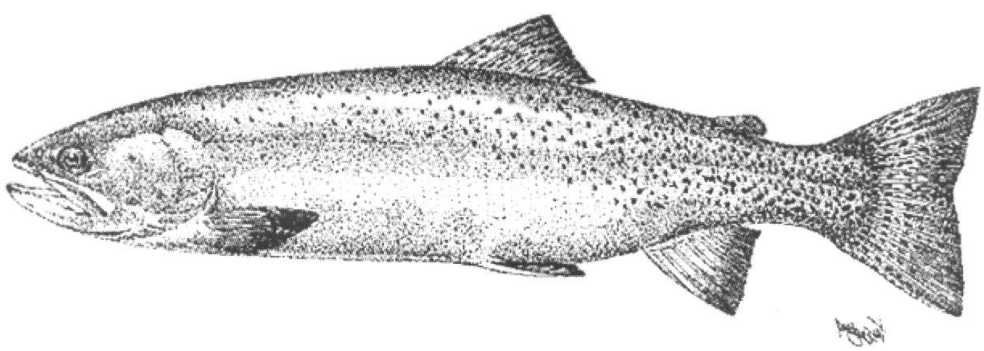
COSEWIC
Assessment and Status Report

on the

westslope cutthroat trout
Oncorhynchus clarkia lewisi

British Columbia population
Alberta population

in Canada



British Columbia population – SPECIAL CONCERN
Alberta population – THREATENED
2006

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Production note:

COSEWIC would like to acknowledge Allan B. Costello and Emily Rubidge for writing the status report on the westslope cutthroat trout (*Oncorhynchus clarkia lewisi*) (British Columbia population and Alberta population) in Canada, prepared under contract with Environment Canada, overseen and edited by Dr. Robert Campbell, Co-chair, Freshwater Fishes Species Specialist Subcommittee.

The status report to support the May 2005 COSEWIC assessments of the westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) (Alberta population and British Columbia population) was not made available following the 2005 assessment.

In November 2006, COSEWIC reassessed the westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) (Alberta population and British Columbia population). The status report was then finalized following the COSEWIC 2006 reassessment.

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Westslope cutthroat trout — *Oncorhynchus clarkii lewisi* (drawing by Loucas Raptis courtesy of the authors).

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COSEWIC
Assessment Summary

Assessment Summary – November 2006

Common name
Westslope cutthroat trout

Scientific name
Oncorhynchus clarkii lewisi

Status
Special Concern

Reason for designation
Populations are stressed by hybridization and competition with introduced species. Furthermore, expanding urban development, agricultural activities and resource-based industries are expected to lead to additional stresses associated with habitat loss and degradation, as well as increased exploitation. It should be noted that this assessment includes only genetically pure, native populations of the species occurring within their historical range. Any populations known to be hybridized significantly (i.e. >1%) with other trout species, or to have been introduced into a system previously free of native populations, were not assessed.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2005. Status re-examined and confirmed in November 2006. Assessment based on a new status report.

Assessment Summary – November 2006

Common name
Westslope cutthroat trout

Scientific name
Oncorhynchus clarkii lewisi

Status
Threatened

Reason for designation
Native populations have been reduced by almost 80% through over-exploitation, habitat degradation, and hybridization / competition with introduced, non-native trout. Remaining, genetically pure, individuals persist as mainly severely fragmented, remnant headwater populations. It should be noted that this assessment includes only genetically pure, native populations of the species occurring within their historical range. Any populations known either to be hybridized significantly (i.e. >1%) with other trout species, or to have been introduced into a system previously free of native populations, were not assessed.

Occurrence
Alberta

Status history
Designated Threatened in May 2005 and in November 2006. Assessment based on a new status report.

COSEWIC
Executive Summary

westslope cutthroat trout
Oncorhynchus clarkia lewisi

British Columbia population
Alberta population

Species information

The cutthroat trout, *Oncorhynchus clarkii* (formerly *Salmo clarkii*), is a polytypic species of salmonid native to western North America. Two subspecies occur naturally in Canada: the coastal cutthroat trout (*O. c. clarkii*) and the westslope cutthroat trout (*O. c. lewisi*). Cutthroat trout are highly variable in terms of phenotypic traits and life history characteristics. The most conspicuous character distinguishing cutthroat from similar species is the presence of bright orange-red slashes beneath the lower jaw.

Based on genetics and range disjunction, two Designatable Units are recognized, *viz* an Alberta population and a BC population.

Distribution

The distribution of westslope cutthroat trout straddles the Continental Divide and includes drainages in Montana, Idaho, Washington, Oregon, and Wyoming in the United States. In Canada, they are restricted to southeastern British Columbia (primarily the Upper Kootenay and Upper Columbia drainages) and southwestern Alberta (primarily the South Saskatchewan drainage). Globally, their range has become extremely fragmented (in high elevation, isolated headwater areas) and the heart of their distribution now centres on the upper Kootenay River drainage in southeastern BC.

Habitat

Westslope cutthroat trout have strict habitat requirements during various life history stages, requiring cold clean water and varied forms of cover (i.e., undercut banks, pool-riffle habitat, and riparian vegetation) to maintain their numbers. They inhabit large rivers and lakes in BC, as well as many small mountain streams. In Alberta, they are now largely restricted to the upper reaches of mainstem rivers and the extreme headwaters of a few major tributaries. They tend to inhabit cooler, less productive streams than other closely related species.

Biology

Populations are usually small but show strongly developed natal philopatry and well-defined population structure. Habitat degradation may make populations especially susceptible to displacement and/or hybridization with introduced species (rainbow trout, other cutthroat trout subspecies). As such, populations in degraded habitats are more likely to decline, and their high degree of demographic independence suggests that losses are not likely to be offset by immigration from nearby sources over the short term.

Population sizes and trends

Little quantitative data exists on westslope cutthroat trout population trends in Canada. Population sizes are generally expected to be smaller than for other freshwater salmonids (typically 1 – 10% within even the largest systems). The number of adult spawners supporting population growth is usually quite small, typically 100 or less per stream. While some populations are likely stable, all available information suggests that many populations are depressed relative to historic levels, and numerous local extirpations have occurred.

Limiting factors and threats

The greatest threats to westslope cutthroat trout are the anthropogenic manipulation and degradation of the environment in which it lives. Forestry, hydroelectric development, mining, urbanization and agriculture have all contributed to the loss and degradation of stream habitat in the range of cutthroat within both Alberta and British Columbia. Introgressive hybridization is widespread (particularly in Alberta), and further introduction of non-native species could affect the genetic integrity of the remaining populations. The number and distribution of pure 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).

Special significance of the species

Cutthroat trout are a unique and important component of Canada’s freshwater fish fauna and are often the only native trout throughout much of their Canadian range. As such, cutthroat trout likely play an important role in structuring many north temperate aquatic ecosystems. Because of their strict habitat requirements, cutthroat are viewed as an indicator species of general ecosystem health. Westslope cutthroat trout are a popular freshwater sport fish in western Canada, second only to rainbow trout/ steelhead in terms of angler interest.

Existing protection and other status designations

Cutthroat trout habitat is protected under both provincial and federal legislation and as a popular sports fish, populations are subject to provincial recreational harvest and National Park regulations. Compliance with habitat protection, harvest and National Park regulations, however, has been lacking in the past. Currently both subspecies are provincially blue-listed as ‘vulnerable’ in BC. In Alberta, no populations are formally listed and the status of westslope cutthroat trout as a subspecies has yet to be formally assessed. Populations in the United States have been petitioned for listing under the *Endangered Species Act* but were deemed not to currently require that level of formal protection. Globally, westslope cutthroat trout are ranked by the Nature Conservancy as ‘vulnerable to extirpation or extinction’ (G4T3).

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and it is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

westslope cutthroat trout
Oncorhynchus clarkia lewisi

British Columbia population
Alberta population

in Canada

2006

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SPECIES INFORMATION

Name and classification

The cutthroat trout (*Oncorhynchus clarkii*) is a polytypic species of salmonid native to western North America. It is widespread in both coastal and interior drainages in a range of habitats, from lakes and headwater streams, to estuaries and large rivers. At least 14 subspecies are currently recognized but only two occur naturally in Canada: the coastal cutthroat trout (*O. c. clarkii*) and the westslope cutthroat trout (*O. c. lewisi*); the latter being the focus of this review. A third type, described by Dymond (1931) from the Revelstoke area in British Columbia as *O. c. alpestris,* is now considered to be synonymous with *O. c. lewisi* (see below):

Phylum:	Chordata
Class:	Actinopterygii
Order:	Salmoniformes
Family:	Salmonidae, subfamily Salmoninae (salmon, trout, charr)
Genus:	*Oncorhynchus* (formerly *Salmo*)
Species:	*Oncorhynchus clarkii* (formerly *Salmo clarkii*)
Subspecies:	Westslope cutthroat trout *O. clarkii lewisi* (Girard) formerly *Salmo clarkii lewisi*; considered synonymous with *S. clarkii alpestris* (Dymond)
Common name:	
English:	Westslope cutthroat trout
French:	Truite Fardée
Other:	cutthroat, interior cutthroat, westslope cutthroat, mountain cutthroat, cutty, spotted trout, (Montana) black-spotted trout, black spots, red-throated trout, Lewis' trout

The extensive phenotypic variation exhibited by this species (in terms of size, colouration, and life-history characteristics) has led to considerable confusion and disagreement among taxonomists in its description, particularly in the number of genuine types and of the proper taxonomic epithets used in describing them. At one time, up to 40 taxonomic designations existed for the species, and relationships within the group remain controversial. Most taxonomists currently recognize 14 subspecies of cutthroat: four major subspecies showing substantial divergence (Coastal, Westslope, Lahontan, and Yellowstone cutthroat), and ten minor subspecies of limited range (Allendorf and Leary 1988; Behnke 2002). 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 clearly differentiates them. Considerable overlap in morphological and meristic characters also exists between cutthroat trout and rainbow trout (*Oncorhynchus mykiss*). Morphological (Behnke 1992), karyotypic (Thorgaard 1983), and genetic data (Gyllensten *et al*. 1985; Shedlock *et al*. 1992), however, confirm that while substantial overlap exists, all cutthroat trout subspecies are indeed more closely related to each other than any is to rainbow trout (Figure 1).

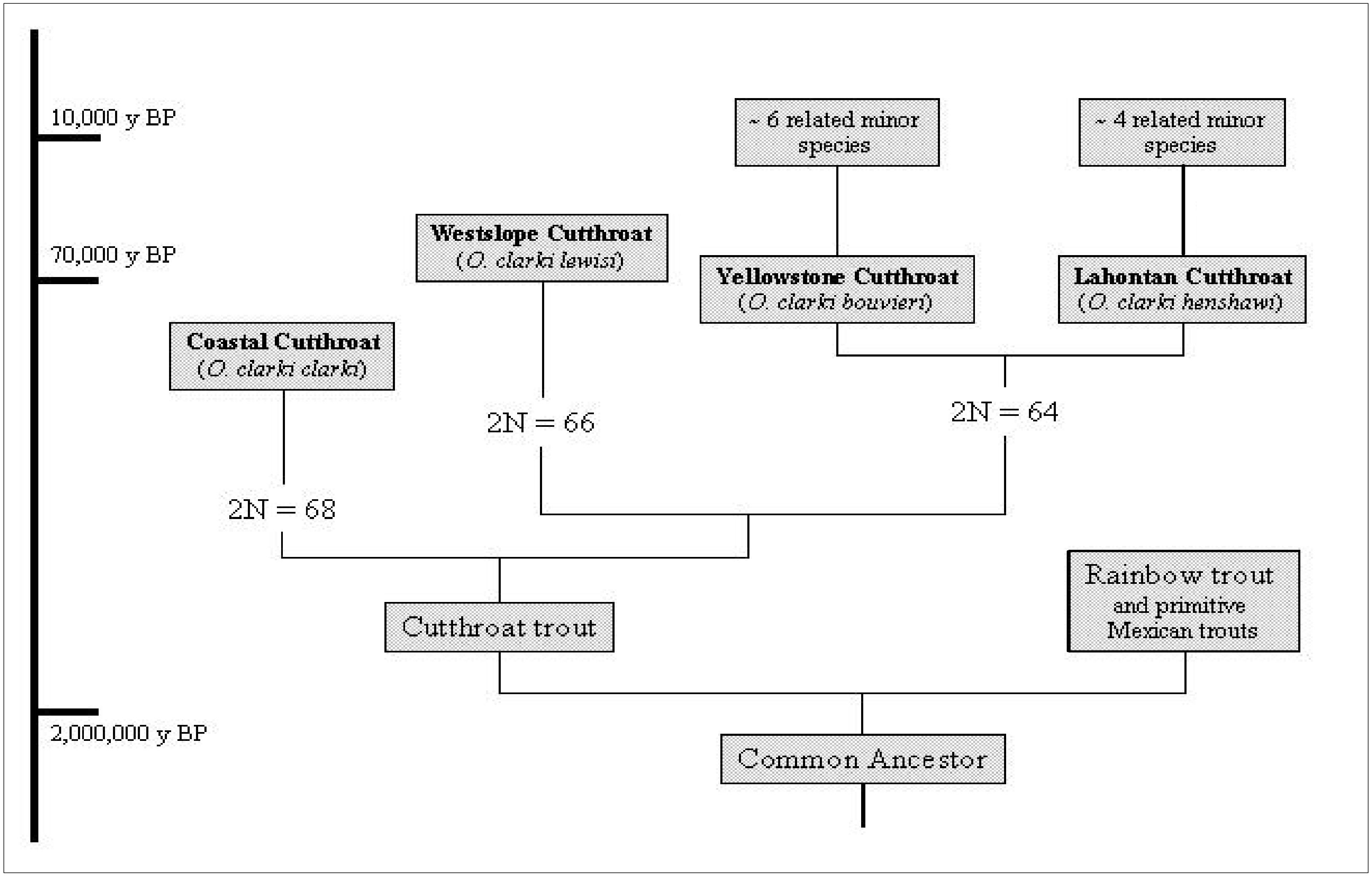

Figure 1. Phylogenetic relationships between the various cutthroat trout subspecies and rainbow trout. Diploid chromosome number (2N) is shown for cutthroat trout subspecies. Modified from Behnke (1997).

Morphological description

Westslope cutthroat trout (hereafter referred to as WCT) have the streamlined body typical of salmonids (terminal mouth, small cycloid scales, and presence of an adipose fin) and are generally trout-like in appearance, with dark spots on a lighter background (Figure 2). Spots are small and irregularly shaped, forming a characteristic arc from the anterior base of the anal fin forward to the pectoral fin (more numerous posteriorly and concentrated above the lateral line). Body colouration ranges from silver to yellowish-green with red on the front and sides of the head. A narrow pink band may be present along the sides, but to a much lesser degree than in the closely related rainbow trout (hereafter referred to as RBT). Spawning fish often develop a bright red colouration over the entire body. Westslope cutthroat trout do not tend to become very large; generally 15-23 cm (28-142 g) with larger ones rarely over 41-46 cm (<1.4 kg) (Behnke 2002).

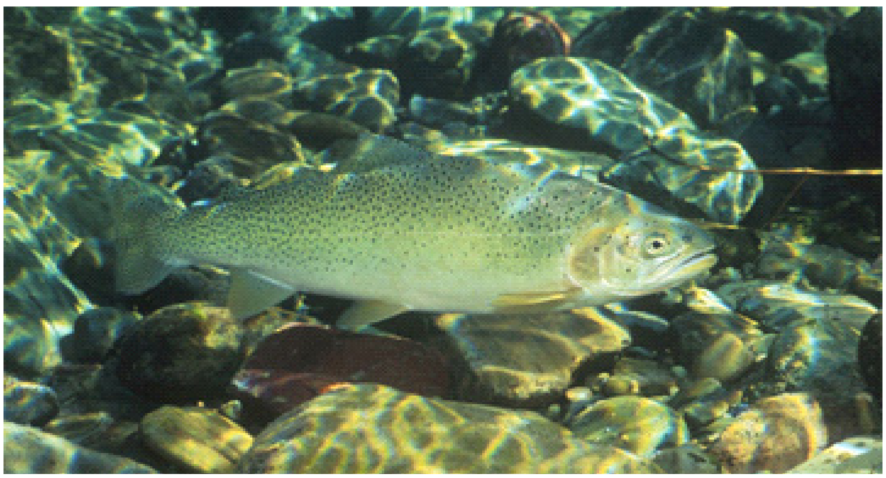

Figure 2. Westslope cutthroat trout from the Wigwam River (Upper Kootenay drainage). Photo courtesy of Ernest Keeley, Idaho State University.

The most conspicuous character distinguishing cutthroat trout throughout its range in Canada is the presence of orange-red slashes beneath the lower jaw. The slashes, however, may be faint or absent in juveniles, making the field identification of WCT and RBT difficult. While field guides and taxonomic keys are available (e.g., McPhail and Carveth 1993; Pollard *et al*. 1997; Joynt and Sullivan 2003), considerable phenotypic variation exists between individual populations in the size, colouration and degree of spotting. Cutthroat trout generally tend to have a larger mouth than RBT with a longer maxillary, which extends past the hind portion of the eye. As well, a series of small basibranchial teeth at the back of the throat are considered to be diagnostic of pure cutthroat trout throughout much of their range (Behnke 1992; Leary *et al*. 1996; Weigel *et al*. 2002). Hybridization with RBT leads to a host of alternate spotting patterns and to the appearance of spots on the top of the head and anterior portion of the body. Hybrids may also lack the basibranchial teeth and the slash beneath the lower jaw, and have a larger head-tail length ratio (Behnke 1992; Weigel *et al*. 2002).

This meristic overlap between forms has undoubtedly been exacerbated by the indiscriminate stocking of non-native species and variously hybridized fishes in the past (See LIMITING FACTORS). While diagnostic testing now exists to identify the genetic composition of introgressed populations (McKay *et al*. 1997; Baker *et al*. 2002; Ostberg and Rodriguez 2002), the ecological and taxonomic status of hybridized populations remain largely unresolved (e.g., US Federal Register 1996; Allendorf *et al*. 2004).

Genetic description

Relatively few studies have investigated population structure in the westslope cutthroat subspecies. Early genetic assays of WCT using allozymes suggested that population subdivision was substantial, with F_{st} values (a widely used measure of genetic subdivision) ranging from 0.08 to 0.45 (Loudenslager & Gall 1980; Leary *et al*. 1987; Allendorf & Leary 1988). Populations appeared well differentiated and were often characterized by unique alleles or those that, while locally abundant, were uncommon over a larger geographic area. More recently, Taylor *et al*. (2003) examined population structure in 32 WCT populations in southeastern British Columbia (including sites in the upper Kootenay, upper Columbia, and upper Fraser drainages). Consistent with previous studies, while the total number of alleles per microsatellite locus ranged from 5 – 20 across the study area, the average number of alleles per microsatellite locus in any one population was low, averaging ~ 3.9. Expected heterozygosities averaged 0.56 but varied widely among populations (from 0.05-0.61). Habitat heterogeneity, in terms of migration barriers, appeared to be a significant factor in structuring this variation. Populations isolated above impassable migration barriers consistently showed significantly reduced variation and increased differentiation compared to populations not similarly constrained {allelic richness (2.1 vs. 2.9), expected heterozygosity (0.303 vs. 0.463), F_{st} (0.45 vs. 0.18); $p< 0.005$ for all tests}.

Population subdivision appears extensive throughout this region (overall F_{st} value of 0.32) and a large proportion of the total genetic variation (32%) is partitioned among populations (i.e., certain populations have a high frequency of alleles that are uncommon over the larger region). Based on the distribution of this allelic variation, Taylor *et al*. (2003) suggested the existence of four main groups of WCT in southeastern BC, loosely corresponding to geographic proximity (Figure 3). Populations isolated above migration barriers had significantly lower levels of genetic variation and were generally more divergent from one another than was observed between below-barrier populations. However, the significant divergence among populations lacking any obvious migration barriers (e.g., Kootenay mainstem populations with F_{st} of 0.12) suggests significant reproductive isolation and a high degree of demographic independence among even mainstem populations. The authors suggest that each individual population likely acts as a distinct biological entity and that the conservation of genetic biodiversity in the region's WCT population will require the maintenance of many such populations throughout the region.

In Alberta, Potvin *et al*. (2003) examined the levels and partitioning of genetic diversity in 24 lakes from Banff and Waterton Lakes national parks. Again using microsatellites, they found populations with low to moderate levels of genetic variation (average heterozygosity ranging from ~ 0.1 – 0.5). The number of alleles per locus was

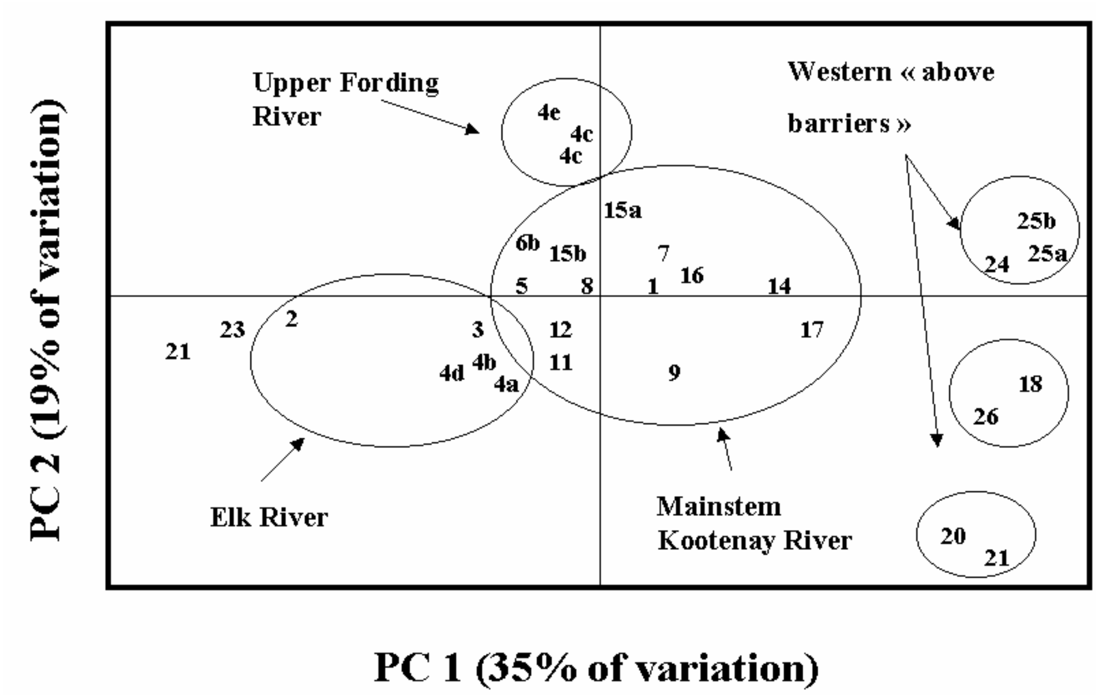

Figure 3. Principal Components Analysis (PCA) of the genetic relationships between southeastern British Columbia WCT populations. Modified from Taylor *et al*. (2003).

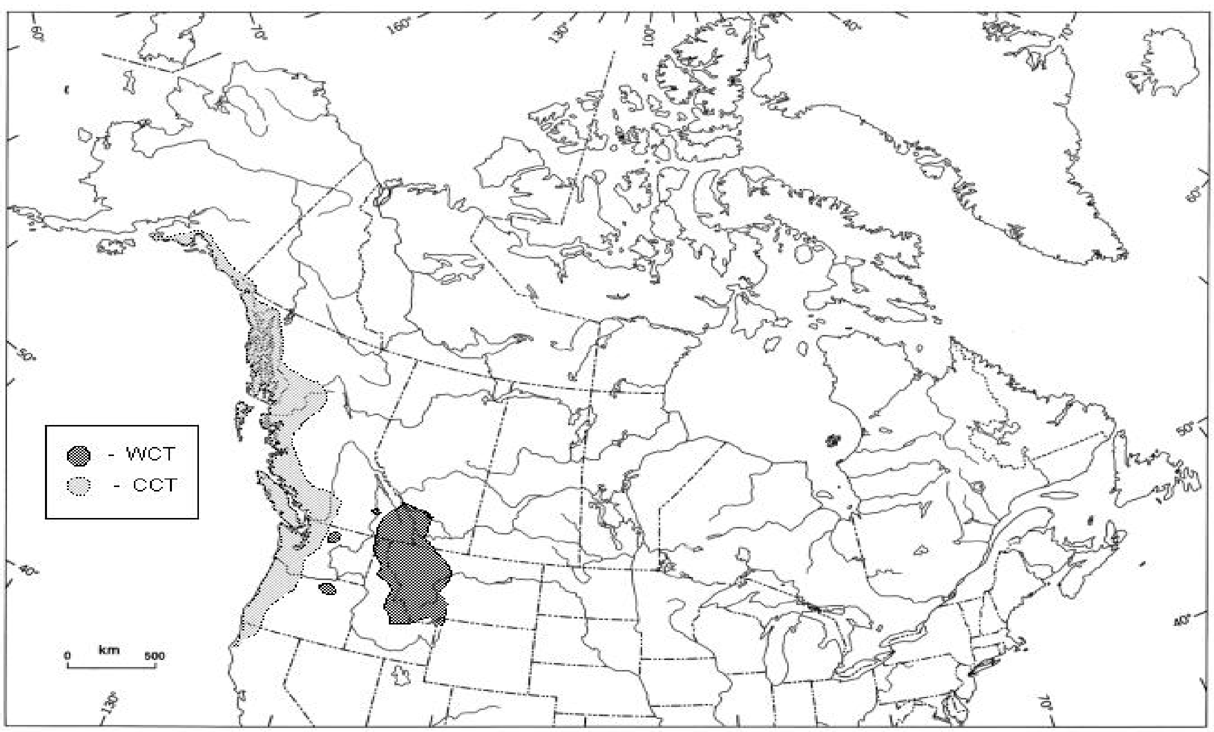

Figure 4. Global/Canadian ranges of native coastal and westslope cutthroat trout. Modified from Behnke (2002), because of the scale the range is only coarsely delineated.

significantly lower in Banff National Park (BNP) than in Waterton Lakes National Park (WLNP; 2.5 vs. 3.5, respectively; p = 0.0039). Factorial correspondence analysis found native populations to cluster closely with low levels of variation (H_e=0.17). In contrast, populations stocked into previously fishless habitat are widely scattered in the plot and have the highest levels of genetic variation (H_e = 0.43). Those containing both native and introduced stocks appear intermediate (H_e = 0.29). The authors suggested that the high levels of variation in introduced populations could be due to the nature of past stocking in the region. The majority of lakes stocked in WLNP were fishless prior to introduction so it may be that the lack of competition with sympatric species allowed more of the introductions to become established, resulting in a genetically heterogeneous mix. Importantly, while levels of variation were lower in native populations, the amount of genetic divergence between them was significant. Genetic subdivision in BNP was, in fact, greater than in WLNP (F_{st} 0.45 vs. 0.19, respectively).

A more recent study addressing rates of hybridization among WCT populations over a larger area in Alberta provides some data on the levels of genetic variation in that region. Janowicz (2004) reported levels of genetic variation at six microsatellite loci that were consistent with studies in other portions of the range (e.g., Leary *et al*. 1987; Taylor *et al*. 2003). Variability was generally low in the study's reference WCT populations (Job Lake, Picklejar Lakes #2 and #4, and Marvel Lake), averaging 3.3 alleles per locus and heterozygosities of 0.36. When a larger subset of WCT populations identified as "pure WCT" as part of the hybridization assay were included, a larger number of alleles per locus were found ranging from 4 – 21, with marginally higher heterozygosities. The authors did not provide a discussion of population structure; however, barriers again appeared to be a significant factor influencing levels of genetic diversity and genetic divergence.

Two microsatellite loci (Omy77 and Ssa85) were shared between these three studies (Table 1) and allowed for some comparison between the two regions. The allelic size range is essentially the same across regions for Omy77, and slightly larger in Alberta for Sfo8. However, for both loci, there are fewer alleles across the allelic size range in Alberta than in BC.

Table 1. Microsatellite loci (Omy77 and Ssa85) allelic size range for Alberta and British Columbia populations (most common allele in parentheses).

Source	Area	Omy77	Ssa85
Taylor *et al*. 2003	SE BC	80 - 140 bp (110 bp)	100 - 164 bp (136 bp*)
Potvin *et al*. 2003	BNP, WLNP	85 - 141 bp (85 bp)	91 - 191 bp (137 bp*)
Janowicz 2004	AB	79 - 107 bp (81 bp)	137 - 155 bp (141 bp)

*likely same allele; different scoring systems

The reduced subset of alleles in Alberta is not unexpected considering that WCT likely recolonized Alberta through headwater transfers across low-lying mountain passes from BC (McPhail and Lindsey 1986). Serial founder events associated with recolonization of Alberta early during the deglaciation process could have led to such a pattern and have been observed in other species in the region (e.g., Costello *et al*. 2003). Although it was not possible to directly compare allele frequencies at the shared loci because of differences in allele scoring between studies, it is apparent that the most common allele at these two loci differed between the two regions. In BC, Omy77*110 and Ssa85*136 are the most common alleles while over a wide range in Alberta, Omy77*81 and Ssa85*141 predominate. This, and the lack of recent dispersal opportunities between the two regions, suggests that significant genetic differentiation likely exists between the two regions. The increased isolation of populations in headwater stream reaches further suggests that the majority of populations in Alberta may show an even greater degree of reproductive isolation and demographic independence than that observed in British Columbia.

Designatable units

In light of the disjunct distribution of populations across the Rocky Mountain divide and expected genetic differentiation between regions, it is appropriate that there be two Designatable Units (DUs) within the subspecies for WCT in Canada:

1. Alberta DU
2. British Columbia DU

Recognition of the two DUs is supported by the biogeographic ecozones inhabited by the two groups: Alberta populations inhabit National Freshwater Ecological Area 4 (Saskatchewan-Nelson) while populations in British Columbia inhabit National Freshwater Ecological Area 11 (Pacific); while these ecozones are adjacent, they are separated by the Rocky Mountains.

Assessed populations

B.C. and Alberta populations of WCT have experienced a large degree of manipulation by humans. The results of these manipulations, particularly those involving stocking activities, raise questions as to which populations (or individuals within populations) are representative of the original range and diversity of the DUs and can be legitimately included for assessment purposes. It should be qualified that this discussion refers only to the portion of the COSEWIC assessment that counts existing populations. All WCT and related hybrid populations should be considered in evaluating conservation threats. The following section provides guidelines for determining which populations should be included in counts.

In general, only native, genetically-pure populations within the original WCT distribution should be included in the count of remaining WCT populations at this time. However, the following situations involving ‘managed populations’ may also be included in the count:

1. A population from a ‘pure’ source (from within the native range of the original DU) that is introduced to a new location (usually also in the native range of the original DU) as a sanctioned recovery or management activity designed to conserve the DU (e.g., genetic refugium);

2. A population from within a DU that has been supplemented (i.e., conservation-based activities using hatchery or wild stock to increase natural production) by hatchery (or wild stock) additions with the source for the latter originating from a population within the same DU, as part of formally sanctioned recovery or management activities, where persistence of the population is not solely dependent on supplementation;
3. A naturally reproducing population within a DU that has reportedly been stocked with WCT at least once (usually to augment fishery, not to increase natural production) but with no evidence to indicate that the receiving system was originally WCT-free or that the existing population has been genetically altered by introductions; and
4. A population within a DU showing evidence of <1% introgression with RT or other CT subspecies. Below this level of introgression, the population is assumed to be non-hybridized since it is difficult, if not impossible, to distinguish between intra-specific polymorphism and a slight amount of introgression (*see* Allendorf *et al*. 2001, 2004, Allendorf *et al*. 2005).

In contrast, hybrid and backcrossed individuals are not WCT and do not contribute to the DU. Hybridized populations of WCT may contain pure individuals that could be used for captive breeding purposes as a tool for recovery. However, hybrid populations with introgression greater than 1% should not generally be included in population counts (Allendorf *et al*. 2001, 2004, 2005, also see note below*). Other situations where managed populations of WCT should not be counted for assessment purposes include:

1. A population from a ‘pure’ WCT source introduced to a new location outside of the native range of the original DU (except under rare cases when this might occur for sanctioned recovery and conservation activities where habitat within the original DU no longer remains);
2. A population of WCT introduced into a system that did not originally contain native WCT (e.g., fishless lake), outside of sanctioned recovery or management activities designed to conserve the DU; and
3. A population with > 1% introgression (but see note* below).

*Note: Hybridization is a complicated issue, and hybrid populations should be considered on a case-by-case basis for assessment, protection and recovery purposes as some populations may still have some conservation value (Allendorf *et al*. 2001). Such populations may be recoverable through captive breeding efforts, or may have elevated value if very few ‘pure’ populations remain within a DU. With respect to the survey work that has been conducted for hybrids in WCT populations in Canada, survey design including geographic scope should be considered. An introgression estimate in a small tributary based on a representative sample is not equivalent to an introgression estimate based on limited sample size for a large system such as the upper Kootenay River. Furthermore, small tributaries may contain physical or temperature barriers to upstream or downstream movement; thus limiting hybridization spatially. Thus, finding hybridization in the downstream section of a system (e.g., lower Bull River) does not mean the entire tributary is affected (e.g., upper Bull River is still ‘pure’).

DISTRIBUTION

Global range

While the original distribution of WCT is not known with certainty, its current native range straddles the Continental Divide (Figure 5). West of the Rocky Mountains, this includes the Salmon, Clearwater, Coeur d'Alene, St. Joe, and Spokane river drainages in Idaho, and the Clark Fork and Kootenai (referred to as Kootenay system in British Columbia) drainages in Idaho, and Montana (downstream to the falls on the Pend d'Oreille River near the Washington-Idaho border; Spahr *et al*. 1991). A further series of disjunct populations extend westward to the Cascades. These include Lake Chelan in Washington, the John Day drainage in Oregon, and the middle-Columbia River tributaries of Methow, Entiat, and Wenatchee rivers in Washington totalling ~72,900 ha (McIntyre and Rieman 1995). These disjunct populations are likely the product of vicariant events associated with catastrophic flood bursts from Glacial Lake Missoula (Behnke 1992), although some may be of hatchery origin (Shepard *et al*. 2003).

Westslope cutthroat trout are also native above barriers in the upper Kootenay and Columbia drainages, as well as in the extreme headwaters of the South Thompson drainage in British Columbia. A series of isolated populations in the region originally described as 'mountain cutthroat' by Dymond (1931) likely represent recent (postglacial) immigration and subsequent fragmentation of WCT populations, as the areas they inhabit only became available upon retreat of the ice sheets from the region (McPhail and Lindsey 1986). On the eastern slopes of the Rocky Mountains, WCT are native to the upper South Saskatchewan River drainage in Alberta (Bow and Oldman rivers), and 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).

With the exception of lake trout (*Salvelinus namaycush*), the original distribution of cutthroat trout was likely greater than any other form of North American trout or salmon (Behnke 2002). Most subspecies, however, particularly the interior forms, have undergone dramatic declines in their numbers and distribution since European settlement (some have disappeared from as much as 90% of the native range). Of the 13 non-coastal subspecies tentatively recognized by Behnke (1992), two are apparently extinct as pure populations. The current global distribution of WCT populations has become extremely fragmented and throughout its range in the United States, WCT are believed to currently occupy ~59% of the 91,000 river kilometres historically occupied circa 1800 (Shepard *et al*. 2003). Recent genetic testing suggested that WCT populations may be genetically unaltered in as little as 8% of this historical range (Shepard *et al*. 2003). Unfortunately, this may be an optimistic estimate in that the sites used for that study were not chosen randomly, but were believed to represent pure WCT populations.

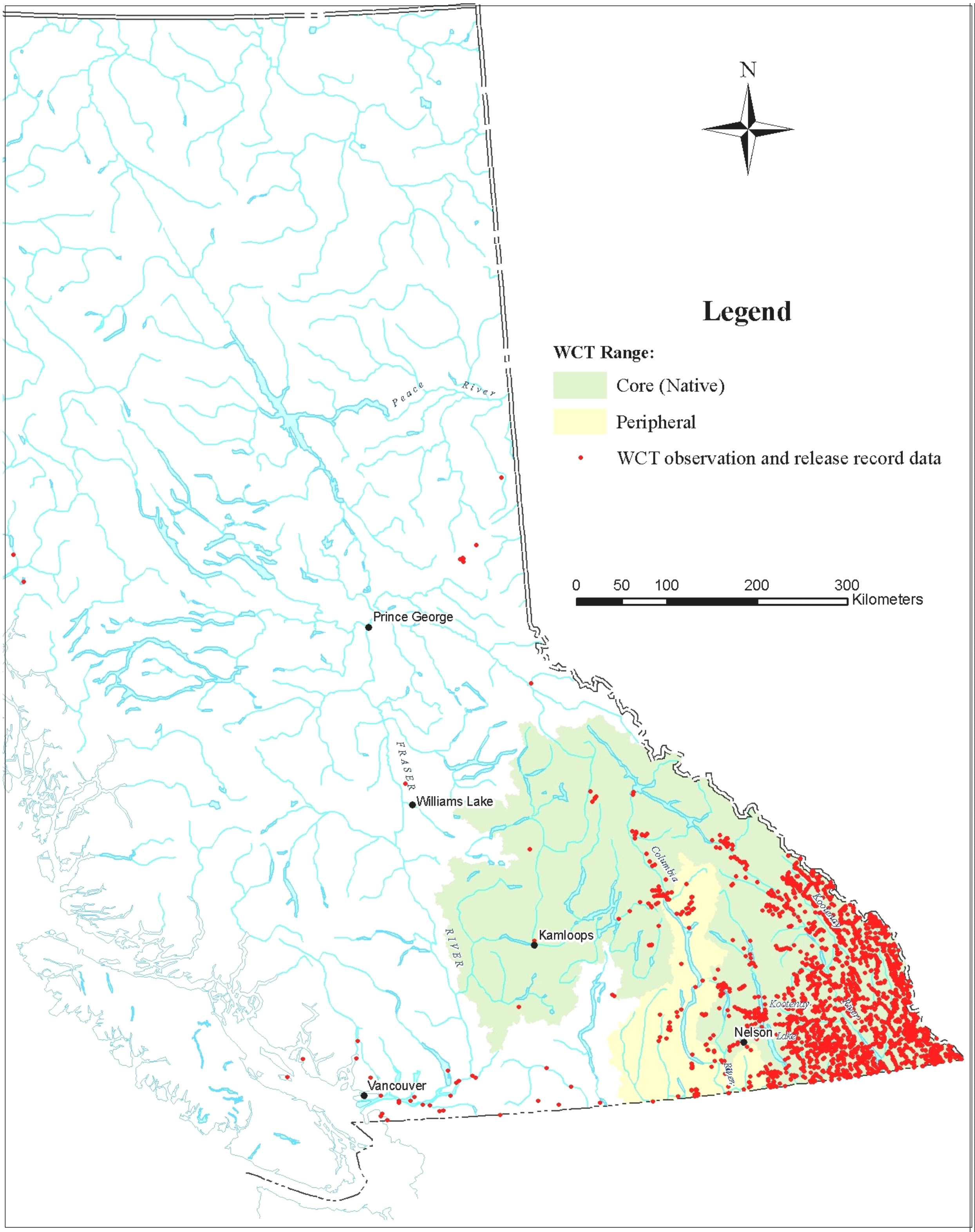

Figure 5. General distribution of native and introduced WCT in British Columbia. Core area indicates core native range while peripheral area indicates likely native range where WCT occur in disjunct locations. Points on the map include all observation and stocking records (BC Ministry of Environment 2006).

Canadian range – British Columbia population

The native range of westslope cutthroat in Canada is centred on the upper Kootenay River drainage in British Columbia (Figure 6) and includes all its major tributaries (the White, Lussier, Wild Horse, St. Mary, Bull, and Elk rivers as well as Findlay, Skookumchuk, and Mather creeks). They are also native to the Moyie River system (flowing south of Cranbrook, BC to join the Kootenai River in Idaho) and the Goat River system (which joins the Kootenay River near Creston, BC). To the southeast, WCT are present throughout the headwaters of the upper Flathead River, which flows south out of the province into Flathead Lake before joining the Clark Fork River drainage near Plains, Montana. The area is recognized as an important stronghold for native WCT in Montana and is home to some of the last genetically pure populations in the US (Liknes and Graham 1988; Deeds *et al*. 1999; Montana Wilderness Association, 2003, Hitt *et al*. 2003). Disjunct populations of WCT are known to inhabit headwater streams and lakes of the upper Columbia, near Revelstoke, BC, as well as tributaries of the South Thompson River (specifically the Shuswap system). These include Yard, Crazy and Frog creeks, which are tributaries of the Eagle River and Mabel Lake, and some small lakes on Mt. Griffin (all in the South Thompson system); as well as Frog, Isaac, and Kirkup creeks near Revelstoke, and Six Mile and Lasca creeks, which flow into the west arm of Kootenay Lake (all in the Columbia system) [Carl *et al*. 1967]. They may have been native to the Kicking Horse River drainage near Field, BC (Columbia basin), having gained access to the area through headwater transfer with the upper Kootenay River (Mayhood 1995, 2000).

Canadian range – Alberta population

In Alberta, the native range of WCT 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 (Sisley 1911; Prince *et al*. 1912; Willock 1969). In the Bow drainage, WCT were originally found from the extreme headwaters above Bow Lake in Banff National Park, 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 are generally small and restricted to the extreme headwaters of a few major tributaries and upper mainstem, occupying less than 5% of the native range outside Banff National Park (Mayhood 1995; Figure 7). They are now present in the Bow River only above Lake Louise, in the extreme 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 of the Ghost River, and in the upper parts of five tributaries of the Elbow River (Mayhood 1995, Mayhood 2000). There appear to be populations in the Highwood River above the Forest Reserve boundary and in a few, short, highly isolated tributary reaches. The Jumpingpound Creek population is similarly present above the Forest Reserve boundary (Mayhood 2000).

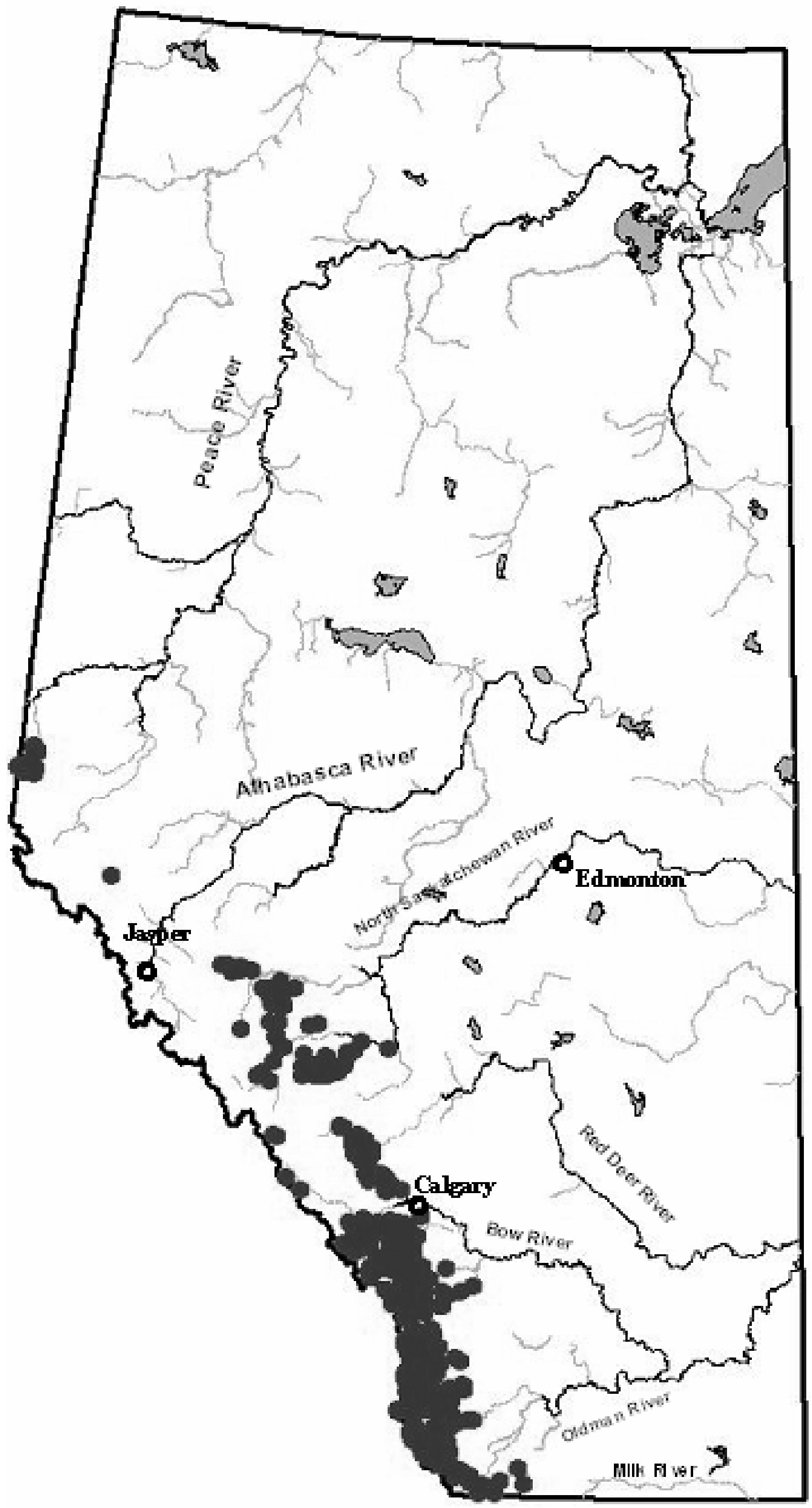

Figure 6. Current distribution of native and introduced WCT in Alberta. Dark circles indicate point observations (Alberta Sustainable Resource Development, 2004).

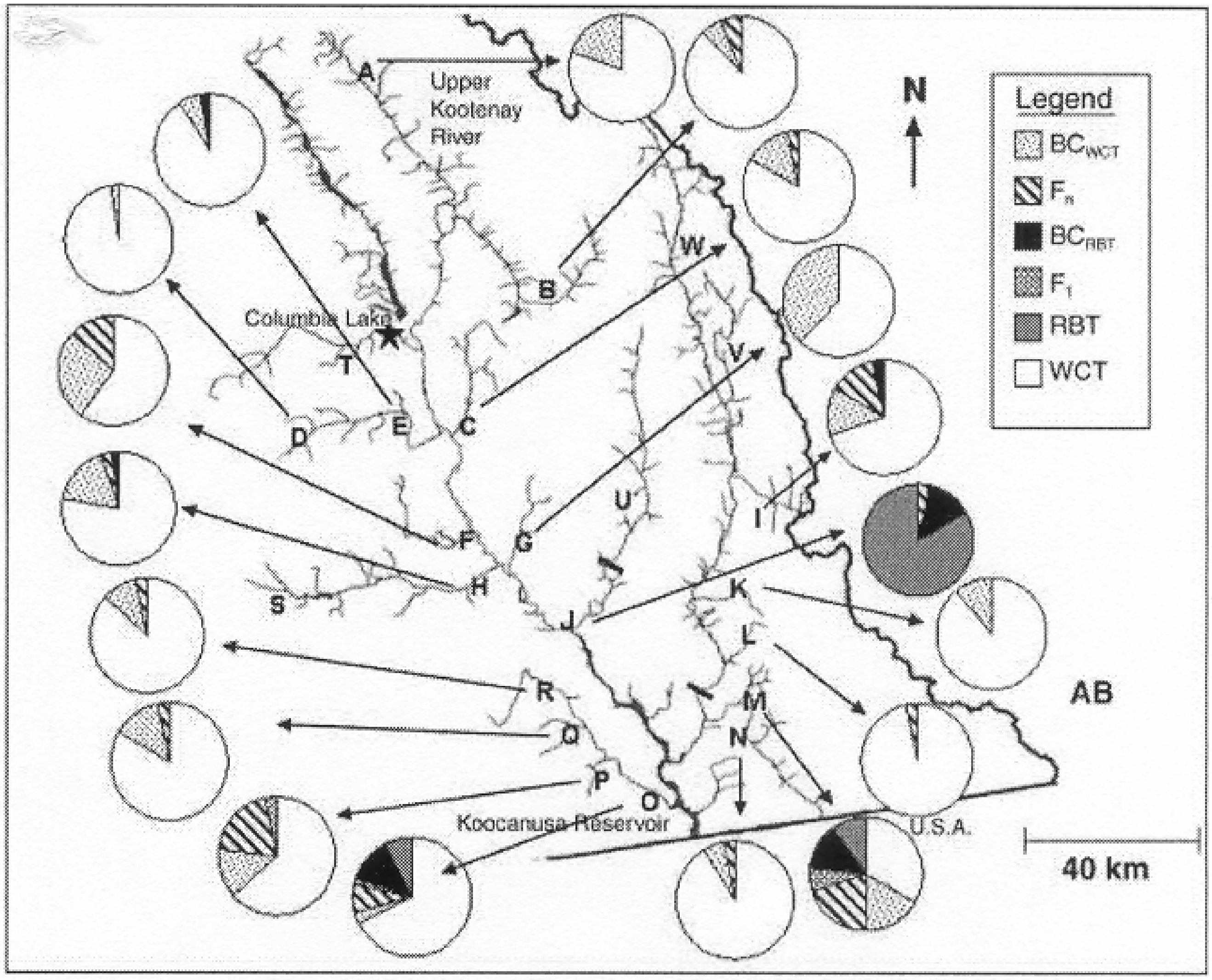

Figure 7. Summary of levels of hybridization in selected Alberta drainages (modified from Janowicz 2004).

In the Oldman River drainage, WCT were present from the headwaters falls below Cache Creek downstream to the plains and in all 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 and most of its accessible tributaries (Radford 1977; 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. 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 the Missouri River. Although WCT were collected there historically (e.g., Willock 1969), their current status is unknown and no recent records of WCT in the Milk River have been found.

Introduced populations in Canada

Westslope cutthroat trout have been widely introduced both within and outside of their original native range. Most stocking has been done to enhance or replace extirpated native populations, or to seed naturally fishless areas. To date, such activities in Canada have focused mainly on providing or enhancing recreational angling opportunities rather than on rebuilding populations. Rarely have cutthroat trout become naturalized much beyond the original distribution (Behnke 1992). Introductions were made from non-local source populations and in some cases; WCT X RBT hybrid populations have been knowingly propagated. The scope and nature of these introductions can make it difficult to assess the status of wild populations, as such introductions often serve to obscure trends in native production and may, in fact, further contribute to the decline of native populations (e.g., Scribner *et al*. 2001; Docker *et al*. 2003; See LIMITING FACTORS).

The stocking of rainbow trout, other sub-species of cutthroat trout and rainbow trout x cutthroat trout hybrids into native WCT habitat has resulted in hybridization and introgression in some native WCT populations. Such populations should not be included in the count of remaining pure WCT populations but should instead be evaluated as a threat for the purposes of this document (see also Assessed Populations and Limiting Factors and Threats sections). The Canadian native range of rainbow trout only overlaps that of WCT in the Upper Columbia, South Thompson and Lower Kootenay (most upstream extent of range is to between Libby and Troy in Montana where Kootenai Falls prevented further upstream movement). No rainbow trout occurred in the Flathead or Upper Kootenay systems naturally (Benhke 1992), which is the core of WCT native range in Canada. However, RT have been stocked into a number of WCT-containing waterbodies in this region (e.g., see Table 2 for BC DU).

The following section identifies systems stocked with WCT both within and outside the native range of WCT in Canada.

<u>British Columbia</u>

Many naturally fishless systems in southeastern BC have probably been stocked with WCT since the 1920s. These include high elevation headwater lakes and streams, as well as small lakes near urban centres. In addition, WCT have been stocked into a variety of lakes, streams and rivers likely already containing native WCT populations. Within the native range of WCT, a total of 301 streams or lakes have been reportedly stocked with WCT at least once since 1923 (BC stocking records, Fisheries Inventory Summary system (FISS) http://srmwww.gov.bc.cba/fish/fiss/index.html, summarized in Table 2). Unfortunately, it is impossible to determine for many of these waterbodies which ones originally contained native WCT populations prior to stocking. It is also very likely that introduction of WCT into new waterbodies prior to record keeping occurred since early settlers were known to move fish around through the southeastern BC region in hopes of establishing fishable populations.

Table 2. Summary of waterbodies (including streams and lakes) in BC containing WCT based on survey data and stocking records. Note that waterbodies stocked with WCT may also contain native, wild populations. Numbers of WCT waterbodies stocked with RT and CCT are also included (compiled by S. Pollard, B.C. Biodiversty Branch, B.C. Ministry of Water, Land and Air Protection).

River Basin	Within native range?	Waterbodies reported to contain WCT (stocked and unstocked)	WCT waterbodies with no record of stocking WCT	Waterbodies stocked with WCT at least once	WCT waterbodies not stocked with WCT, but stocked with RT	WCT waterbodies not stocked with WCT, but stocked with CCT[6]
Upper Kootenay	Yes	644	503	141	6[1]	15
Lower Kootenay	Yes	322	236	86	21[2]	3
Pend d'Oreille (incl. Flathead)	Yes	113	93	20	2[3]	3
Columbia (mainstem tributaries)	Yes, disjunct	139	93	46	8[4]	9
South Thompson	Yes, disjunct	11	3	8	1[5]	1
Total native range		1229	928	301	38	31
Kettle	Maybe?	19	11	8	0	0
Okanagan	Maybe?	6	0	6	1	0
Other minor Columbia basins	Maybe?	12	7	5	1	0
Fraser mainstem	No	19	0	19	n/a	n/a
North Thompson	No	7	0	7	n/a	n/a
Other (coastal, Peace)	No	12	0	12	n/a	n/a
Total outside range		75	18	57	n/a	n/a

[1] Three waterbodies stocked >5 times with RT (incl. Kikomun Cr=13, Horseshoe L.=70, Tamarack L.=75x)
[2] Five waterbodies stocked >5 times with RT (incl. Kootenay L.=67, Slocan R.=34, Slocan L.=51, Meadow Cr.=27, Lamb Cr.=10)
[3] One waterbody stocked > 5 times with RT (incl. Salmo R.=25)
[4] Six watebodies stocked > 5 times with RT (including, U. Arrow L.=32, L. Arrow L.=49, Columbia River=21, Cedar L.=60x, Halfway L.=25, Lillian L. = 78.
[5] One waterbody stocked with RT >5 times (incl. Eagle Cr.=12)
[6] No waterbodies stocked more than 5 times with CCT except Angus Cr. in U. Kootenay stocked 8 times)

There have also been a number of WCT introductions into lakes and streams outside of the native range including the lower Fraser River basin, the Okanagan/Kettle/Similkameen basin, coastal systems and the Peace basin. For example, there have been introductions to the tributary systems of the Similkameen River including the Ashnola River, Ladyslipper Lake, Quinesco Lake, Lake of the Woods and Pyramid lake in Cathedral Park. Limited stocking has occurred at two sites in the coastal Bella Coola River system (Blue and Octopus lakes) but was discontinued in 1995 (Mike Ramsay, BC Ministry of Environment, Williams Lake, BC, personal communication 2003). Approximately 70 such waterbodies outside of the native range of WCT have been stocked at least once.

Early stocking records do not consistently list the origin of the hatchery stocks used for these introductions. In at least one case (Seton River), the cutthroat stocked was of coastal origin from the Cowichan River on Vancouver Island. A variety known as 'Cranbrook Trout' (an intentionally crossed RBT X WCT hybrid produced by the Cranbrook Hatchery), was stocked throughout Alberta and to a more limited extent in British Columbia until 1964 when the hatchery closed. Other WCT X RBT hybrid stocks (Monroe and Rosebud) were also introduced for a period (1923 -1945) into small lakes and creeks in the upper Kootenay River drainage. Since 1971, all stocked WCT have been derived from Connor Lakes broodstock, considered to be pure WCT from within the native range of the DU (E. Taylor, Department of Zoology University of B.C., Vancouver, B.C.; personal communication 2006; Taylor *et al*. 2003), and these fish have been mainly stocked within the native range of the DU.

There is no doubt that the stocking of rainbow trout and other cutthroat trout subspecies has affected the genetic integrity of WCT populations in BC. In recent years, almost all rainbow trout stocking within the native range of WCT has been limited to releases into small lakes. Furthermore, a significant portion of these fish are triploid and/or all female stocks. However, the degree to which these lakes are considered 'closed' is uncertain, and over 100 water bodies have been stocked since 2000. Furthermore, reproductively viable juvenile Gerrard strain rainbow trout were stocked multiple times into a tributary of Kookanusa Reservoir from 1986 to 1998 (FISS stocking records). During this period, the Montana government also stocked large numbers of reproductively viable rainbow trout from Murray Springs Hatchery into the reservoir. These fish would have access to all connected tributaries and outlets of the reservoir.

<u>Alberta</u>

In Alberta, WCT have been widely introduced in several major drainages, both within and outside of the original native range, most commonly into previously fishless headwater lakes located above impassable barriers. They have been introduced into several streams in the Oldman and Bow river systems (Mayhood 2000) and into many naturally fishless lakes in Waterton Lakes National Park (Landry *et al*. 2000). In the upper North Saskatchewan River, a system in which they did not naturally occur (Sisley 1911; Prince *et al*. 1912), 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). While transplanted WCT 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). Populations stocked outside of the natural range are not included in the assessment.

Again, it is often difficult to trace the origin of these introduced stocks. Many of the early introductions were made with eggs and fry imported from the United States (particularly in Waterton Lakes National Park). For several years, eggs were taken from a native population in the Spray Lakes (AB), but when that population was no longer available, fish were obtained from a variety of sources including coastal cutthroat trout stock from Washington State, and a Yellowstone cutthroat trout variety from the Cranbrook hatchery in BC (Ward 1974).

The majority of recent (since 1998) WCT stocking in Alberta has come from Job Lake, a high elevation lake in the North Saskatchewan River basin. Approximately 2-300,000 WCT eggs are taken from Job Lake every other year to the Sam Livingstone Hatchery for rearing and later planted as fingerlings into various lakes and streams in Alberta (Carl and Stelfox 1989). An average of about 124,000 fish were stocked out every other year from 1988 – 2004 (Alberta Fisheries Management system 2005). Job Lake was barren of fish until 1965 when it was stocked with WCT from Marvel Lake (Banff National Park; McAllister *et al*. 1981). These fish originally came from a single population native to the Spray Lakes that has since been extirpated due to the construction of the Spray Lakes Reservoir (Ward 1974, Mayhood 2000). The Job Lake hatchery stock, is considered wild stock from within the native range; however, most plantings have been done in lakes, and rarely in streams and rivers (J. Stelfox, Alberta Sustainable Resource Development, personal communication, 2004).

It is certainly true that past introductions have affected the genetic integrity of pure populations. However, there are no instances in Alberta in the past eight years where rainbow trout have been introduced into waters where pure westslope cutthroat trout are still present. In all cases where rainbow trout continue to be stocked in Alberta, there is no longer a pure cutthroat trout population present and a self-sustaining population of rainbow trout has been established from past introduction, but the damage has already been done (Stelfox, pers. comm. 2006).

As indicated above populations outside of the native range are not included in the assessment, and given the uncertainty of the purity of source stocks, neither are introductions or augmentations within the native range. The only steams remaining within the native range in Alberta that still are thought to contain pure populations of what are considered to be pure WCT are those listed in Table 3.

Table 3. Streams in Alberta containing or suspected of containing pure cutthroat trout populations (Stelfox, unpubl. data).

Stream	Stocked*	WCT historically present	Pure WCT still present	Pure WCT at risk	Genetic data available	Risks
Bryant		Yes	Yes	Yes		Identified hybrids in Smuts Creek, potentially can get into Bryant
Lesueur	Y	Yes	Yes	Yes		Brook Trout
Meadow	Y	Yes	Yes	Yes		Brook Trout
Spray River	Y	Yes	Yes	Yes	Yes	Culvert may become passable, and allow Rainbow Trout & Brook Trout upstream
Lookout Creek		Yes	Yes	Yes		Brook Trout
Elpoca		Yes	Yes	Yes	Yes	Hybrids present in nearby tributary
Evan-Thomas	Y	Yes	Yes	Yes	Yes	Brook Trout, Brown Trout further downstream
Johnson		Yes	Yes	Yes	Yes	Brook Trout
Pocaterra	Y	Yes	Yes	Yes	Yes	Hybrids present in Spotted Wolf
Porcupine		Yes	Yes	Yes	Yes	Brook Trout, Brown Trout further downstream
Rocky		Yes	Yes	Yes	Yes	Brook Trout, Brown Trout further downstream
Margaret		Yes	Yes	Yes	Yes	Brook Trout - Potential for escapment from Margaret Lake
Waiparous	Y	Yes	Yes	Yes	Yes	Brook Trout
Watridge		Yes	Yes	Yes	Yes	Identified hybrids in Smuts Creek, potentially can get into Watridge
Barnaby Creek		Yes	Yes	Yes		Golden Trout at head of creek
Beaver Creek		Yes	Yes	Yes	Yes	
Beehive Creek		Yes	Yes			Relatively Safe, barrier downstream
Cache Creek		Yes	Yes			Relatively Safe, barrier downstream
Connelly Creek		Yes	Yes			
Deep Creek		Yes	Yes			
Font Creek		Yes	Yes			
Honeymoon Creek		Yes	Yes			
Isalnd Creek		Yes	Yes	Yes		Brook Trout, Rainbow Trout in Island Lake
Lyall Creek		Yes	Yes			Relatively Safe, barrier downstream
MacDonald Creek		Yes	Yes			
Mean Creek		Yes	Yes			
North Lost Creek		Yes	Yes			
Pasque Creek		Yes	Yes			
Ridge Creek		Yes	Yes			
Salt Creek		Yes	Yes			
Scarpe Creek		Yes	Yes			
Slacker Creek		Yes	Yes			
Soda Creek		Yes	Yes			
South Hidden Creek		Yes	Yes			

Stream	Stocked*	WCT historically present	Pure WCT still present	Pure WCT at risk	Genetic data available	Risks
South Lost Creek		Yes	Yes			
South Racehorse Creek		Yes	Yes			
Speers Creek		Yes	Yes			
Straight Creek		Yes	Yes			
Syncline Brook		Yes	Yes	Yes		Rainbow Trout in West Castle
Dome Creek		Yes	Yes			
First Creek		Yes	Yes			
Isolation Creek		Yes	Yes			
Smith Creek		Yes	Yes			
Spoon Creek		Yes	Yes			
Wintering Creek		Yes	Yes			
Gorge Creek		P	Yes	Yes	Yes	
Daisy Creek		Yes	Yes	Yes	Yes	Rainbow Trout in Racehorse
Dutch Creek		Yes	Yes	Yes	Yes	Rainbow Trout in Oldman
Lynx Creek	Y	P	Yes		Yes	
North Racehorse Creek		Yes	Yes	Yes	Yes	
North Twin Creek		Yes	Yes		Yes	
Oyster Creek		Yes	Yes		Yes	
Vicary Creek		Yes	Yes	Yes	Yes	Rainbow Trout in Racehorse - Range Expansion
Moose Mountain Creek		Yes	Yes	Possibly		Culvert may become passable, and allow Rainbow Trout & Brook Trout upstream
Picklejar Creek	Y	Yes	Yes			
Prairie Creek	Y	Yes	Yes	Yes		Brook Trout
Canyon Creek	Y	Yes	Yes	Possibly	Yes	Culvert may become passable, and allow Rainbow Trout & Brook Trout upstream
Quirk Creek	Y	Yes	Yes	Yes	Yes	Brook Trout
Silvester Creek		Yes	Yes		Yes	
Cutthroat Creek		Yes	Yes	Possibly	Yes	
Elbow River	Y	Yes	Yes	Yes	Yes	Brook Trout
Totals	12	61	61	29	24	

*Lower reaches of some streams with WCT in the headwaters were stocked in the 1940s-1950s with pure WCT of unknown origin. These streams are still considered to contain pure WCT populations.

P = Possibly, Y = yes, WCT = Westslope Cutthroat Trout

Average stream length = 8.4 km. Average number of pure WCT per stream = 100 (range 30 - 200)

HABITAT

Habitat requirements

Cutthroat trout are found in a wide range of habitats in Canada. Their relatively small size at maturity makes them particularly able to utilize smaller streams compared with other salmonids. Westslope cutthroat trout inhabit large rivers and lakes in BC, as well as many small mountain streams. In Alberta, genetically pure native populations are now largely restricted to the upper reaches of mainstem rivers and the headwaters of a few major tributaries. Stocked or apparently hybridized populations are more common, but are still largely restricted to headwater areas (Mayhood 2000). While the scope and nature of variation between the two designatable units for ecological and life history traits is not known, the subspecies as a whole seems to thrive in streams with abundant pool habitat and cover. As with other salmonids, four main types of habitat are required to complete its life cycle:

1. Spawning – Small, low-gradient streams with cold well-oxygenated water and clean unsilted gravels; spawning often occurs in the tailouts of deep pools at moderate to high-flow events, which are often of short duration (Brown and McKay 1995b; Schmetterling 2001). 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 (LWD), boulders, or bedrock. This instream structure creates the necessary pool habitat to catch and retain spawning gravels as well as providing cover from predation. High mortality often results when suitable cover is lacking (Behnke 1992; Brown and Mackay 1995b). Shoal spawning has been confirmed (e.g., Carl and Stelfox 1989; Stelfox, pers. comm. 2006), but does not appear to be common.

2. Rearing – Small streams (first to third order) which 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 (some populations may rear in lakes). Larger juveniles move into pools where they establish social dominance based on size. Parr require large territories and the availability of pool habitat often limits their productivity even in productive streams (e.g., Schmetterling 2001).

3. history type involved (See BIOLOGY). The resident component of populations may remain in the natal stream 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 higher. For fluvial (riverine) forms, slow pools formed by boulders or LWD with fast adjacent water and plenty of cover (undercut banks, riparian vegetation, instream structure) are required. Adfluvial adults (migrating between lakes and rivers) will spend summer months feeding in lakes and reservoirs with temperatures less than 16°C (McIntyre and Rieman 1995).

4. Overwintering – Overwintering habitat suitability appears to be largely determined by groundwater influx and the absence of anchor ice (e.g., Brown and Mackay 1995a). During winter months, fluvial adults will congregate in slow deep pools sheltered from high flows. Juveniles often utilize 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.

Essential habitat parameters

The wide range of environmental conditions encountered by WCT might suggest some manner of flexibility in habitat utilization. However, it is apparent that populations have very strict habitat requirements during various life history stages and generally only do well in intact lotic environments requiring cold clean water and varied forms of cover (i.e., undercut banks, pool-riffle habitat, and riparian vegetation) to maintain their numbers.

Temperature

Stream temperature is likely an important habitat parameter affecting cold-water salmonids like WCT. Water temperature influences a host of biological processes including growth rate, swimming ability, as well as the capacity to ward off disease and capture food (Reiser and Bjornn 1979). 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). Exposure to temperatures as high as 28-30°C quickly leads to loss of equilibrium, swimming difficulty, and ultimately death (Heath 1963). Preferred temperatures likely range from 9-12°C. Spawning generally occurs from 6-17°C (Hunter 1973). Optimum stream temperature for incubation of eggs is ~ 10-11°C and ~15°C for juvenile rearing (Merriman 1935; Snyder and Turner 1960). Their preference for cooler water temperatures appears to make WCT a superior competitor at higher elevation stream reaches (Griffith 1988, Fausch 1989, Paul and Post 2001). The current distribution of WCT populations in many headwater areas supports the idea of a “temperature/ elevation refugia” for WCT where populations are most able to resist invasion by non-native species (e.g., Paul and Post 2001)

Current Velocity/ Stream Flow

While cutthroat occupy a wide range of habitats, they generally inhabit smaller streams with lower energy discharges. Spawning occurs at water depths of 20-50 cm and mean water velocities from 0.3-0.4 m/sec (Liknes 1984, Shepard *et al*. 1984). Young-of-the-year fry inhabit lateral habitat with flows ~ 0.06 m/s and depths over 3 cm (Bozek and Rahel 1991). Platts (1974) found that WCT densities peaked at a channel gradient of about 10%, which was higher than that for peak densities of bull trout (*Salvelinus confluentus*), brook trout (*Salvelinus fontinalis*), or RBT. Changes to natural flow regimes and inadequate base flows have a significant impact on stream-dwelling salmonids (e.g., Spence *et al*. 1996). 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 delivery to parr in pools. Low base flows can lead to substantial losses of marginal rearing habitat, elevated stream temperatures and may inhibit normal patterns of migration when populations become isolated to pockets of water (e.g., Slaney *et al*. 1996; Rosenau and Angelo 2003). Westslope cutthroat trout appear to have evolved to move with the rising limb and peak of the hydrograph, allowing them to negotiate seasonal barriers within streams where increased flows may be necessary to gain access (see BIOLOGY – Movement/ Dispersal).

Riparian and Instream Cover

Riparian cover and varied instream structure are essential elements of WCT habitat, contributing greatly to stream complexity and to the creation of areas of refuge. Riparian vegetation (e.g., alders, salmonberry, willow, poplar, etc.) serves to stabilize stream banks, reduce predation, and keep stream temperatures low by reducing solar insolation (reviewed by Reeves *et al*. 1997; Rosenfeld 2001). As well, the riparian input of terrestrial insects is often a significant food source for WCT during summer months (Behnke 1992). Undercut banks, root wads and boulders are also important in partitioning habitat and as areas of refuge. Bedrock outcroppings are perhaps of more importance in areas where trees are smaller, and debris jams are less frequent. The abundance of larger juveniles in streams is often limited by the availability of pools and large woody debris (e.g., Schmetterling 2001). Processes such as riparian logging and the removal of large woody debris are known to adversely affect pool habitat, and lead to the loss of stream complexity, bank instability, sedimentation and the infilling of pools. They reduce egg-to-fry survival, the availability of rearing habitat and future production of aquatic invertebrates (reviewed by Reeves *et al*. 1997; Rosenfeld 2001).

Habitat trends in Canada

The native range of WCT is limited to the western provinces of British Columbia and Alberta, where economies are largely driven by land use and resource extraction. All available data suggest significant habitat loss and degradation throughout the range of both subspecies in Canada over the last 100 years. The largest losses have occurred as a result of resource extraction and associated road construction. Habitat loss and alteration due to water impoundment for hydroelectric projects and agricultural irrigation has also been implicated in several declines. Protected areas do exist within the range of WCT in Canada, but they are often small and do not necessarily encompass all the habitats required by the various life history forms within an area (particularly migratory forms). It is apparent that in the absence of more rigorous protection, required habitat will continue to be degraded and populations increasingly fragmented.

British Columbia

The major habitat threats to WCT habitat in BC include logging, mining and urbanization. Logging is by far the dominant resource industry in BC; forest products accounted for more than half ($15 billion, or 52%) of the province's total exports in 1999 (BC Stats, 2001). The loss of forest cover is known to adversely affect fish populations by changing temperature and hydrological regimes within streams. For many years, poor and outdated harvest practices have contributed greatly to habitat loss in Canada, and until recently, the numerous small streams and tributaries associated with these forests often received little formal protection. They are often still improperly culverted or logged to the streambanks (See BIOLOGY – Movements/ Dispersal). Urbanization and local development have adversely affected some populations. The East Kootenay region, for example, is home to ~ 65,000 people, most of whom live in the Cranbrook-Kimberly area. The City of Cranbrook has grown extensively around Joseph Creek (St. Mary's River drainage). According to traditional First Nations knowledge, the creek used to be a very important spawning area for WCT (Prince and Morris 2002). Extensive habitat degradation and alteration (e.g., impassable culverts, storm-drain runoff, siltation) and extremely low flows during summer months have severely impacted juvenile rearing in the system (Bill Westover, BC Ministry of Water, Land, and Air Protection, personal communication, 2003) Currently, this creek does not appear to support WCT but does support non-native brook trout.

In terms of mining activity, there are currently eleven operating mines in the East Kootenay region of BC. Six of these are industrial mineral mines, and five are coal mines. Impacts include the construction of rock drains on creeks (typically the infilling of valley bottoms and related habitat destruction), chemical loading (e.g., selenium) and stream diversion. The most detrimental impact of the mining industry on freshwater habitat is water contamination. Rainbow trout collected downstream from a coal mine end-pit lake in Alberta had higher concentrations of selenium in muscle and gonad tissues than control fish. These elevated selenium levels increased the overall mortality to the swim-up stage and increased the incidence of spinal deformities and edema in fry (Holm *et al*. 2003). Accompanying these primary industries has been an increase in road density that promotes further habitat fragmentation, degradation, and the opening of new access points for harvest and non-native introductions (e.g., Reeves *et al*. 1997).

<u>Alberta</u>

Urbanization, water diversion, and agricultural practices have had obvious impacts on WCT habitat in Alberta. Cumulative impact assessments conducted on 98 fourth order or higher watersheds in the upper Oldman, Crowsnest, and Carbondale (Castle River drainage) basins found that approximately two-thirds of the watersheds are at moderate risk of degradation, which would result in further loss of WCT habitat. In addition, all but three of the remainder are at high risk of degradation from increased peak flows and surface erosion caused by extensive clearcutting and road development (Mayhood *et al*. 1997; reviewed in Mayhood 2000). Resource exploration has led to a dramatic increase in road density in Alberta, translating into an explosion of wilderness access points (e.g., roads, cut-lines). Increasingly, off-road vehicle traffic is leading to increased stream bank erosion and sedimentation, as well as increased angling pressure. For example, in the Ghost-Waiparous area, there are 189 km of designated trails, but on long weekends up to 2000 km of largely undesignated trails are actually being used by nearly 15,000 people (Alberta Wilderness Association 2002). Habitat degradation along the Bow River is severe; the city of Calgary is built around its banks and several major transportation thoroughfares run along much of its course.

The human population in the South Saskatchewan River basin is expected to grow to ~ 2 million by 2021 (from 1.3 million in 1996; Alberta Environment 2003a). Accompanying this population growth there will be a projected increase in domestic water demand of 29-66%. This is troubling considering that Alberta has no substantial ground water supply to draw upon; 97.5% of the water used in Alberta is from surface runoff (Alberta Environment 2003b). Presently, 41.5 % of the running waters of the Bow River valley watershed in Banff have 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 Associates Ltd. 2003). In 2001, the amount of water flowing down the Bow and Oldman rivers where they merge into the South Saskatchewan River (near Medicine Hat) hit a 31-year low. At least 70.4% of the median natural flow in the Oldman River (and 68.1% for the Bow River) is now allocated for industrial and domestic purposes (Environment Canada 2003). Irrigation licences account for about 75% of the total volume of South Saskatchewan River basin allocations (Alberta Environment 2003b). Alteration of flow rates and regimes may be detrimental to the long-term well-being of WCT (see Limiting Factors).

While the major withdrawals occur in the lower parts of these systems and below existing WCT populations, it is likely that such withdrawals have contributed to the extirpation of populations in the Highwood, Bow, and Oldman rivers. Their disappearance came soon after the development of the dams and the stocking of rainbow trout into the reservoirs (Nelson 1965). The pattern is not unique. Dams have been a major factor in the decline of the Kananaskis, lower Spray and Cascade WCT populations. While abundant in lower Kananaskis and Spray lakes before they were dammed, WCT are now virtually absent (Stelfox 1987a, b). Before dam construction in 1913, WCT were also 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 WCT were found between the Ghost Dam on the Bow River and the Bearspaw Reservoir (RL & L Environmental 1998) or from the TransAlta Pocaterra Power plant to Pocaterra Creek (Kananaskis River drainage; Golder and Associates Ltd. 1999). Both areas historically supported WCT populations.

Habitat protection/ownership

All fish habitat in Canada is protected under provisions in the *Fisheries Act*. In addition this species is found within Waterton and Banff National Parks as well as a number of federal reserves east of the Rockies, and in such cases are regulated pursuant to the *National Parks Act*. The Department of Fisheries and Oceans (DFO), in partnership with provincial governmental agencies, has the legislative mandate to protect fisheries resources, fish habitat, and water quality in Canada. However, resource managers are often limited in their ability to avoid or mitigate developmental impacts where the land base is privately owned, and compliance with existing policies may appear equivocal (e.g., Harper and Quigley 2000; G3 Consulting, Ltd. 2000).

Various park systems and protected areas do exist throughout the range of WCT in Canada (http://www.pdac.ca/pdac/advocacy/land-use/protected-areas.html). Yet, the majority of their range remains subject to development and various types of resource extraction. Several higher land use planning processes have been undertaken. However, in the East Kootenay region of BC for example, less than 16% of the land base is formally protected; 9% is privately owned and the remaining 75% is subject to resource extraction, recreational use, and environmental stewardship (Owen 1994). In October 2002, the BC government implemented the Kootenay Boundary higher-level plan, which removes industry's obligation to maintain mature forest cover in the region (Bergenske 2002). In Alberta, a relatively large proportion (28%) of the land base is privately owned; only 12.4% of the landbase is protected and resource extraction may be permitted in ecological reserves and provincial parks with government approval (Prospectors and Developers Association of Canada, 2003).

BIOLOGY

General

Cutthroat trout show a remarkable diversity in phenotypic traits and life history characteristics throughout their range. The scope of this diversity and its underlying biology, however, remains understudied and poorly understood relative to other salmonid species. It is evident that WCT inhabit smaller, less productive streams, preferring cooler water temperatures than other closely related species. Populations are generally small but show strongly developed natal philopatry and well-defined population structure (see previous sections). Populations appear sensitive to habitat perturbation and the introduction of non-native fishes. Habitat degradation may make populations especially susceptible to displacement and/ or hybridization with introduced species. As such, populations in degraded habitats are likely subject to declines, and their high degree of demographic independence suggests that losses are not likely to be offset by immigration from nearby sources over the short term.

Life history diversity

Cutthroat trout are arguably the most diverse salmonid species in North America and show extensive phenotypic variation in the size, colouration, and life history characteristics typical of populations (reviewed by Trotter 1987, Behnke 2002). Much of this diversity is adaptive in nature and has evolved in response to local environmental conditions (*sensu* Taylor 1991). Several different life history types are present throughout the range of WCT: fluvial and resident populations are common throughout the Canadian range (adfluvial perhaps less so); different strategies may often be present within the same population. The relationships between these life history types and the amount of interaction between them is not clear, particularly with respect to shared resources and habitat utilization (much of the available information on particular life history types has been collected in the US). Within an area, however, it is apparent that different life history types are more closely related to each other than to similar types from other areas (e.g., reviewed by Johnson *et al*. 1999). Rather than having a common origin, the life history patterns within a particular area appear to evolve independently as part of a necessary ecological succession to minimize competition for resources. Different life history components of a population may share certain habitats (e.g., the same overwintering or summer habitat) while exploiting different spawning habitat. The relative size differences between individuals with different life history strategies may provide some opportunity for spatial/ temporal isolation on spawning grounds: stream resident WCT seldom exceed 25 – 30 cm fork length, while fluvial and adfluvial fish can attain sizes of >30 cm FL and 0.9-1.4 kg in weight (Shepard *et al*. 1984; McIntyre and Rieiman 1995).

Reproduction

Cutthroat trout exhibit a mating system typical of other salmonids (reviewed by Fleming 1998). Spawners 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). Brown and Mackay (1995b) found fluvial WCT in the Ram River, Alberta to maintain territories of ~400 m in the natal creek. Within this area, females would dig several redds and males would attempt to mate with all females within its section. Sex ratios on the spawning grounds appear to vary considerably and may partly correspond with life history type. For example, Downs *et al*. (1997) found that the sex ratio favoured males in headwater resident populations (1.3:1). Published estimates for migratory populations reviewed by Downs *et al*. (1997) were generally lower, ranging between 0.2 and 0.9 males per female. The authors suggest that a proportion of males (which are likely more susceptible to angling due to their aggressive territorial behaviour) may be removed from larger systems prior to spawning. Headwater resident populations, which are generally less accessible, are less likely to receive the same type of angling pressure.

The age and size of individuals at sexual maturity similarly varies across populations and life history types. Downs *et al*. (1997) found that males in isolated headwater populations from Montana first reach maturity at age 2 and all were mature by 4 years of age. The youngest female found to be mature was 3 years old while most were mature by the age of 5 years. Length was found to be a better predictor of sexual maturity than age; males matured at 110-160 mm fork length (FL) and females at 150 – 180 mm FL. Mean fecundity (±SD) was 227 eggs (±41.1) for fish 150 – 174 mm, 346 (±85.6) for 175 – 199 mm fish, and 459 (±150.8) for fish 200 mm and longer. Migratory fish which generally mature at a larger size have correspondingly higher fecundities.

Large migratory females with a forklength of 350 mm may contain 1000-1500 eggs (Liknes and Graham 1988).

Spawning generally takes place between May and August in Canada (depending on location) and is likely stimulated by rising water temperatures (~ 5 – 6.5°C). Its timing often coincides with freshet conditions in many interior areas, making WCT prone to year-class failure where habitat degradation leads to increased levels of erosion and sedimentation near redds. Spawning may occur relatively quickly; while fluvial WCT in the Blackfoot River, Montana were found to occupy spawning tributaries from 4 to 63 days, they were found to spawn over a relatively short period (1-3 d) with spawners spending less time in smaller creeks (Downs *et al*. 1997). Eggs generally incubate in the spawning gravels for 6-7 weeks, depending on water temperature. Eggs in the Flathead River drainage (just south of the BC/ Montana border) required ~ 310 temperature units (degree days) for full development. Once hatched, alevins remained in the substrate until their yolk sac was absorbed (a further 100-150 temperature units; Shepard *et al*. 1984). Fry are ~ 20 mm when they emerge from the streambed in early July to late August and quickly migrate to low energy lateral habitats.

Cutthroat trout are iteroparous and some fish may reproduce every year or every alternate year but post-mating mortality may be high, especially for males. There appear to be very few repeat spawners (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, (Giger 1972; Downs *et al*. 1997), the importance of maintaining these repeat spawners is particularly relevant for small populations subject to habitat degradation. Not only do larger females produce more eggs, but the eggs are larger and produce larger alevins, increasing their chances for survival. Unfortunately, while size restrictions and other harvest regulations are often in place, large females are highly prized by sport fisherman and may be subject to high harvesting pressure or to by-catch in other fisheries.

Survival

Survival rates for cutthroat trout are extremely hard to determine as many factors affect species survival at different life history stages (e.g., Johnston and Mercer 1976). The time of greatest mortality likely occurs early in life; from the egg to juvenile stage. Eggs and newly hatched alevins 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*), brook trout, northern pikeminnow (*Ptychocheilus oregonensis*) and other salmonids). Adults are susceptible to a number of terrestrial 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).

Movements/dispersal

Cutthroat trout exhibit one of the broadest and most variable spectra of migratory behaviours of all the salmonids, owing perhaps to the diversity of life history types and habitats occupied by the species (Northcote 1997; Hilderbrand and Kershner 2000a). Cutthroat trout undergo a series of different types of movement during their lifetime: seasonal movements (feeding, overwintering), spawning runs, and those associated with life history regime shifts. Importantly, mixed migratory strategies for different life history types is likely an adaptation to buffer periodic environmental disturbances (e.g., Rieman and Clayton 1997).

During their first year of life, fry disperse from areas of high density to low density; generally into lateral habitats with sufficient cover. Juveniles reside in natal streams from 1 to 4 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 sub-adults 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*. 1998) while fluvial and adfluvial WCT may migrate over large distances (in excess of 100 km) to find suitable feeding grounds or overwintering habitat (Schmetterling 2001). Recent telemetric data from the lower Elk River in southeastern BC suggests that home ranges of WCT in that system average ~ 11 km. Home ranges in the upper river were nearly twice that (averaging ~ 23 km) and likely reflect a lack of suitable overwintering pool habitat in the upper river (Prince and Morris 2003). The age of outmigration for migratory forms typically appears to be 2-3 years of age (95-170 mm FL; McIntyre and Rieman 1995). Again, timing depends on local conditions, but peaks early to mid-summer with migrants leaving natal streams at night. Movement during the summer will often cease once suitable feeding habitat has been found.

In late summer and early fall, WCT begin to seek suitable overwintering sites in response to decreasing water temperatures and ice formation. Again, individuals may travel considerable distances to find suitable habitat but may remain sedentary through winter months in stream sections lacking anchor ice. In streams with dynamic ice conditions, movement can continue throughout the winter (Brown and Mackay 1995b; Schmetterling 2001, Prince and Morris 2002). In response to lengthening days and increasing water temperatures, WCT will often rapidly leave their overwintering habitat in late winter-early spring to return to small natal tributaries to spawn. This may occur between March and July, but most typically between May and June. Having arrived at the natal system, there are typically a large number of small movements within a small section of stream (i.e., within breeding territory). 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.

Nutrition and interspecific interactions

Cutthroat trout tend to be highly opportunistic in terms of their diet, often feeding voraciously on whatever prey item is seasonally abundant. Unlike the coastal variety, WCT are not highly piscivorous and tend rather to specialize as invertebrate feeders, even where forage fish are abundant (Shepard *et al*. 1984). This is likely a result of their sympatric evolution with two highly piscivorous species, the bull trout and the northern pikeminnow (Behnke 1992). For young-of-the-year fry, chironomid larvae in lateral habitats are an important food source. Older juveniles and adults feed both on terrestrial insects and planktivorous invertebrates; dipterans (true flies, other than chironomidae such as crane flies, fruit flies, etc.) and ephemeropterans (mayflies) are the most important dietary components. Trichopterans (caddisflies) are important for fish 110 mm long or longer (reviewed by Liknes and Graham 1988). Winged insects are not important in the diets of smaller fish, but the diversity of food items increases with increasing size. For adfluvial forms, zooplankton are an important food source, particularly during winter months (Shepard *et al*. 1984).

Cutthroat trout possess traits that appear to reduce their interspecific interactions with other salmonids. The small size of cutthroat trout at maturity allows them to utilize smaller streams than those typically inhabited by larger salmonids. Platts (1974) found that WCT densities peaked at a channel gradient of about 10%, which was higher than that for peak densities of bull trout, RBT or brook trout. These densities may reflect that such habitats are less optimal for other salmonids, not necessarily that they are preferred by WCT. Their preference for cooler water temperatures appears to make WCT a superior competitor at higher elevation stream reaches and supports the idea of a "temperature/elevation refugia" for WCT (Griffith 1988, Fausch 1989, Paul and Post 2001). It appears, however, that WCT 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 WCT (Varley and Gresswell 1988). Brook trout have a competitive advantage over WCT at warmer temperatures (De Staso and Rahel 1994) and mature earlier in life than WCT. It may be that WCT are marginalized by other mechanisms such as habitat degradation or overfishing, and are then replaced by brook trout. Once a WCT population is replaced by another salmonid species, however, it is unlikely that that space will ever be regained by WCT (e.g., Moyle and Vondracek 1985).

Finally, WCT are subject to introgressive hybridization when closely related species (i.e., RBT, other cutthroat subspecies) are introduced into their range. Several factors appear to contribute to the breakdown in species barriers. Firstly, RBT and the various interior subspecies of cutthroat trout appear to have evolved in relative isolation from one another (Behnke 2002). As such, only weak ethological isolating mechanisms have evolved to maintain separation between the different species. Secondly, the similarity in chromosome number between species can, in many cases, allow for fertile crosses between species (Thorgaard 1983; Allendorf and Leary 1988).

While the relative fitness of hybrids remains uncertain, the ongoing spread of introgression in the wild (e.g., Rubidge *et al*. 2001; Hitt *et al*. 2003) suggests that at least some hybrids do survive and are capable of successful reproduction. While some first-generation (F1) hybrids have been identified, most appear to be later generation hybrids and backcrossed individuals (Rubidge 2003, Hitt *et al*. 2003; Janowicz 2004). The majority of backcrossed hybrids appear to involve RBT males and WCT females although reciprocal crosses have been observed. The apparent absence of selection against hybrids suggests that introgressed genotypes can persist in wild populations, and have the potential to ultimately lead to the formation of hybrid swarms. 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 (Leary *et al*. 1995; Allendorf *et al*. 2003).

Behaviour/adaptability

All available information suggests that cutthroat trout are highly susceptible to habitat perturbation, particularly processes affecting water quality, temperature, or the amount of instream structure (Liknes and Graham 1988; Reeves *et al*. 1997; Porter *et al*. 2000). In several long-term studies, the loss of riparian buffer integrity generally leads to a dramatic decline in trout biomass, and populations remain suppressed for 5-20 years until the riparian zone regenerates (Hartman *et al*. 1996; Reeves *et al*. 1997). Such habitat perturbations involve a complex series of changes that disrupt natural growth processes within populations and cause increased mortality at certain age classes (Hartman *et al*. 1996). It further disrupts normal habitat partitioning and leads to increased competition for resources. Westslope cutthroat trout may be particularly sensitive to changes in natural flow regimes (Brown and MacKay 1995a; Downs *et al*. 1997). In agricultural or urbanized areas where water has been appropriated for irrigation or domestic use, WCT populations suffer dramatic declines as the loss of water affects all life history stages (e.g., Joseph Creek example, HABITAT TRENDS).

A popular sport fish in western Canada, cutthroat trout are perhaps second only to RBT in terms of angler interest throughout their range. This may be, in part, because they are more easily caught than other species (MacPhee 1966, Paul and Post 2001; Paul 2003). Their sometimes voracious feeding habits and accessibility in small streams make cutthroat trout subject to overharvesting (Giger 1972; Varley and Gresswell 1988). In a recent creel survey in the Elk River, WCT made up 94.5% of the total catch of 98,031 fish (Heidt 2002). While 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 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).

POPULATION SIZES AND TRENDS

Few quantitative estimates of population size exist for WCT in Canada, especially for British Columbia. Because they tend to occupy colder, less productive habitats, population sizes for WCT are expected to be smaller than for other sympatric 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). Age structure may be highly variable as juveniles may reside in natal streams for up to five years before becoming sexually mature (Behnke 1992). Westslope cutthroat trout are iteroparous (repeat spawning) so that several age classes may contribute to annual spawning efforts. The actual number of spawners appears to vary from year to year, but effective population sizes (the percentage actually contributing to reproduction) may be on the order of only 8 - 10% of the total census population so that the number of adult spawners supporting population growth may be quite small (Frankham 1996; Brown and MacKay 1995b; A. Costello unpublished data).

British Columbia population

We suggest a probable range of values of between 30 and 100 mature individuals per population (these values will be used to give rough estimates of total population size in the Technical Review section). These values are in keeping with what is known about cutthroat trout biology and the nature of the smaller, less productive streams they inhabit. “Best guess” population estimates for coastal cutthroat trout streams on the east coast of Vancouver Island, for example, average between 30 and 50 adults (Scholten 1997) and in the absence of better data for inland populations, we will assume similar values for WCT. We will further assume that there is a minimum of one “population” per stream or lake. For small systems (i.e., first to third order streams), this assumption can be supported by genetic data which suggests that the majority of WCT populations are structured over small geographic distances (e.g., Taylor *et al*. 2003) as all life history forms of WCT return to small tributary streams to spawn (see Carl and Stelfox (1989) for a rare exception). For larger river systems, it is likely that this assumption will be violated and that several independent component stocks (from isolated stream reaches or tributary streams) will be unaccounted for. As noted earlier, Brown and Mackay (1995b) found that fluvial WCT in the Ram River, Alberta maintained breeding territories of ~ 400 m in their natal creeks. For this reason, we extend the upper limit of probable population size to 100 to allow for any missed population subdivision in larger systems. GIS-based analysis of the number and size of the individual systems inhabited by WCT, and the informed, “best-guess” approach of regional fisheries biologists, could be used in future to generate more accurate estimates.

Within the native range of WCT in BC, WCT have been reported in 928 water bodies (including creeks, rivers and lakes) where no record of WCT hatchery releases exists, based on survey data. The majority of these streams are in the Kootenay River and Flathead watersheds but a number of disjunct systems containing WCT also occur in the Upper Columbia and South Thompson watersheds. Of these 928 waterbodies, 38 have received hatchery rainbow trout at least once, and 31 have received hatchery coastal cutthroat trout at least once. Another 301 waterbodies within the native range of WCT have been stocked with WCT at least once since 1923, but many of these may have originally contained native WCT populations as well (S. Pollard, BC Ministry of Water, Land and Air Protection, Victoria, BC, personal communication 2006; Table 2).

Fluvial populations in large rivers appear to be stable, based on creel surveys (J. Baxter, Fisheries Biologist, BC Hydro, Castlegar, BC, personal communication, 2004) but are clearly subject to increasing fishing pressure and hybridization (Rubidge *et al*. 2001; Bill Westover, BC Ministry of Water, Land and Air Protection, Cranbrook, BC, personal communication, 2003). Many WCT populations were overexploited in BC from the 1960s to the 1980s leading to dramatic declines (Heidt 2002). River closures and restrictive sport fishing regulations were implemented in the 1980s and 1990s and have been somewhat effective in stabilizing or restoring WCT populations in large rivers such as the Elk, Skookumchuck, and St. Mary's rivers. However, fishing pressure in the East Kootenay region continues to increase annually. During 1991, for example, just 81-guided days were recorded on the Elk River. By 2000, that number had jumped to 1458 (Westover, pers.comm. 2003). In a recent creel survey in the Elk River, WCT made up 94.5% of a total catch estimate of 98,031 fish (~ 1.48 fish/rod hour; Heidt 2002). Similar increases have occurred in other major WCT fishing rivers. As noted, this could simply reflect their greater relative abundance. However, it is likely that fish are caught numerous times during a season, which would lead to creel survey estimates that are biased upwards. Furthermore, creel surveys do not account for a typical salmonid hooking mortality of 3-5% (Marnell and Hunsaker 1970), which suggests approximately 3000-5000 cutthroat caught in the Elk River may have died after being released.

In the upper Kootenay River watershed, it is evident that many populations have become adversely impacted by hybridization with non-native rainbow trout introduced to supply sport-fishing demand (Figure 8). Evidence of hybridization with introduced rainbow trout has been reported in 78% of the streams genetically tested in the area (ntotal=23; Rubidge 2003). The Lodgepole Creek population in particular (tributary of the Wigwam River in the Elk River drainage) has experienced advanced hybridization (37.5% heterospecific alleles) and appears to be forming a hybrid swarm. Hybrid swarms have been shown to form between cutthroat and rainbow trout in as little as five generations (Hitt 2002) and pose a critical risk to the remaining WCT populations throughout their range (see LIMITING FACTORS). Increasingly, the 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 (Rubidge *et al*. 2001; Westover, pers. comm. 2003). In fact, recent survey work in the upper Kootenay watershed suggests that any lower tributary reaches accessible from the Kookanusa Reservoir are likely to contain some level of hybridization (S. Bennett, Aquatic, Watershed, and Earth Sciences, Utah State University, Logan, Utah; personal communication 2006), Rubidge and Taylor 2004, Fig. 8). To date, no systematic surveys of BC waters have been conducted that would permit a description of the amount of introgression existing throughout the B.C. range (Pollard, pers. comm. 2006). Thus, the existing hybrid data can only be used to assess threats to populations, not the number of WCT populations remaining. It is critical that systematic survey work be completed to establish the extent of introgression in BC to better quantify this threat

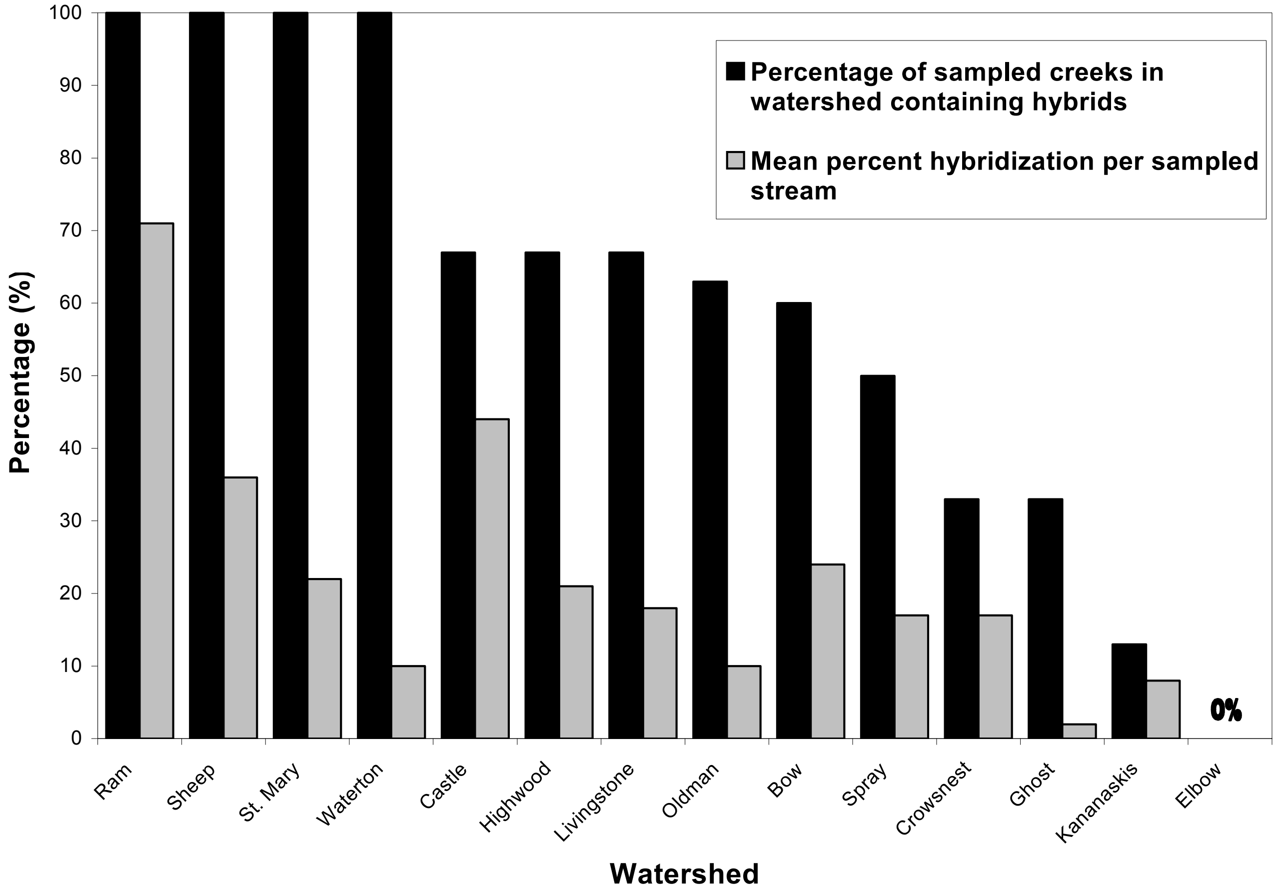

Figure 8. Summary of levels of hybridization in selected Alberta drainages (modified from Janowicz 2004).

and level of impact this DU has already experienced. Regardless, existing data suggests that these populations may become increasingly restricted to isolated headwater streams where they are subject to stochastic extinction events such as rockslides or drought.

Currently, an estimated 928 to 1229 (if we include stocked systems) streams and lakes in the native range may contain WCT populations (Pollard, pers. comm. 2006). Applying an average of between 30 – 100 individuals per stream/lake, we get an estimate for the total British Columbia population ranging from 29,400 to 122,900 mature individuals. The situation may be considerably worse depending on level of introgression; a significant portion of these estimates could be introgressed individuals depending on the spread of rainbow trout genes from the original site of introduction.

Alberta population

A total of 274 streams in Alberta are believed to have contained native populations of cutthroat trout; of these only 61 (22%) are now known or suspected to still have pure strains of westslope cutthroat trout (Alberta Fisheries Management Information System

2004; Stelfox pers. comm. 2006). Stream census data (Stelfox, unpubl. data) indicates that the majority of these streams average about 8 km in length and contain from 30 to 200 (mean = 100) adults. Stelfox (pers. comm. 2006) suggests that the population size for most streams is probably closer to 30 than to 100, but a few larger steams result in the higher mean. Applying the average number of individuals per stream (n=100) from Table 3, the native Alberta population is probably less than 6100 mature individuals. Of these, 29 (48%) are deemed to be at risk of extirpation, primarily due to hybridization and/or competition with exotic salmonids. Wherever cutthroat trout and rainbow trout co-exist it is only a matter of time before pure cutthroat trout are extirpated (Stelfox, pers. comm. 2006). Recent rates of decline (since the 1990s, i.e., within the last three generations) 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.

Habitat degradation and the stocking of non-native species in Alberta have led to the displacement/replacement of WCT from many areas and the hybridization of several of the remaining native populations (Carl and Stelfox 1989; Strobeck 1994). Westslope cutthroat trout are known to have disappeared from an estimated 30% of their historic range in Banff National Park (Schindler and Pacas 1996) and now occupy less than 5% of the native range in the Bow River drainage. Several WCT populations are considered to be severely depressed or extirpated [e.g., Quirk, Bragg, Lesueur, Meadow, Sullivan, Loomis, Flat, Odlum, McPhail, Carnarvon, Pekisko, Ware, Threepoint, Fisher, Fish, and Jumpingpound creeks; (Stelfox, pers. comm. 2003)].

Quirk Creek provides one example of these trends. Quirk Creek is a small creek in the Elbow River drainage (Bow River drainage) in southwestern Alberta that was the subject of a WCT population study between 1995 and 2002. This creek supported only native bull trout and WCT prior to the introduction of brook trout to the Elbow River watershed in 1940 (Stelfox *et al*. 2001). 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 comprised 35% of the fish population (Tripp *et al*. 1979). Electrofishing surveys in 1987 showed catches were still dominated by native WCT and bull trout, but by 1995, brook trout had spread throughout the entire creek and comprised ~ 92% of the fish population. Despite the selective harvest of brook trout since 1998 (Stelfox *et al*. 2001) the relative composition of fishes in Quirk Creek remained fairly stable from 1995 - 2002 with an average relative composition of 83% brook trout, 15% westslope cutthroat trout and 2% bull trout (Paul 2003). A similar trend is evident in Fish Creek (also in the Bow River drainage). Historically, Fish Creek supported a significant WCT 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 (reported in Baayens and Brewin 1999). More recent surveys reveal that the WCT 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 RBT at 59 fish/km and native WCT at only 4 fish/km in the spring of 1993. It is a pattern common throughout the region.

In areas stocked with RBT, WCT are more subject to hybridization than to displacement. For example, population estimates of the Gorge Creek WCT population (Sheep River drainage) were approximately 800 fish/mile in 1949 (Andrekson 1949). Rainbow trout were introduced into Gorge Creek in 1941 and hybrids are now present in that population (Janowicz 2004). Hybridization between RBT and cutthroat subspecies is widespread throughout Alberta (Mayhood 2000; Potvin *et al*. 2003; Janowicz 2004). Again, introduced brook trout and RBT appear to prefer lower elevation mainstem stream reaches (Paul and Post 2001). For this reason, many remaining genetically pure WCT populations are present in small, isolated headwater populations (Donald 1987; Hilderbrand and Kershner 2000b).

The current status of many populations in Banff National Park is unresolved. Early in the last century, WCT were noted to be plentiful in the area of Banff National Park and were recorded in a number of systems in that area. Surveys of the Bow River mainstem through Banff National Park performed during the 1990s, however, found very few WCT between Redearth Creek and Forty Mile Creek; brook trout are now common in the area and the few WCT that were seen appeared to be WCT x RBT hybrids (C. Pacas, Aquatic Ecosystems Specialist, Banff, AB, Parks Canada, personal communication, 2003). There is also evidence of WCT x RBT hybridization in several lakes (Landry *et al*. 2000; Potvin *et al*. 2003; see Table 3). It has been suggested that fluvial populations no longer exist in Banff National Park, although at least a small portion of lacustrine populations (WCT were stocked into 64 lakes in the park) appear to be stable. At least one lake (Baker Lake) currently only supports brook trout, and it is believed that the WCT may have been fished out (Pacas, pers. comm. 2003).

LIMITING FACTORS AND THREATS

A number of factors appear to be limiting the abundance of WCT in Canada. While some of these occur naturally, it is clear that the most imminent and serious threats to cutthroat are of anthropogenic origin; primarily habitat loss, overharvesting, and the introduction of non-native species and/or genotypes through inappropriate stocking practices.

Naturally occurring factors

<u>Cutthroat trout biology</u>

Westslope cutthroat trout possess biological characteristics that make them naturally susceptible to a host of limiting factors. First, the habitat requirements of the subspecies are such that populations typically inhabit coldwater habitat with limited productivity, making them historically subject to thermal and physical isolation (Behnke 2002). Populations appear small and supported by variable numbers of spawners, and so may be subject to stochastic events such as epizootics or catastrophic environmental change (e.g., drought, earthquakes, landslides). The small effective population sizes typical of the species may further predispose them to inbreeding and increased losses of genetic diversity (Amos and Harwood 1998; Vucetich and Waite 2001). Cutthroat trout are subject to significant predation mortality and negative interactions with other salmonids. As well, their well-developed natal philopatry suggests high levels of demographic independence among adjacent populations so that declining populations and extirpated areas are not likely to be recolonized over the short term (see BIOLOGY). The lack of more robust population-specific information has likely contributed to localized declines. Little biological information has been collected for WCT in a consistent and standardized manner over long time periods and no rigorous system is in place to monitor catch/creel results throughout much of the range. Relationships between life history types and their particular habitat requirements are understudied, as is the scope and variation typical of WCT movements, the range and extent of distinct breeding units, or the determinants of substantial population structure in the wild.

Anthropogenic factors

The dramatic declines in WCT populations over the last century clearly indicate that the greatest threats to cutthroat trout are the anthropogenic manipulation and degradation of the environment in which it lives (Allendorf and Leary 1988; Liknes and Graham 1988; Nehlsen *et al*. 1991; Slaney *et al*. 1996; Johnson *et al*. 1999; Shepard *et al*. 2003). Throughout its 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).

Climate change

It is likely that climate change brought on by global warming may play an important role in further limiting the distribution of WCT in the future. The Canadian climate in 1998 was the warmest on record, in one of the warmest decades on record. This may pose a problem for cutthroat trout, which are a coldwater-adapted species. 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 WCT 27°C has been reported to be lower than those estimated for brook trout and rainbow trout: 29.8°C and 31.6° C, respectively (Feldmuth and Eriksen 1978 cited in McIntyre and Rieman 1995). Increasing water temperatures resulting from global warming may, therefore, give non-native fish a competitive advantage over WCT in marginal habitats. A summary of available climate change models suggests that mean air temperatures in the Pacific Northwest could increase by 2 - 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). In particular, a recent trend analysis of daily average temperatures found that from 1895 to 1995, the Southern Interior Mountain region (which contains the core of WCT in BC) has increased in average summer temperatures by 1.2°C (BC Ministry of Environment 2006). Increasing temperatures are thought to be at least in part responsible for the massive infestations of mountain pine beetle (*Dendroctonus ponderosae*) much of BC is currently experiencing. These infestations are expected to affect stream bed substrate composition (including sedimentation), channel morphology, large woody debris presence and water temperatures over time — all key features affecting WCT habitat suitability.

The potential impacts of climate change are not trivial as they will affect the related aspects of precipitation pattern changes, hydrologic changes, stream morphology changes and loss of glaciers which provide summer flows in many important WCT streams such as the Bull, White and Upper Kootenay Rivers.

Habitat loss

As noted above (Habitat trends), timber extraction, mining, and hydro-electrical developments have been responsible for loss and degradation of WCT habitat and decline of several populations (e.g., Joseph Creek, Spray and Kananaskis rivers). The road networks associated with primary resource extraction have encroached upon untold numbers of streams, causing many to be culverted or otherwise altered. As well, it has led to an explosion of access points for angling and recreational activities (off-roading, ATV use) which further serve to degrade sensitive habitats. Protected areas exist within the range of WCT in Canada, but they are often small and do not necessarily encompass all the habitats required by the various life history forms within an area (particularly migratory forms). It is apparent that in the absence of more rigorous protection, required habitat will continue to be degraded and populations increasingly fragmented.

While the exact nature of their movements is relatively unknown for many populations in Canada, it seems likely that WCT are adapted to move during moderate to high flow events. Their movements often coincide with the rising limb and peak of the hydrograph, allowing them to negotiate seasonal barriers within streams where increased flows may be necessary to gain access (Brown and MacKay 1995a; Schmetterling 2001). This, of course, has obvious implications for landscape planning, road building, and long-term population viability (Hilderbrand and Kershner 2000b). While it is apparent that WCT can and do move significant distances to find required habitat, migration of this type is dependent on the preservation of suitable migration corridors between habitat types. Unfortunately, many culverts may not be designed to accommodate fish passage at high flows. Culverted crossings of spawning tributaries must allow for fish passage under a range of different flow conditions. The dramatic decline of anadromous and fluvial populations throughout the lower Columbia River and parts of Alberta attests to the profound influence of migration barriers on those systems (e.g., Nehlsen *et al*. 1991). The loss of these migratory forms may be particularly egregious, as it tends to limit the recolonization potential of areas with locally extirpated resident populations. Because many such populations appear to be demographically independent, local declines or extirpations are not likely to be reversed by immigration from even nearby populations.

The main causes of habitat degradation cited above are forest harvesting, mining and urbanization. While it is true that forest harvesting, urbanization and mining cause major impact, the current pressure from development of rural lands and foreshore areas (lakes and rivers) by the recreation industry – golf courses, ski hills, resort and summer home development, marinas, docks, retaining walls, beach development and other foreshore development and increasing boat use must not be overlooked. This industry extracts significant volumes of surface water, hardens shorelines, removes riparian vegetation and degrades water quality. It should be noted that there is no end in sight to this development pressure and the impacts are expanding from site-specific to watershed level (Bruce Macdonald, Habitat and Enforcement Branch, Department of Fisheries and Oceans, Nelson, BC, personal communication 2006).

In addition there is increasing and extensive mining exploration and the development of new mines particularly coal mines. The impacts of coal mines were reported above (see Habitat trends), but the scale of the present and future impacts of mining development in the upper Elk River was not fully discussed. In some tributaries of the Elk River entire headwater reaches have been annihilated and the populations fragmented by rock drains. It is probable that these headwater reaches contain valuable genetically pure populations. Large areas of the Flathead River and Elk River basins, two of the main WCT river systems in BC, are now being considered for coal bed methane development (Macdonald, pers. comm. 2006).

Transportation infrastructure, roads and railways, is expanding and in many cases parallels WCT streams resulting in hardening of the stream banks to protect the infrastructure. One example of this increasing development is that there have been several derailments of coal trains in the last year all causing some impact to streams and fish habitat (Macdonald, pers. comm. 2006).

Agriculture development is one of the most significant users of surface water in the WCT range. Agriculture has also been responsible for extensive removal of riparian habitat along WCT streams. Also, the possible effects of an expanding independent power production industry should not be overlooked. Many of these proposals are for headwater systems, which may appear to be removed from main fish streams but in fact propose to dewater higher elevation and headwater stream reaches (Macdonald, pers. comm. 2006).

Overharvesting

Cutthroat trout are a popular sport fish in western Canada, perhaps second only to rainbow trout in terms of angler interest. Like many other sport fish in Canada, angling pressure is likely a significant factor limiting natural production (reviewed by Post *et al*. 2002). The overfishing of native fish stocks began with European settlement of western Canada in the 1880s and many CT populations declined during a hundred-year period of liberal fishing regulations in the region (Mayhood 2000). The sometimes voracious feeding habits of cutthroat trout and their accessibility in smaller systems make them particularly susceptible to over harvesting. As early as the 1950s, significant declines were noted in Canadian populations and were most pronounced near urban areas where human population densities are greatest. Harvest rates in Alberta during the 1980s averaged ~11 million fish per year (some 7 million kg) with a large proportion of that being trout (Nelson and Paetz 1992). Since that time, more restrictive catch regulations have been implemented in Alberta (as they have in BC); however, this may be an indication of the kind of pressures faced by native fish populations throughout western Canada as human populations continue to grow and harvest pressures increase. While catch-and-release fisheries have been implemented in particularly sensitive areas and have stemmed declines in some cases (Baxter, pers. comm. 2004), hooking mortality following release may have a significant impact on populations which have already been marginalized by habitat loss or the introduction of non-native fishes (Marnell and Hunsaker 1970; Nehlsen *et al*. 1991; Slaney *et al*. 1996). Even when not directly targeted by fishing efforts, WCT may often be subject to significant bycatch mortality in other fisheries.

Introductions

One of the greatest threats facing native populations of WCT in Canada is the harmful effect of introductions, especially of hatchery-origin salmonids. 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 and the desire to provide fishing opportunities. However, it is becoming apparent that hatchery fish have been routinely stocked without an understanding of the effectiveness of the transfer, the fate of the released fish, or the impacts on wild populations. In the United States, the introduction of non-native species is believed to be the primary cause for the declines of several inland species of cutthroat trout. The introduction of hatchery-origin salmonids can result in both genetic (e.g., hybridization, outbreeding depression), and ecological impacts (e.g., displacement, competition, disease) on native cutthroat trout populations, depending on the species introduced.

Hybridization and Introgression

Rainbow trout and Yellowstone cutthroat trout introductions have resulted in significant levels of introgressive hybridization throughout the historic range of WCT (Leary *et al*. 1984; Leary *et al*. 1987; Allendorf and Leary 1988, Hitt *et al*. 2003). Less than 29% of occupied habitats in the United States are believed to support populations at or near the habitat's potential capacity. Genetic testing suggests that WCT populations may be genetically unaltered in less than 8% of its historical range in the US (Shepard *et al*. 2003). Hybrid swarms between RBT and WCT have now been documented in both Alberta and British Columbia (Rubidge 2003; Janowicz 2004) and levels of introgression appear to be spreading rapidly among streams and upstream from mainstem rivers (Hitt *et al*. 2003; Rubidge 2003; Weigel *et al*. 2002; Janowicz 2004) [see also POPULATION SIZES AND TRENDS section]. The factors influencing the spread of this introgressive hybridization are poorly understood at this time. It has been suggested that since RBT are unlikely to successfully colonize and exploit colder, high elevation habitats (e.g., Paul and Post 2001), the spread of hybridization into high elevation sites may be impeded by natural physical or ecological barriers (Weigel *et al*.

2002). Considering the widespread history of stocking in Canada and the fact that RBT and non-native salmonids continue to be introduced throughout the native range of WCT in Canada, it is likely that many genetically pure WCT populations are at risk and will increasingly be restricted to isolated headwater streams.

(1) British Columbia: In the upper Kootenay River drainage, it is apparent that introgressive hybridization between introduced RBT and native WCT has increased in the last 15 years. Leary *et al*. (1987) detected approximately 5% hybridization between WCT and RBT within the White River watershed (a large tributary of the upper Kootenay River). More recent surveys indicated that hybridization has increased since 1986 and has spread to the lower reaches of seven other tributaries including Wild Horse, Mather, Skookumchuk, and Gold creeks, as well as the Elk, St. Mary and Lussier rivers (Rubidge 2003). In the US, Hitt *et al*. (2003) reported a similar increase in the number of introgressed populations in the upper Flathead drainage (24 of 42 sites (57%); seven more than a previous study in 1984). In both cases, the spread of hybridization appears to be spreading in an upstream direction from the site of most RBT introductions: Lake Koocanusa and Flathead Lake, respectively. Evidence from these areas suggests that the spread of hybridization may not be prevented by the ecological gradients (other than, perhaps, impassible upstream barriers) but is instead related to the distance from the nearest site of stocking. Table 2 summarizes the numbers of systems reported to contain WCT that have been stocked at least once with either rainbow trout or coastal cutthroat trout in BC. However, spread to non-stocked systems has undoubtedly occurred where stocking occurs in 'open' systems.

(2) Alberta: An early study of hybridization in Alberta found limited evidence for hybridization between native WCT and introduced species. McAllister *et al*. (1981), examined morphological and biochemical variation in WCT from Banff National Park (10 lakes), Kootenay National Park (Floe Lake), Waterton Lakes National Park (Sofa Creek), as well as a sample from the Connor Lakes in British Columbia. The authors found that 10 of the 13 sites contained pure WCT; two sites were found to contain WCT x Yellowstone CT hybrids (Baker Lake (BNP) and Sofa Lake (WLNP)) and a third, Taylor Lake (BNP), was found to contain a pure introduced population of Yellowstone cutthroat trout. No hybridization with RBT was indicated. However, the morphological comparisons and allozyme markers used in the study appear to have had limited resolution to detect RBT introgression. For example, half of the populations showed no genetic variability at the 10 allozyme loci used and 4 of the 10 loci showed no species-specific diagnostic bands and were unable to distinguish between WCT and RBT. Furthermore, all samples were collected from alpine systems (elevation > 2000m) and were chosen with the expectation that they would contain pure WCT populations. The stocking of non-native species in the sampled populations was believed to be minimal or non-existent.

Recent genetic testing in Alberta suggested that hybridization is widespread in the eastern slopes of the Rocky Mountains. Janowicz (2004) detected hybridized populations in 13/14 watersheds sampled (see Figure 8). Degrees of hybridization within watersheds ranged from 100% of sampled creeks in Ram River (North Saskatchewan drainage) and Sheep River (South Saskatchewan drainage) to 22% in the Kananaskis River. The Elbow River watershed was the only system in which hybridization was not detected. 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 appear to be of hybrid origin. Many populations, in fact, exhibited highly mixed genotypes (more than 50% with heterospecific alleles) indicating that hybridization was advanced and progressing towards hybrid swarms in these creeks. Hybrid swarms present a great danger to the persistence of native species as the unique genotypes typical of pure parental populations are lost once randomly mating hybrid swarms are formed (Leary *et al*. 1995).

It should be noted that the low number of reference WCT populations in the study might lead to overestimation of the number of hybrids observed in the sample. Only three reference WCT populations were included so that the number of diagnostic WCT alleles was low (averaging ~ 3.3 per microsatellite locus). As noted earlier, WCT populations are often characterized by unique alleles or those that, while locally abundant, are uncommon over a larger geographic area. For example, Taylor *et al*. (2003) found the total number of alleles across 29 WCT populations in British Columbia averaged ~ 13 per locus while the average in any one population was less than ~ 4. It may be that WCT alleles present in non-reference populations have been misidentified as RBT alleles when in fact they were not. Countering this potential upwards bias, however, is the fact that many of the sampled streams were not chosen randomly, but with the belief that they contained pure WCT populations. While hybridized populations may be of some importance in terms of fisheries opportunities, their ecological and taxonomic status remains largely unresolved (e.g., US Federal Register 1996; Allendorf *et al*. 2003). It is clear, however, that extensively hybridized populations are of little conservation value for efforts to preserve pure WCT. As such, every effort should be made to identify and determine the conservation status of the remaining pure unstocked populations in Alberta and to halt any further spread of hybridization.

Outbreeding

Hatchery WCT have been stocked within the native range of WCT in both British Columbia and Alberta to ‘supplement’ native production usually for angling purposes (see Table 2 for numbers of systems stocked with WCT in BC). However, locally adapted biodiversity has not been considered, and no effort to use local stocks has been made as is evident by the very limited source populations used in hatchery production. For example, British Columbia has relied on a single source (Connor Lake) of WCT for all stockings in the past three decades. In other western salmonid species, such programs have resulted in increased straying and homogenization of genetic population structure, as well as genetic swamping and outbreeding depression (reviewed by Rhymer and Simberloff 1996, Allendorf *et al*. 2001). Since significant genetic substructuring exists for this species, even greater impacts in terms of homogenization and outbreeding depression might be expected. However, no such evaluations have been done for WCT, and there is very little information available to determine how many native populations have been supplemented with hatchery WCT. Thus the degree to which this impact might affect WCT populations in Canada is unknown.

Ecological impacts

While it is unclear whether other species of introduced salmonids actively displace native cutthroat or simply replace WCT populations depressed by other factors, it is clear that introductions of non-native brook trout have typically resulted in range constriction or elimination of cutthroat trout from large portions of their native habitat (Donald 1987; Fausch 1989; Griffith 1988). Non-native brook trout have been stocked throughout much of the WCT native range in British Columbia and Alberta. Brook trout appear to effectively displace or replace WCT, particularly at low elevation locations in Alberta (Paul and Post 2001, see examples under POPULATION SIZES AND TRENDS), contributing to the present restriction of WCT to mainly isolated higher elevation headwaters here. Similar patterns have not been recorded in British Columbia but may be present in some systems.

Finally, a number of other non-salmonid species have been introduced via authorized and unauthorized means in both provinces. In particular, walleye (*Stizostedion vitreum*), smallmouth (*Micropterus dolomieui*) and largemouth bass (*M. salmoides*), yellow perch (*Perca flavens*), and northern pike (*Esox lucius*) have been documented in a number of systems within the native WCT range (Pollard, pers. comm.). These species are all predatory and most have been implicated in salmonid declines in inland waters of the US (Fuller *et al*. 1999).

SPECIAL SIGNIFICANCE OF THE SPECIES

Cutthroat trout are a unique and important component of Canada's freshwater fish fauna. As one of the first salmonids to recolonize western Canada in the wake of retreating glaciers, they are often the only native trout throughout much of their Canadian range. As such, they likely play an important role in structuring many north temperate aquatic ecosystems (McPhail and Carveth 1992). Their small size at maturity allows them to penetrate smaller streams than most other salmonids, where they may make significant contributions to the growth of riparian vegetation and forests in terms of nutrient recovery (*sensu* Willson and Halupka 1995). Furthermore, their strict habitat requirements make cutthroat trout an indicator species for the general health of many ecosystems; they have often been referred to as "the canary in a coal mine". Canadian populations inhabit a variety of extreme habitats (in terms of elevation, temperature, and other physiogeographic factors). Populations of WCT in British Columbia and Alberta, for example, exist on the northern periphery of the subspecies' original range and likely contain a number of unique specializations for colder, less productive ecosystems typical of the area. Adaptations to marginal habitat might be necessary for reintroduction to extirpated areas and, as such, constitute an important component of species biodiversity. Westslope cutthroat trout are of traditional importance to several First Nations groups and are a popular sport fish in western Canada (second perhaps only to rainbow trout/steelhead in terms of angler interest). Sportfishing revenues from recreational fisheries provide a substantial contribution to many local economies. While historically a widespread species, WCT have shown dramatic global declines in the number and distribution of populations so that the core distribution of both populations now occurs in Canada. The maintenance of quality populations here in Canada may be required for attempts to re-establish populations that have been extirpated, and the future preservation of the species as a whole.

EXISTING PROTECTION OR OTHER STATUS

In Canada, the responsibility for the conservation and protection of all fishes lies with the Department of Fisheries and Oceans under the federal *Fisheries Act* (http://laws.justice.gc.ca/en/F-14/).

The federal government has delegated to the provinces (BC and Alberta) the authority to promulgate provincial regulations for the day-to-day management of the resource A key component of this responsibility is the protection of fish and fish habitat. As an important sport fish, the harvesting of WCT are subject to fishing restrictions in BC (http://wlapwww.gov.bc.ca/fw/fish/regulations/intro.html) and Alberta (http://www.albertaoutdoorsmen.ca/fishingregs/index.html). Additionally, WCT within National Parks receive protection under the *National Parks Act*, and measures such as a zero-possession limit in Banff and Kootenay National Parks, and the complete fishing closure of Dungarvan and Sofa creeks in Waterton Lakes National Park have been put in place for the conservation of the species (Peter Achuff, Parks Canada, Waterton Park, Alberta, personal communication 2006).

To enhance the level of protection and management of fisheries, several provincial acts have been developed in British Columbia and Alberta (http://www.canadianenvironmental.com/legislation/). In British Columbia (similar acts apply in Alberta), much of the legislation controlling the use of water is embodied in the *British Columbia Water Act* (http://www.qp.gov.bc - ca/statreg/stat/W/96483_01.htm). Unfortunately, the act has never been able to provide for the adequate habitat requirements of fish in terms of ensuring adequate stream flows. Often, the issuance and control of water withdrawal licences has been conducted without proper hydrological budgeting or a scientific basis (Rosenau and Angelo 2003). Changes to the act and the introduction of the *British Columbia Fish Protection Act* in 1997 (http://www.qp.gov.bc.ca/statreg/stat - /F/97021_01.htm) are expected to provide government agencies the means to more adequately protect critical streamflows for fish populations.

Neither of the acts has been fully implemented and the regulation of water licensing on small, ‘general’ streams is still lacking, especially in streams flowing through privately owned lands (Rosenau and Angelo 2003; Ron Ptolemy, BC Ministry of Water, Land and Air Protection, Victoria, BC, personal communication, 2004). Better identification and protection of WCT habitat is essential in all areas of the range. Such problems need to be addressed as the scope and nature of WCT habitat requirements and seasonal movements have obvious implications for long-term population viability (Hilderbrand and Kershner 2000). While the amount of habitat currently available to

WCT in these areas appears to be adequate, its current level of protection may not (see, for example, Harper and Quigley 2000; G3 Consulting Ltd. 2000), and increased levels of compliance-monitoring are required to reach better performance with respect to No-Net-Loss policies in western Canada.

Currently, no populations are specifically protected in Canada although both subspecies of cutthroat trout in British Columbia are blue-listed as “vulnerable” (BC Conservation Data Centre 2003). In Alberta, the species, cutthroat trout (*Oncorhynchus clarkii*), was assessed as “Secure” in 2000, and subsequently reassessed as “Undetermined” in 2003 (AB Ministry of Sustainable Resource Development, 2000; see also http://www.wildspecies.ca/). To date, the status of WCT (as a subspecies) has not yet been assessed in Alberta. Nationally in the United States, WCT are listed as imperiled in Idaho (S2), vulnerable in Montana (S3), vulnerable in Oregon (S3), critically imperiled in Wyoming (S1), and given an inexact numeric rank in Washington (S?). Globally, WCT are ranked by the Nature Conservancy as G4T3. The G4 ranking is defined as ‘apparently secure, uncommon but not rare’. The T-ranking refers to a taxonomic subunit (in this case, subspecies). WCT are ranked ‘vulnerable to extirpation or extinction’ (T3).

Westslope cutthroat trout were petitioned for protection under the US *Endangered Species Act* in 1997. In 2000, that listing was deemed unwarranted by the US Fish and Wildlife Service (USFWS) but the ruling was appealed by conservation groups on the basis that the threat of hybridization to this subspecies had not been sufficiently determined. Upon subsequent re-examination of the available genetic data (e.g., Allendorf *et al*. 2001, 2004, 2005; Shepard *et al*. 2003; Campton and Kaeing 2005), the USFWS decided in July 2003, not to list westslope cutthroat as “endangered” under the act at this time because of the uncertainties regarding the entity to be listed.

TECHNICAL SUMMARY
British Columbia Population

Oncorhynchus clarkii lewisi
Common name: westslope cutthroat trout Common name (French): truite fardée
Range of Occurrence in Canada: British Columbia

Extent and Area information	
• *extent of occurrence (EO)* [from text and Figure 5]	~ 150,000 km²
• *specify trend (decline, stable, increasing, unknown)*	Generally stable
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	Unlikely
• *area of occupancy (AO)* [Populations are structured over small distances (1-2 km) coinciding with small watershed groups and different stream sections in larger systems]	<30,000 km²
• *specify trend (decline, stable, increasing, unknown)*	Generally stable
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	Unknown
• *number of extant locations (includes lakes and streams, 301 of which have been stocked with WCT)*	~ 928 (1229 including stocked waterbodies)
• *specify trend in # locations (decline, stable, increasing, unknown)*	Decline
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	Unlikely
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Decline
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	3-5 years
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)* (based on 30-100 adults/population and whether or not stocked systems are included)	29,400 – 122,900
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals* [No province-wide surveys have been conducted to accurately determine the number of pure populations remaining]	Hybrid data suggests total number of pure individuals declining
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Unknown
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Likely
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	Unknown, suspected that many isolated in headwater streams, or geographically isolated by falls and rapids from hybrid populations
• *list each population and the number of mature individuals in each*	As many as 928 -1229 populations each containing 30-100 mature individuals
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Number of pure populations declining due to introgression; headwater populations of unknown status

• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	Unlikely
Threats (actual or imminent threats to populations or habitats)	
- Hybridization with introduced rainbow trout, other CT subspp. - Competition with introduced salmonids (rainbow trout, brook trout), and non-salmonids (e.g., yellow perch, bass species, walleye) - Habitat loss/dewatering (damming, urbanization, irrigation withdrawals) - Habitat degradation (road construction, agriculture, mining) - Over-harvesting - Climate change	
Rescue Effect (immigration from an outside source)	Low
• *does species exist elsewhere (in Canada or outside)?*	Yes
• *status of the outside population(s)?*	Pure populations severely isolated and depressed
• *is immigration known or possible?*	Possible, but unlikely except from Flathead
• *would immigrants be adapted to survive here?*	Unknown
• *is there sufficient habitat for immigrants here?*	Likely yes
Quantitative Analysis	Not available

Existing Status

Nature Conservancy Ranks (Naturserve 2004)

Global – T3

National

US – N2

Canada NNR

Regional

US – Colorado – SNA, Idaho – S2, Montana – S3, Oregon – S3, Washington – SNR, Wyoming S1

Canada – BC - S3

Wild Species 2005 (Canadian Endangered Species Council 2006)

National – 4

Regional – BC – 4

COSEWIC

Special Concern May 2005

Status and Reasons for Designation

<table>
<tr><td>Status: Special Concern</td><td>Alpha-numeric code: Not Applicable</td></tr>
<tr><td colspan="2">Reasons for Designation:
Populations are stressed by hybridization and competition with introduced species. Furthermore, expanding urban development, agricultural activities and resource-based industries are expected to lead to additional stresses associated with habitat loss and degradation, as well as increased exploitation. It should be noted that this assessment includes only genetically pure, native populations of the species occurring within their native historical range. Any populations known to be hybridized significantly (i.e., > 1%) with other trout species, or to have been introduced into a system previously free of natve populations, were not assessed.</td></tr>
<tr><td colspan="2">Applicability of Criteria
Criterion A: (Declining Total Population): Not Applicable – Rate of decline is unknown; however, in 1999, in the upper Kootenay, of the 928-1229 streams known to harbour WCT, hybridization was found at 18 of 23 streams tested, an increase over previous sampling in 1986.
Criterion B: (Small Distribution, and Decline or Fluctuation): Not applicable – threshold values are exceeded.
Criterion C: (Small Total Population Size and Decline): Not applicable – Number of mature individuals exceeds threshold levels; however, the population structure is highly fragmented and no population contains more than 100 mature individuals. The rate of population decline is unknown, but more than 57% of sites sampled indicate that hybridization is occurring at a frequency >5% and the spread of hybridization is increasing.
Criterion D: (Very Small Population or Restricted Distribution): Not Applicable – Number of mature individuals, as well as EO and EO exceed the threshold values.
Criterion E: (Quantitative Analysis): Not Applicable – Data not available.</td></tr>
</table>

TECHNICAL SUMMARY
Alberta Population

Oncorhynchus clarkii lewisi
Common name: westslope cutthroat trout
Common name (French): truite fardée
Range of Occurrence in Canada: Alberta

Extent and Area information	
• *extent of occurrence (EO)* [from text and Figure 6]	~ 20,000 km²
• *specify trend (decline, stable, increasing, unknown)*	Decreasing
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	Unlikely
• *area of occupancy (AO)* [Populations are structured over small distances (1-2 km) coinciding with small watershed groups and different stream sections in larger systems}	<2000 km^2
• *specify trend (decline, stable, increasing, unknown)*	Declining 213 of 274 locations lost
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	Unknown
• *number of extant locations*	61 named streams in 2 river systems
• *specify trend in # locations (decline, stable, increasing, unknown)*	Declining
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	Unlikely
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Declining
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	3-5 years
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	61 streams 100 mature individuals/stream) = 6100 (Table 3)
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	Decline
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period* [Although 78% of the historical populations have been lost, the trend started in the early 1900s due to over-harvesting; the % decline during the last 3 generations is unknown]	Unknown
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Unknown
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	Yes, many populations isolated in headwater systems
• *list each population and the number of mature individuals in each*	An average of 100/stream in each of 61 streams in 2 river systems
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Pure populations declining
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	Unlikely

Threats (actual or imminent threats to populations or habitats)	
- Hybridization with introduced rainbow trout, other CT subspp. - Competition with non-native salmonids (rainbow trout, brook trout, Yellowstone CT, coarse fish) - Habitat loss/dewatering (damming, urbanization, irrigation withdrawals) - Habitat Degradation (Road construction, agriculture, mining) - Over-harvesting	
Rescue Effect (immigration from an outside source)	Low
• *does species exist elsewhere (in Canada or outside)?*	Yes
• *status of the outside population(s)?*	Pure populations severely isolated and depressed
• *is immigration known or possible?*	Unlikely
• *would immigrants be adapted to survive here?*	Unknown
• *is there sufficient habitat for immigrants here?*	Unknown
Quantitative Analysis	Not Available

Existing Status

Nature Conservancy Ranks (Naturserve 2004)

Global – T3

National

US – N2

Canada NNR

Regional

US – Colorado – SNA, Idaho – S2, Montana – S3, Oregon – S3, Washington – SNR, Wyoming S1

Canada – AB – S1

Wild Species 2005 (Canadian Endangered Species Council 2006**)**

National – 4

Regional – AB – 2

COSEWIC

Threatened May 2005

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code**: B1+2ab(i,ii,ii,iv,v)+ 2ab(i,ii,iii,iv,v); C2a(i)

Reasons for Designation:
Native populations have been reduced by almost 80% through over-exploitation, habitat degradation, and hybridization / competition with introduced, non-native trout. Remaining genetically pure, individuals persist as mainly severely fragmented, remnant headwater populations. It should be noted that this assessment includes only genetically pure, native populations of the species occurring within their historical range. Any populations known either to be hybridized significantly (i.e. >1%) with other trout species, or to have been introduced into a system previously free of native populations were not assessed.

Applicability of Criteria

Criterion A (Declining Total Population): Not Applicable – decline rate in the last 3 generations is not known.

Criterion B (Small distribution, and Decline or Fluctuation): Meets criterion 1 and 2 for Threatened (EO < 20,000 Km2, AO < 2000 km2), and the population structure is one of extreme fragmentation (criterion a). Continuing decline in extent of occurrence, area of occupancy, area and extent of habitat, number of locations and number of mature individuals (criterion b(i,ii,ii,iv,v.)

Criterion C (Small Total Population Size and Decline): Meets criteria 2a(i) for Threatened. The total is probably less than 6100 mature individuals and is declining due to over-harvest, habitat loss and degradation, and competition and hybridization with other introduced salmonids. The population structure is extremely fragmented and no population appears to contain more than 200 individuals. The rate of decline is not known, but 59% of sampled steams provide evidence of hybridization at a mean frequency of 34% (see Table 4).

Criterion D (Very Small Population or Restricted Distribution: Not Applicable – Number of individuals and area of occupancy exceed threshold values.

Criterion E (Quantitative Analysis): Not applicable – Data not available.

Table 4. Summary data of levels of hybridization for selected populations within the native range in Alberta. N represents the number of individuals that were genotyped, followed by the number determined to represent pure westslope cutthroat, rainbow, Yellowstone cutthroat, or hybrids, respectively (modified from Janowicz 2004).

Drainage	Watershed	Population	N	WCT	RBT	YCT	HYB	% Hybrid
South Saskatchewan River								
Bow	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 tributary	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
	Spray	Commonwealth	1	1	0	0	0	0.0
		Hogarth	20	12	0	0	8	40.0
		Smuts	26	19	0	0	7	26.9
		Watridge	32	32	0	0	0	0.0
		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	Boulton	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
		Pocaterra	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
	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
St. Mary	St. Mary	Lee	9	0*	7	0	2	22.2
Drainage	Watershed	Population	N	WCT	RBT	YCT	HYB	% Hybrid
Oldman	Oldman	N. Racehorse	15	14	0	0	1	6.7
Oldman	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
		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
	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
	Castle	Beaver Mines	23	0*	17	0	6	26.1

Drainage	Watershed	Population	N	WCT	RBT	YCT	HYB	% Hybrid
		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
	Waterton	Dungarvan	10	9	0	0	1	10.0

*These populations are probably extirpated. Wherever rainbow trout are present, it is only a matter of time before the WCT are gone (Stelfox, pers. comm. 2006).

Total number of populations = 55, of which 29 (53 %) display a > 1% admixture (mean rate of hybridization =.32.4 %).

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Allan B. Costello has been working in the fields of conservation biology / molecular ecology as a researcher for the past several years and is currently completing his doctorate work at the University of British Columbia. His research there examines the roles of ecological and evolutionary forces in shaping patterns of genetic and life history diversity in two species of native fish: the bull trout (*Salvelinus confluentus*) and the cutthroat trout (*Oncorhynchus clarkii*). Using molecular and ecological data, his work will help delineate the major groups for conservation in the province as well as quantifying the structuring and demographic independence of adjacent populations in the wild.

Emily Rubidge has worked extensively in the general fields of fish biology, conservation biology and molecular ecology. Most recently, her research has focused on the population dynamics of species; specifically, how anthropogenic changes to habitat (i.e., degradation, exotic species introductions, etc.) affect the population structure and dynamics of species. She has just completed her M.Sc. thesis at the Department of Zoology, University of British Columbia, examining a hybrid zone between introduced rainbow trout and native cutthroat trout in the East Kootenay Region of British Columbia. This project includes a broad-scale genetic assessment of hybridization in this region as well as a more in-depth examination of the factors that promote or inhibit such hybridization events.

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