNR/NNR/SNR	Unranked—conservation status not yet assessed.

E. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Appendix 2. Summary data on levels of hybridization for selected populations in Alberta. N represents the number of individuals that were genotyped, followed by the number of westslope cutthroat (WCT), rainbow (RBT), Yellowstone cutthroat (YCT), or hybrids (HYB), respectively (modified from Janowicz 2004).

Drainage	Watershed	Population	N	WCT	RBT	YCT	HYB	% Hybrid
South Saskatchewan River								
	Bow	Boom	16	11	0	0	5	31.3
		Helen	5	5	0	0	0	0
		Moraine	5	1	0	0	4	80.0
		Mosquito	14	13	0	0	1	7.1
		Jumpingpound trib.	15	15	0	0	0	0.0
	Castle	Beaver Mines	23	0	17	0	6	26.1
		Gladstone	15	4	2	0	9	60.0
		Grizzly	2	1	0	0	1	50.0
		Lynx/ Castle	15	15	0	0	0	0.0
		Suicide	6	1	0	0	5	83.3
	Crowsnest	Allison	4	2	0	0	2	50.0
		Blairmore	20	20	0	0	0	0.0
		Gold	15	15	0	0	0	0.0
	Elbow	Quirk	23	23	0	0	0	0.0
		Canyon trib.	12	12	0	0	0	0.0
		Silvester	22	22	0	0	0	0.0
	Ghost	Johnson	15	14	0	0	1	6.7
		Margaret	15	15	0	0	0	0.0
		Waiparous	11	11	0	0	0	0.0
	Highwood	Highwood	7	4	1	0	2	28.6
		Cutthroat	18	18	0	0	0	0.0
		Etherington	4	2	0	0	2	50.0
		Head	2	2	0	0	0	0.0
		Pekisko	19	2	15	0	2	10.5
		Sullivan	19	11	1	0	7	36.8
	Kananaskis	Bulton	1	1	0	0	0	0.0
		Elpoca	1	1	0	0	0	0.0
		Evan-Thomas	55	55	0	0	0	0.0
		Muskeg	14	1	13	0	0	0.0
		Pocatera	3	3	0	0	0	0.0
		Porcupine	14	14	0	0	0	0.0
		Rocky	23	23	0	0	0	0.0
		Spotted Wolf	11	3	1	0	7	63.6
	Livingstone	North Twin	19	19	0	0	0	0.0
		Savannah	2	1	0	0	1	50.0
		Livingstone trib.	19	18	0	0	1	5.3

Appendix 2 continued.

	Oldman	Bob	9	0	8	0	1	11.1
		Camp	20	14	0	0	6	30.0
		Dutch	14	14	0	0	0	0.0
		Oyster	17	17	0	0	0	0.0
		Daisy	20	20	0	0	0	0.0
		N. Racehorse	15	14	0	0	1	6.7
		Vicary	20	20	0	0	0	0.0
		N. Timber	20	1	12	0	7	35.0
		Westrup	12	11	0	0	1	8.3
	Sheep	Coal	23	0	17	0	6	26.1
		Fisher	20	11	0	0	9	45.0
		Gorge	21	19	0	0	2	9.5
		Ware	19	5	2	0	12	63.2
	Spray	Commonwealth	1	1	0	0	0	0.0
		Smuts	26	19	0	0	7	26.9
		Watridge	32	32	0	0	0	0.0
		Hogarth	20	12	0	0	8	40.0
	St. Mary	Lee	9	0	7	0	2	22.2
	Waterton	Dungarvan	10	9	0	0	1	10.0
North Saskatchewan River								
	Ram	Cripple	20	9	0	0	11	55.0
		Lynx/ Ram	20	2	0	5	13	65.0
		Nice	11	2	0	0	9	81.8
		Kiska	1	0	0	0	1	100.0
		Onion	25	12	0	0	13	52.0

Appendix 3. Partial summary of rainbow trout stocking between 1926 and 2004 for several major drainages in Alberta (modified from Janowicz 2004). Note that early stocking was primarily done in streams and rivers, but has been done rarely outside of lakes since the early 1980s (J. Stelfox pers. comm. 2004).

Year	Bow	Castle	Crowsnest	Elbow	Highwood	Kananaskis	Livingstone	Oldman	Ram	Spray
1926								X		
1927					X					
1928										
1929				X						
1930										
1931				X						
1932										
1933	X			X					X	
1934	X	X		X				X		
1935		X		X		X			X	
1936	X	X		X		X				
1937			X	X						X
1938										
1939	X									
1940	X		X	X	X	X	X	X		
1941	X		X	X	X	X		X		
1942	X			X	X					
1943	X		X	X	X	X		X		
1944	X		X	X	X	X	X	X		X
1945			X	X	X	X	X	X		
1946	X			X	X	X	X	X		
1947	X		X	X	X	X		X	X	X
1948			X				X	X		
1949			X					X		

Appendix 3 continued.

Year	Bow	Castle	Crowsnest	Elbow	Highwood	Kananaskis	Livingstone	Oldman	Ram	Spray
1950	X			X		X	X	X		X
1951										
1952										
1953				X						
1954	X									
1955						X				X
1956				X	X	X				
1957										X
1958	X									X
1959				X		X				
1960	X					X		X		
1961	X							X		
1962	X							X		
1963	X							X		
1964	X	X		X				X		
1965	X	X		X	X	X		X		
1966	X	X		X	X	X		X		
1967	X			X	X	X		X		
1968	X			X	X	X		X		
1969	X			X	X	X		X		
1970	X			X	X	X		X		
1971	X			X	X	X		X		
1972	X			X	X	X		X		
1973	X			X	X	X		X		X

Appendix 3 continued.

Year	Bow	Castle	Crowsnest	Elbow	Highwood	Kananaskis	Livingstone	Oldman	Ram	Spray
1974	**X**			**X**	**X**	**X**		**X**		**X**
1975	**X**			**X**	**X**	**X**		**X**		**X**
1976	**X**			**X**	**X**	**X**		**X**		**X**
1977	**X**			**X**	**X**	**X**		**X**		
1978	**X**			**X**	**X**	**X**		**X**		
1979	**X**				**X**	**X**		**X**		
1980	**X**			**X**	**X**	**X**		**X**		
1981	**X**			**X**	**X**	**X**		**X**		
1982	**X**			**X**	**X**	**X**		**X**		
1983	**X**			**X**	**X**	**X**		**X**		
1984	**X**			**X**	**X**	**X**		**X**		
1985	**X**			**X**	**X**	**X**		**X**		
1986	**X**			**X**	**X**	**X**		**X**		
1987	**X**			**X**	**X**	**X**		**X**		
1988	**X**			**X**	**X**	**X**		**X**		
1989				**X**				**X**		
1990	**X**			**X**				**X**		
1991	**X**			**X**	**X**	**X**		**X**		**X**
1992	**X**			**X**	**X**	**X**		**X**		**X**
1993	**X**			**X**	**X**	**X**		**X**		**X**
1994	**X**			**X**	**X**	**X**		**X**		**X**
1995	**X**			**X**	**X**	**X**		**X**		**X**
1996	**X**			**X**	**X**	**X**		**X**		**X**
1997	**X**			**X**	**X**	**X**		**X**		**X**

Appendix 3 continued.

Year	Bow	Castle	Crowsnest	Elbow	Highwood	Kananaskis	Livingstone	Oldman	Ram	Spray
1998	**X**			**X**	**X**	**X**		**X**		**X**
1999	**X**			**X**	**X**	**X**		**X**		**X**
2000	**X**			**X**	**X**	**X**		**X**		**X**
2001	**X**			**X**	**X**	**X**		**X**		**X**
2002	**X**			**X**	**X**	**X**		**X**		**X**
2003	**X**			**X**	**X**	**X**		**X**		**X**
2004	**X**			**X**	**X**	**X**		**X**		**X**

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