The Fishes of the Central Canadian Rockies Ecosystem

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Abstract

I surveyed existing information in historical documents; technical publications and reports; selected file data held by Parks Canada, Alberta Fish and Wildlife and the British Columbia Ministry of Environment Lands and Parks; and interviewed reliable observers knowledgeable about selected waters to determine the native and present distribution of fishes within the Central Canadian Rockies Ecosystem (CCRE).

Fifty-four species of fishes in 12 families have been reported to exist in or near the CCRE. Of these, only 33 are, or once were, native to some part of the study area or in connected adjacent waters. At least 10 native fishes have suffered impacts of significant conservation concern. One native subspecies (Banff longnose dace) is now extinct. One native species (chinook salmon) is certainly extirpated in the CCRE. Several other anadromous species (Pacific lamprey, white sturgeon, sockeye and steelhead stocks) native to the study area in the Columbia River mainstem or adjacent connected waters presumably are extirpated or landlocked. Many individual stocks of native fish also have been extirpated. Cutthroat trout and bull trout native stocks especially have been eliminated or severely depleted: both are now rare in most of the Bow River drainage. In particular, genetically-pure stocks of native westslope cutthroat trout in their native habitats are exceedingly rare and should be treated as endangered. A limited number of cutthroat stocks have been successfully introduced into previously fish-free drainages above barriers.

Of the 21 introduced species, at least 13 have managed to persist somewhere within the CCRE. Introduced brook and brown trout have been especially successful, largely replacing native cutthroat and bull trout in many east slopes waters. Most rainbow trout stocks introduced into the upper Bow drainage evidently have failed to persist in the long term, but have introgressed extensively with native westslope cutthroats, especially in the Bow mainstem, Jumpingpound Creek, Elbow, Sheep and Highwood river drainages. Introduced lake trout stocks have replaced native bull trout in at least two BNP lakes even though certain native stocks of these two species coexist elsewhere in the CCRE. An introduced stock of northern Dolly Varden may pose a threat to a native bull trout stock being restored in the upper Kananaskis drainage. One introduced stock (cisco in Lake Minnewanka) derived from the Great Lakes may be of special value for conservation because stocks in lakes Ontario and Erie are thought to be endangered.

The present fish fauna of the CCRE is overwhelmingly artificial, depauperate and dominated by exotic stocks; the native fish fauna largely obliterated. The ecological integrity of the natural Central Rockies Ecosystem has been irretrievably lost. A system of triage is required to salvage whatever remains of the natural state. A new set of ecosystem boundaries based on regional watersheds is proposed within which to organize aquatic ecosystem conservation and management in the future.

Acknowledgements

Numerous locality records for fishes were provided by Parks Canada, Banff National Park (BNP); the Alberta Fish and Wildlife Service (AFW), Calgary and Rocky Mountain House; and the British Columbia Ministry of Environment, Lands and Parks (BCME), Cranbrook. Marnie Pole provided some locality records for Yoho National Park. Charlie Pacas, Tom Hurd and John Paczkowski contributed some recent locality records for the Clearwater, Red Deer, lower Spray and Cascade rivers in BNP. Jim Stelfox, Mel Kraft, Larry Rhude and Steve Herman of AFW allowed me to use reports, distribution maps and file data for waters in their jurisdiction, while Bill Westover of BCME did the same for the Columbia and Kootenay drainages in British Columbia. All of the above provided much useful discussion, corrections and additions based on their local knowledge. Ray Blanchard and Jim Rennels directed me to certain cutthroat trout records. Charlie Pacas and Larry Rhude provided helpful comments on an earlier draft. Part of this study was funded by Canadian Parks Service contract KBP-2059, managed for BNP by Tom Hurd (1992-93) and Charlie Pacas (1993-94). This report is submitted in partial fulfillment of that contract.

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Figures & Tables

Introduction

Banff National Park (BNP) engaged Freshwater Research in September 1992

1. to prepare a fish management plan for BNP,

2. to conduct a preliminary fall survey of the fishes of the Bow River from above Bow Falls to the headwaters, and

3. to prepare a chapter for the Central Canadian Rockies Ecosystem (CCRE) Atlas on the distribution and status of fishes within the CCRE.

This report is an overview of the distribution and status of the fish stocks within the CCRE. Earlier drafts (1993, 1994) formed the background and supporting documentation for the chapter in the CCRE Atlas noted under item (3), above. This final version incorporates the most complete species accounts, distribution maps and interpretation of the data, as well as the documentation for the native and present fish distributions.

Yoho, Kootenay and Banff national parks comprise the core of the CCRE, which at the time this study was initiated had the following boundaries. West of the Continental Divide the study area consists of the Columbia River right bank headwaters from the Bush River upstream, including the mainstem Columbia River; the Kootenay River headwaters above Canal Flats; and the Elk River and Fording River headwaters north of Elkford. East of the Continental Divide the study area includes the North Saskatchewan, Red Deer and Bow River drainages upstream of the Forest Reserve boundary. A very small part of the extreme headwaters of the Willow Creek drainage, Oldman system, are included along the south boundary of the study area. The general locality and precise boundaries are illustrated in Figure 1.

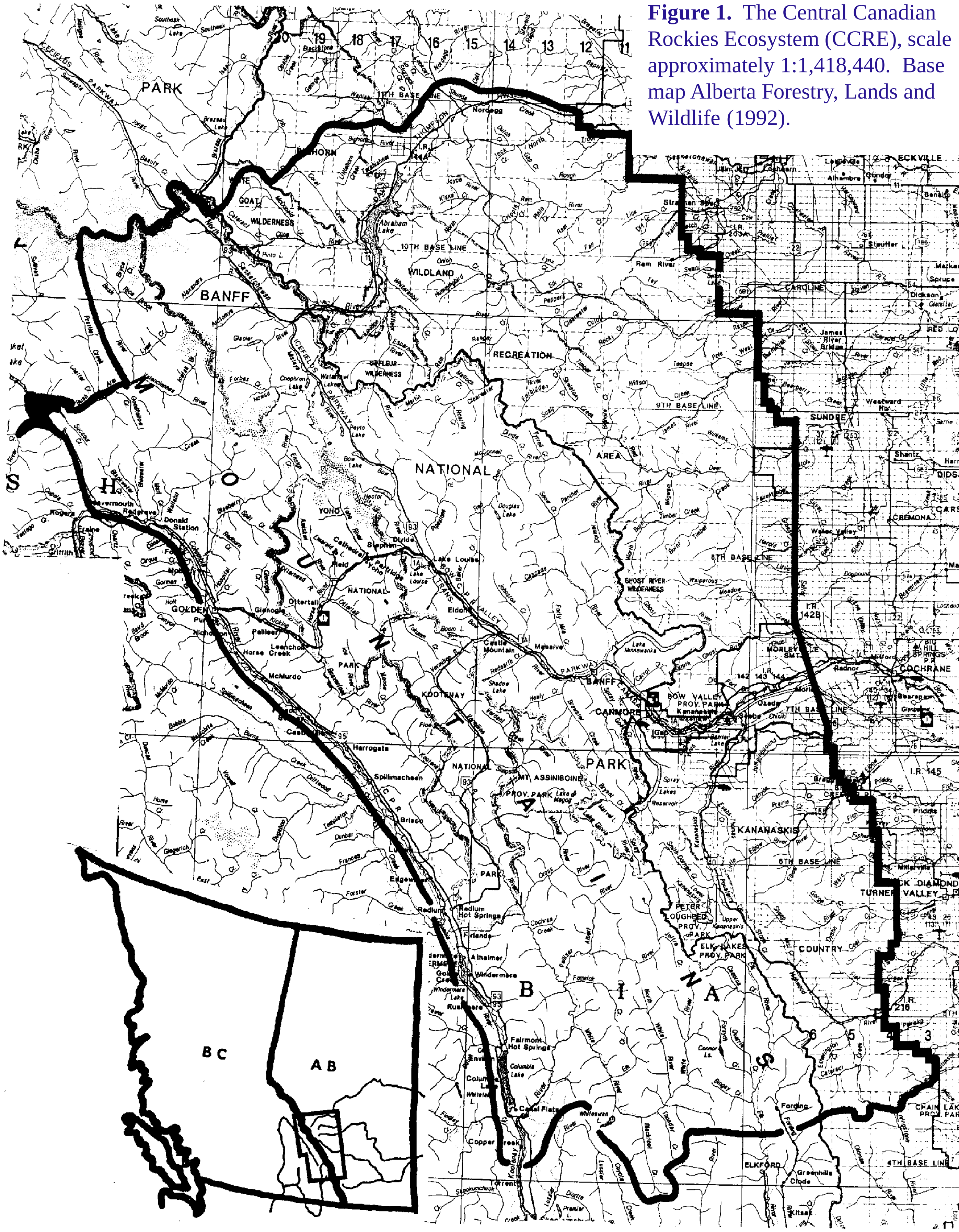

Figure 1. The Central Canadian Rockies Ecosystem (CCRE), scale approximately 1:1,418,440. Base map Alberta Forestry, Lands and Wildlife (1992).

Methods

This report was prepared entirely from existing data. The distribution and historical abundance conclusions represent my interpretations of information in publications, technical reports and selected file data held by the government agencies responsible for fish management in the three jurisdictions included in the CCRE, interviews with reliable observers knowledgeable about certain waters, and incidental observations in a large number of historical records. The specific sources used to establish distributions of fishes within each major drainage basin are as follows.

General study area: Department of the Interior (1879 to 1918), Sisley (1911), Prince et al. (1912), Whitehouse (1919), Cuerrier and Ward (1952, 1953, 1954), Carl et al. (1959), Henderson and Peter (1969), Paetz and Nelson (1970), Scott and Crossman (1973), Ward (1974), Mudry and Anderson (1977), Cavender (1978), Lee et al. (1980), Donald (1987), Nelson and Paetz (1976, 1992), Haas and McPhail (1991)

Columbia River basin: De Smet (1847), Hector (1863), Lees and Clutterbuck (1888), Green (1890), Eigenmann and Eigenmann (1892), Eigenmann (1895), Stutfield and Collie (1903), Henshaw (1906), Dymond (1932), McHugh (1940, 1941), Nelson (1968), McCart (1970), Mudry and Anderson (1975), Erasmus (1984), Triton Environmental Consultants Ltd. (1992), Fielden et al. (1992), RL&L Environmental Services Ltd. (1993), M. Pole (CPS Field, BC, personal communication 1991), W. Westover (BCME Cranbrook, BC, interview 1993)

Kootenay River basin: Lees and Clutterbuck (1888), Hornaday (1907), Dymond (1932), Nelson (1968), McAllister et al. (1981), Alger and Donald (1984), Donald and Alger (1984), SHIP Environmental Consultants Ltd. (1991), B. Sheehan (Warden Service, Kootenay National Park, BC, interview 1993), W. Westover (BCME Cranbrook, BC, interview 1993)

North Saskatchewan River basin: Stutfield and Collie (1903), Schäffer (1911), Miller and Paetz (1953), Tebby (1974); Allan (1980); Donald and Alger (1993); AFW summary file data mapped to 1993; S. Herman, M. Kraft and L. Rhude (AFW Rocky Mountain House, interviews 1993)

Red Deer River basin: Miller and Paetz (1953), Anderson and Donald (1978), AFW summary file data mapped to 1993; S. Herman, M. Kraft and L. Rhude (AFW Rocky Mountain House, interviews 1993)

Bow River basin: De Smet (1847); Hector (1863); Palliser (1863); Whitcher (1887); Eigenmann and Eigenmann (1892); Eigenmann (1895); Wilcox (1896, 1900); Stutfield (1899); Stutfield and Collie (1903); Macoun (1905); Outram (1905); Vick (1913); Rawson (1939, 1942, 1945, 1947); McHugh (1940, 1941); Edwards (1950); Miller and Macdonald (1950); Cuerrier (1954); Cunningham (1961, 1962, 1964); Nelson (1965); McAllister (1969); Thompson (1975, 1977, 1978); Davies and Thompson (1976); Howes (1976); Mayhood and Anderson (1976); Mayhood et al. (1976); Mudry and Green (1976, 1977); Thompson and Davies (1976); Anderson and Donald (1978); Mayhood (1978, 1983, 1985); Wiebe (1978); Tripp et al. (1979); Donald et al. (1980); Techman Ltd. (1980); Stelfox and Konynenbelt (1980); McAllister et al. (1981); Monenco Consultants Limited (1982); Stelfox and Ladd (1982); Lamoureux et al. (1983); McIllrie and White-Fraser (1983); Nelson (1983); Stelfox (1983, 1985); Nibourg (1985); Matkowski and Fernet (1987); Carl and Stelfox (1989); Colpitts (1991); Hills and Stelfox (1991); Edworthy (1992); Sentar (1992); Donald and Alger (1993); Mayhood and Paczkowski (1993); J. Stelfox (AFW Calgary, AB, interviews to 1994); T. Hurd, C. Pacas and J. Paczkowski (CPS Banff, AB, interviews to 1994).

The historical documents were useful for establishing the native presence of trout and salmon in many waters. Although there were some important exceptions, seldom were historical descriptions clear enough to identify species; nor were the authors' own identifications reliable enough to accept at face value in most cases. Detailed analyses of technical and historical documents upon which much of the present interpretation of native trout distributions in the Rocky Mountains is based are currently being prepared and will be presented elsewhere.

In general I obtained the most complete and reliable information for the Bow drainage, and for Yoho and Kootenay national parks in the Columbia and Kootenay drainages, respectively. Additional primary material in extensive agency files remains to be included for all basins, especially the North Saskatchewan and Red Deer drainages under the jurisdiction of the Province of Alberta, and the Columbia and Kootenay drainages under the jurisdiction of the Province of British Columbia. Existing data for the

Kootenay basin within BC provincial jurisdiction appear to extend some fish distributions far downstream based on upstream occurrence records; actual distributions in that drainage may be much less continuous than shown on the distribution maps. Ongoing surveys of the Columbia watershed under the Mica Dam Compensation Program are adding new information for the latter drainage, the northern part of which has been changed dramatically by the closure of the Mica Dam.

The Fishes

Scientific and common names of the fishes mentioned in this report are listed in Table 1. The distribution of fishes in the CCRE is summarized by major drainage basin in Table 2. The detailed distributions of several species for which substantial data were available are illustrated in separate figures.

Pacific lamprey — Carl et al. (1959) gave the distribution of this species as including "the headwaters of the Columbia." There is a specimen record for the Columbia River apparently near the Bush River in the CCRE (Scott and Crossman 1973:43). There have been numerous recent changes in the habitat here due to damming, and the present status of this fish in the CCRE is in doubt: lampreys have not been reported by recent investigators in this area (Fielden et al. 1992, Triton Environmental Consultants Ltd. 1992).

An unusual feature of this fish is that it is able to use its sucker to scale waterfalls, dams and other impediments that are barriers to other fishes (Carl et al. 1959:27, Scott and Crossman 1973:43). There surely must be some doubt, however, whether it is capable of ascending the 13 dams on the Columbia mainstem, some among the largest in the world, over the nearly 1500-km distance from the Pacific to Kinbasket reservoir. Whether the population in the upper Columbia is a strictly freshwater form was not reported. The conservation status of the species has not been investigated in Canada (Campbell 1993:396-397). The conservation status in North America is unlisted, except for one as yet undescribed subspecies of special concern in California and Oregon (Williams et al. 1989:3).

Beamish (1982) described a new species, the Vancouver lamprey, which is similar to the Pacific lamprey and easily mistaken for it. The new species is a freshwater form, whereas the Pacific lamprey ostensibly is obligately anadromous. The Vancouver lamprey is presently listed as vulnerable by COSEWIC (Campbell 1993:396, as lake lamprey). It is therefore of considerable interest to know whether a lamprey population still exists in the CCRE, and if so, if it is truly the Pacific lamprey, the new species, or a similar but as yet undescribed form.

Table 1. Scientific and common names of fishes mentioned in this report (Robins 1991a, 1991b). Subspecies names from Renaud and McAllister (1988) and Behnke (1992). The spelling of charr follows Morton (1980).

Petromyzontidae - lampreys	
Vancouver lamprey	*Lampetra macrostoma* Beamish, 1982
Pacific lamprey	*Lampetra tridentata* (Gairdner, 1836)
Acipenseridae - sturgeons	
lake sturgeon	*Acipenser fulvescens* Rafinesque, 1817
white sturgeon	*Acipenser transmontanus* Richardson, 1836
Cyprinidae - minnows	
chiselmouth	*Acrocheilus alutaceus* Agassiz & Pickering, 1855
lake chub	*Couesius plumbeus* (Agassiz, 1850)
brassy minnow	*Hybognathus hankinsoni* Hubbs, 1929
pearl dace	*Margariscus margarita* Cope, 1868
peamouth	*Mylocheilus caurinus* (Richardson, 1836)
northern redbelly dace	*Phoxinus eos* (Cope, 1862)
finescale dace	*Phoxinus neogaeus* Cope, 1868
fathead minnow	*Pimephales promelas* Rafinesque, 1820
northern squawfish	*Ptychocheilus oregonensis* (Richardson, 1836)
blacknose dace	*Rhinichthys atratulus* (Hermann, 1804)
longnose dace	*Rhinichthys cataractae* (Valenciennes, 1842)
Banff longnose dace	*R. c. smithi* Nichols, 1916
leopard dace	*Rhinichthys falcatus* (Eigenmann & Eigenmann, 1893)
redside shiner	*Richardsonius balteatus* (Richardson, 1836)
Catostomidae - suckers	
longnose sucker	*Catostomus catostomus* (Forster, 1773)
white sucker	*Catostomus commersoni* (Lacepède, 1803)
largescale sucker	*Catostomus macrocheilus* Girard, 1856
mountain sucker	*Catostomus platyrhynchus* (Cope, 1874)
Esocidae - pikes	
northern pike	*Esox lucius* Linnaeus, 1758
Salmonidae - salmons, trouts, charrs, whitefishes & graylings	
whitefishes	
cisco	*Coregonus artedi* Lesueur, 1818
lake whitefish	*Coregonus clupeaformis* (Mitchill, 1818)
pygmy whitefish	*Prosopium coulteri* (Eigenmann & Eigenmann, 1892)
mountain whitefish	*Prosopium williamsoni* (Girard, 1856)
western trouts	
golden trout	*Oncorhynchus aguabonita* (Jordan, 1893)
cutthroat trout	*Oncorhynchus clarki* (Richardson, 1836)
Yellowstone	*O. c. bouvieri* (Bendire, 1882)
coastal	*O. c. clarki* (Richardson, 1836)
westslope	*O. c. lewisi* (Girard, 1856)
rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)

continued …

Table 1. concluded

Pacific salmons	
coho salmon	*Oncorhynchus kisutch* (Walbaum, 1792)
sockeye salmon	*Oncorhynchus nerka* (Walbaum, 1792)
chinook salmon	*Oncorhynchus tshawytscha* (Walbaum, 1792)
eastern trout and salmon	
Atlantic salmon	*Salmo salar* Linnaeus, 1758
brown trout	*Salmo trutta* Linnaeus, 1758
charrs	
Arctic charr	*Salvelinus alpinus* (Linnaeus, 1758)
bull trout	*Salvelinus confluentus* (Suckley, 1858)
brook trout	*Salvelinus fontinalis* (Mitchill, 1814)
Dolly Varden	*Salvelinus malma* (Walbaum, 1792)
lake trout	*Salvelinus namaycush* (Walbaum, 1792)
splake	*Salvelinus fontinalis* × *S. namaycush*
graylings	
Arctic grayling	*Thymallus arcticus* (Pallas, 1776)
Percopsidae - trout-perches	
trout-perch	*Percopsis omiscomaycus* (Walbaum, 1792)
Gadidae - cods	
burbot	*Lota lota* (Linnaeus, 1758)
Poeciliidae - live-bearers	
western mosquitofish	*Gambusia affinis* (Baird & Girard, 1853)
sailfin molly	*Poecilia latipinna* (Lesueur, 1821)
guppy	*Poecilia reticulata* Peters, 1859
green swordtail	*Xiphophorus helleri* Heckel, 1848
Gasterosteidae - sticklebacks	
brook stickleback	*Culaea inconstans* (Kirtland, 1841)
Cottidae - sculpins	
mottled sculpin	*Cottus bairdi* Girard, 1850
slimy sculpin	*Cottus cognatus* Richardson, 1836
torrent sculpin	*Cottus rhotheus* (Smith, 1882)
spoonhead sculpin	*Cottus ricei* (Nelson, 1876)
Centrarchidae - sunfishes	
sunfish (unidentified)	*Lepomis* sp.
smallmouth bass	*Micropterus dolomieu* Lacepède 1802
largemouth bass	*Micropterus salmoides* (Lacepède 1802)
Cichlidae - cichlids	
convict cichlid	*Cichlasoma nigrofasciatum* (Günther, 1867)
African jewelfish	*Hemichromis bimaculatus* Gill, 1862
freshwater angelfish	*Pterophyllum scalare* (Lichtenstein, 1823)

Table 2. The fishes of the Central Canadian Rockies Ecosystem. ● - native, ❍ - native in adjacent connected waters, I - introduced, U - unsuccessful introduction, ? - questionable record. Some species and stocks have been extirpated, and many others are at risk. The Kicking Horse records refer only to occurrences above Wapta Falls.

Species	Bow	Red Deer	North Sask-atchewan	Columbia	Kicking Horse	Kootenay
Petromyzontidae - lampreys						
Pacific lamprey				●		
Acipenseridae - sturgeons						
lake sturgeon	❍?		❍			
white sturgeon				❍		
Cyprinidae - minnows						
lake chub	●	●	●	?		
pearl dace	●	●	●			
northern redbelly dace			●			
finescale dace			●			
fathead minnow	❍	●	●			
longnose dace	●	●	●	●		●
chiselmouth				●		
peamouth				●		
northern squawfish				●		❍
leopard dace						❍?
redside shiner				●		❍
Catostomidae - suckers						
longnose sucker	●	●	●	●	●?	●
white sucker	●	●	●			
mountain sucker	●	●	●			
largescale sucker				●	●?	?
Esocidae - pikes						
northern pike	❍	●	●			
Salmonidae - salmons, trouts, charrs, whitefishes & graylings						
chinook salmon				●		
sockeye salmon				❍?		
kokanee				I		I
coho salmon						I?
golden trout	U		I		U	U
cutthroat trout	●	I	I	●	●?	●
rainbow trout	I	I	I	●	●?	I
brown trout	I	I	I			
Atlantic salmon	U				U	
bull trout	●	●	●	●	●	●
brook trout	I	I	I	I	I	I
Dolly Varden	I					
lake trout	●		●		I	
Arctic charr	U					
splake	I		U		U	U
cisco	I					
lake whitefish	I?					

continued …

Table 2. concluded

Species	Bow	Red Deer	North Sask-atchewan	Columbia	Kicking Horse	Kootenay
pygmy whitefish				●	●	
mountain whitefish	●	●	●	●	●	●
Percopsidae - trout-perches						
trout-perch	●	●				
Gadidae - cods						
burbot	●	●	●	●		
Poeciliidae - live-bearers						
western mosquitofish	I					
sailfin molly	I					
guppy	U					
green swordtail	U					
Gasterosteidae - sticklebacks						
brook stickleback	●		●			
Cottidae -sculpins						
spoonhead sculpin	❍	●	●			
slimy sculpin				●	●	●
torrent sculpin				❍	●	❍
mottled sculpin				●?		
Centrarchidae - sunfishes						
sunfish unidentified				I		
largemouth bass	U?			I		
smallmouth bass	U?					
Cichlidae - cichlids						
African jewelfish	I					
convict cichlid	U					
freshwater angelfish	U					

Lake sturgeon — There is a 1970 specimen record as near to the CCRE as the Clearwater River (North Saskatchewan drainage) between Chedderville and Ricinus, according to Nelson and Paetz (1976), citing a personal communication with W. E. Roberts. Writing in 1890, J. H. McIllrie (McIllrie and White-Fraser 1983) reported that "a few sturgeon come up [rivers in the Calgary district] until the water gets too rapid for them". Whether they reached the CCRE in the Bow, Elbow or Highwood is not clear: there are no records, but there are no impassable natural obstacles either. Dams now prevent them from from ascending the Bow drainage above the extreme lower reach of the Bow River. The Dickson dam on the Red Deer presently prevents movements of lake sturgeon into the CCRE in that drainage, unless a population has become established in the reservoir. The species is considered threatened throughout North America (Williams et al. 1989:3). Although COSEWIC currently lists it as "report

accepted, no status designation required" in Canada, this designation is presently under review (Campbell 1993:396, 398). Rochard et al. (1990:131) concluded that *all* species of sturgeon can be considered endangered, based on considerations of life histories and threats to existence for 24 species worldwide.

White sturgeon — Carl et al. (1959) showed the distribution of this fish as including the entire upper Columbia River drainage, but the closest actual specimen record to the CCRE is for the Columbia River above Revelstoke (Scott and Crossman 1973:97). Its present status in the CCRE is unknown. Its conservation status in North America is unlisted (Williams et al. 1989), but the genetically-distinct Kootenai (Kootenay) River population is being considered for listing as endangered under the Endangered Species Act in the United States (Duke 1993). The species is listed as vulnerable by COSEWIC (Campbell 1993:396). Rochard et al. (1990:131) concluded that *all* species of sturgeon can be considered endangered, based on considerations of life histories and threats to existence for 24 species worldwide.

Chiselmouth — There is one record of this minnow within the CCRE: from Windermere Lake, on the Columbia River mainstem (Carl et al. 1959:119). The species is known in Canada only from a few widely-separated localities, all of them in the Fraser and Columbia systems of British Columbia. The chiselmouth presently is under review by COSEWIC for possible listing as vulnerable in British Columbia (Campbell 1993:398).

Lake chub — Lake chub are widespread in the CCRE in the North Saskatchewan, Red Deer and Bow drainages. They are said to exist also in the east Kootenay region of the Columbia system (Carl et al. 1959:122), but there appears to be only a single published locality record for that area — near Cranbrook, south of the CCRE (Scott and Crossman 1973:403, Lee et al. 1980:150). The species has not been reported in recent collections in the East Kootenay portion of the study area (Alger and Donald 1984, Donald and Alger 1984, Fielden et al. 1992, Triton Environmental Consultants Ltd. 1992, RL & L Environmental Services Ltd. 1993). Lake chub have recently been discovered in Dog Lake, Kootenay drainage, Kootenay National Park, where they are believed to have been illegally introduced (B. Sheehan, personal communication 1993; cf. Donald and Alger 1984). Introduced stocks in the profoundly disrupted habitats of reservoirs are

known to hybridize with introduced longnose dace (Nelson 1966).

Lake chub east and west of the Continental Divide likely represent two distinct geographic stocks, possibly separate subspecies (McPhail and Lindsey 1970:244-5).

Brassy minnow — A specimen record for this species in the Bow River drainage in or near the CCRE (Lee et al. 1980:175) undoubtedly is erroneous (cf. Nelson and Paetz 1992:133). There is no indisputable record of the brassy minnow within the CCRE.

Pearl dace — Pearl dace have been recorded from the CCRE in the headwaters of Shunda Creek, North Saskatchewan drainage (Nelson and Paetz 1992), from James River, Red Deer drainage (Henderson and Peter 1969:330), and from Little Jumpingpound Creek (Nibourg 1985), all on the extreme eastern edge of the study area. Pearl dace also have been recorded from the Bow drainage close to the CCRE in the Sheep River watershed (Nelson and Paetz 1992). They are to be expected in suitable habitat (boggy waters lacking piscivorous fish) east of the mountain front throughout the study area.

Peamouth — This species is said to be widespread in the upper Columbia system (Carl et al. 1959:112, Scott and Crossman 1973:425-6). There are collection records for peamouth in the CCRE at Golden (Eigenmann 1895) and in Columbia Lake on the Columbia mainstem (Scott and Crossman 1973:425, Lee et al. 1980:208, RL & L Environmental Services Ltd. 1993).

Northern redbelly dace — There is a single record of this species in the CCRE, from the North Saskatchewan drainage near Nordegg, at the extreme northeastern edge of the study area (Nelson and Paetz 1992:152). This and the following species commonly hybridize. The hybrid may constitute a separate single-sex (all female) species that requires males of one of the parental species for successful clonal reproduction (Dawley et al. 1987, Goddard and Dawley 1990, Nelson and Paetz 1992:153-154). The hybrid should be carefully sought in the CCRE wherever either parental species is found.

Finescale dace — There is a single record of this species in the CCRE, from the North Saskatchewan drainage near Nordegg, at the extreme

northeastern edge of the study area (Nelson and Paetz 1992:156). See the discussion of hybridization of this species with northern redbelly dace in the above entry.

Fathead minnow — Fathead minnows have been captured from two locations within the CCRE: near Nordegg, in the North Saskatchewan drainage, and from the James River drainage in the Red Deer system (Nelson and Paetz 1992:161). The species also occurs in Bighill Creek, a Bow River tributary a few miles below the CCRE (Nelson 1965:744).

Northern squawfish — Squawfish are widespread in the upper Columbia system, where the species has been recorded within the CCRE in the Columbia River mainstem, and near the CCRE in the Kootenay drainage (Carl et al. 1959, Lee et al. 1980:349). There are no records of the species in the Kicking Horse watershed above Wapta Falls, however (M. J. Pole, personal communication).

Blacknose dace — Rawson (1939:12, 1942:12) reported this species (as *Rhinichthys atronasus*) in collections from Lake Minnewanka, BNP (Bow drainage). Nelson and Paetz (1992:379) suggest that these fish were most likely hybrids of lake chub and longnose dace. Blacknose dace, an eastern species, are otherwise unknown in either British Columbia or Alberta waters (Lee et al. 1980:352).

Longnose dace — This minnow is widespread within the CCRE in the Bow and North Saskatchewan drainages, but has been reported only in the James River drainage in the Red Deer basin within the study area (Henderson and Peter 1969:330, Nelson and Paetz 1992:171). There are several locality records above impassable falls in the Ram River drainage, North Saskatchewan system (Henderson and Peter 1969:330; Paetz and Nelson 1970:132; Nelson and Paetz 1992:171, 172; L. Rhude, Alberta Fish and Wildlife Service, personal communication). Although these raise a strong suspicion of illicit introduction by bait bucket, they could in fact be native: detailed morphological, genetic and distributional studies are needed. The species is said to be widespread in the Kootenay and upper Columbia drainages (Carl et al. 1959:128). There are recent specimen records from the Columbia mainstem drainage, one within the CCRE in Succour Creek, tributary to the Bush River (Fielden et al. 1992, Triton Consulting Services Ltd. 1992). This species has not been recorded from the Kicking Horse drainage above Wapta Falls (M. J. Pole, personal

communication 1991). Introduced longnose dace hybridize with introduced lake chub in the disrupted habitats of mountain reservoirs (Nelson 1966, Nelson and Paetz 1992:379).

The Banff longnose dace (*R. c. smithi*), an endemic subspecies described from Cave and Basin Hotsprings in BNP by Nichols (1916), is now extinct (Renaud and McAllister 1988, Miller et al. 1989, Campbell 1993:397).

Leopard dace — The single record of this species anywhere near the CCRE, in the Kootenay drainage near Cranbrook (Carl et al. 1959:120, Scott and Crossman 1973, Lee et al. 1980), was considered questionable by Peden (1991:181). Peden (1991) believes Columbia River populations in British Columbia are vulnerable, mainly as a result of extensive hydroelectric development.

Redside shiner — Carl et al. (1959:106) indicate that the redside shiner is generally distributed throughout the upper Columbia system, including the headwaters of the Kootenay River. The species has been recorded within the CCRE from the Columbia River mainstem tributaries and Columbia Lake (Eigenmann 1895, Triton Consulting Services Ltd. 1992, RL & L Environmental Services Ltd. 1993). A published specimen record exists for the Kootenay drainage just south of the CCRE (Lee et al. 1980:358).

Longnose sucker — The longnose sucker is widespread in the CCRE in the North Saskatchewan and Bow drainages, though curiously it has not been recorded further upstream than the CCRE eastern boundary in the James River drainage of the Red Deer basin (Nelson and Paetz 1992:191). A recently-discovered population beside a major road above impassable falls on the Ram River, North Saskatchewan drainage (L. Rhude, Alberta Fish and Wildlife Service, personal communication) requires morphological and genetic study to determine if it is native or an illicit introduction. The species is said to occur throughout the Columbia River system in BC (Carl et al. 1959:91). Specimen records exist for the Columbia mainstem near Kinbasket Lake below the CCRE (Scott and Crossman 1973:533, Lee et al. 1980:372), and within the CCRE at Golden (Eigenmann 1895) and Succour Creek (Fielden et al. 1992). RL & L Environmental Services Ltd. (1993) reported capturing a single specimen from Columbia Lake. The species is known from the Kootenay drainage within the study area in Daer Pond

and Dog Lake, KNP (Donald and Alger 1984, Donald 1987), where it is presumed to be native. It has been suggested that longnose suckers in the Kicking Horse drainage above Wapta Falls are not native there (M. J. Pole, personal communication). Introduced longnose suckers hybridize with introduced white suckers in certain mountain hydroelectric reservoirs in the CCRE (Nelson 1973).

White sucker — White suckers have been reported from the North Saskatchewan, Red Deer and Bow drainages within the CCRE (Henderson and Peter 1969:331, Nelson and Paetz 1992:194). West of the Continental Divide within the study area this species is absent, being replaced by the largescale sucker (Carl et al. 1959:87, Lee et al. 1980). White suckers in the upper Kicking Horse drainage (M. Pole, personal communication 1991) are undoubtedly introduced. White suckers evidently have expanded their range in the Bow drainage to above Bow Falls, probably as a result of human intervention (Sentar 1992, Mayhood and Paczkowski 1993). Introduced white suckers hybridize with introduced longnose suckers in the highly disturbed habitats provided by some mountain hydroelectric reservoirs (Nelson 1973).

Largescale sucker — Carl et al. (1959:87) indicate by map shading that largescale suckers are found throughout the Columbia and Kootenay drainages. Recent specimen records have been reported in the CCRE for Columbia Lake (RL & L Environmental Services Ltd. 1993). Triton Environmental Consultants Ltd. (1992) reported largescale suckers in their catches from upper Columbia River tributaries just outside the CCRE. Largescale suckers in Ottertail River, in Yoho National Park above Wapta Falls, are believed to have been introduced (M. Pole, personal communication 1991).

Mountain sucker — The mountain sucker is absent from the CCRE west of the Continental Divide (Carl et al. 1959, Lee et al. 1980), but has been found in the study area east of the divide in the North Saskatchewan, Red Deer and Bow drainages (Henderson and Peter 1969:331, Nelson and Paetz 1992:200).

Northern pike — Pike have been found in the CCRE the James River drainage of the Red Deer basin (Henderson and Peter 1969:329). The species is also known from Abraham Reservoir and Swan Lake, North Saskatchewan drainage (Nelson and Paetz 1992:219, Alberta Fish and

Wildlife Service file data). Pike occur elsewhere in the North Saskatchewan drainage downstream from the study area (Henderson and Peter 1969:329, Nelson and Paetz 1992:218). Monenco Consultants Limited (1982) reported a single specimen from lower Threepoint Creek, just downstream from the CCRE in the Bow system. Conceivably the species occasionally enters the study area in this drainage. Pike are not native to the Columbia system, occurring there only as introduced populations in a few locations far downstream in the USA (Scott and Crossman 1973, Lee et al. 1980).

Golden trout — Attempts to establish non-native golden trout in CCRE waters have been made in Banff, Kootenay and Yoho national parks (Ward 1974; B. Sheehan, personal communication 1993), and in the North Saskatchewan (Coral, Gap, Michelle lakes), Red Deer (Lost Guide Lake) and Bow (Three Isle and Galatea lakes, Kananaskis drainage) systems under Alberta provincial jurisdiction (Nelson and Paetz 1992:272, Alberta Fish and Wildlife Service file data). Of these, only Coral Lake still holds the species (Ward 1974; Nelson and Paetz 1992; L. Rhude, Alberta Fish and Wildlife Service, personal communication). One stock in California is threatened (Williams et al. 1989).

Cutthroat trout — The probable native distribution of westslope cutthroat trout in the CCRE is presented in Figure 2. In interpreting the existing record, I have usually used barriers to migration where these are known to me to set the upstream limits of native cutthroat distributions. In general I have assumed that waters with apparently suitable cutthroat habitat that are or were accessible to known native stocks were once used by those stocks.

Figure 2 is necessarily somewhat speculative, representing my interpretation of numerous disparate technical reports and many dozens of sometimes confusing historical records. Early observers were clearly bewildered by the many apparent varieties of trout, knew them by numerous undescriptive and apparently interchangeable common names, and rarely described the types in sufficient detail to be identifiable by present-day biologists. In fact the cutthroat trout often was not distinguished from rainbow trout — even by biologists — in the last half of the nineteenth century (Eigenmann 1895, Macoun 1905, Scott and Crossman 1973:182-3, cf. 191). The species was not given the common

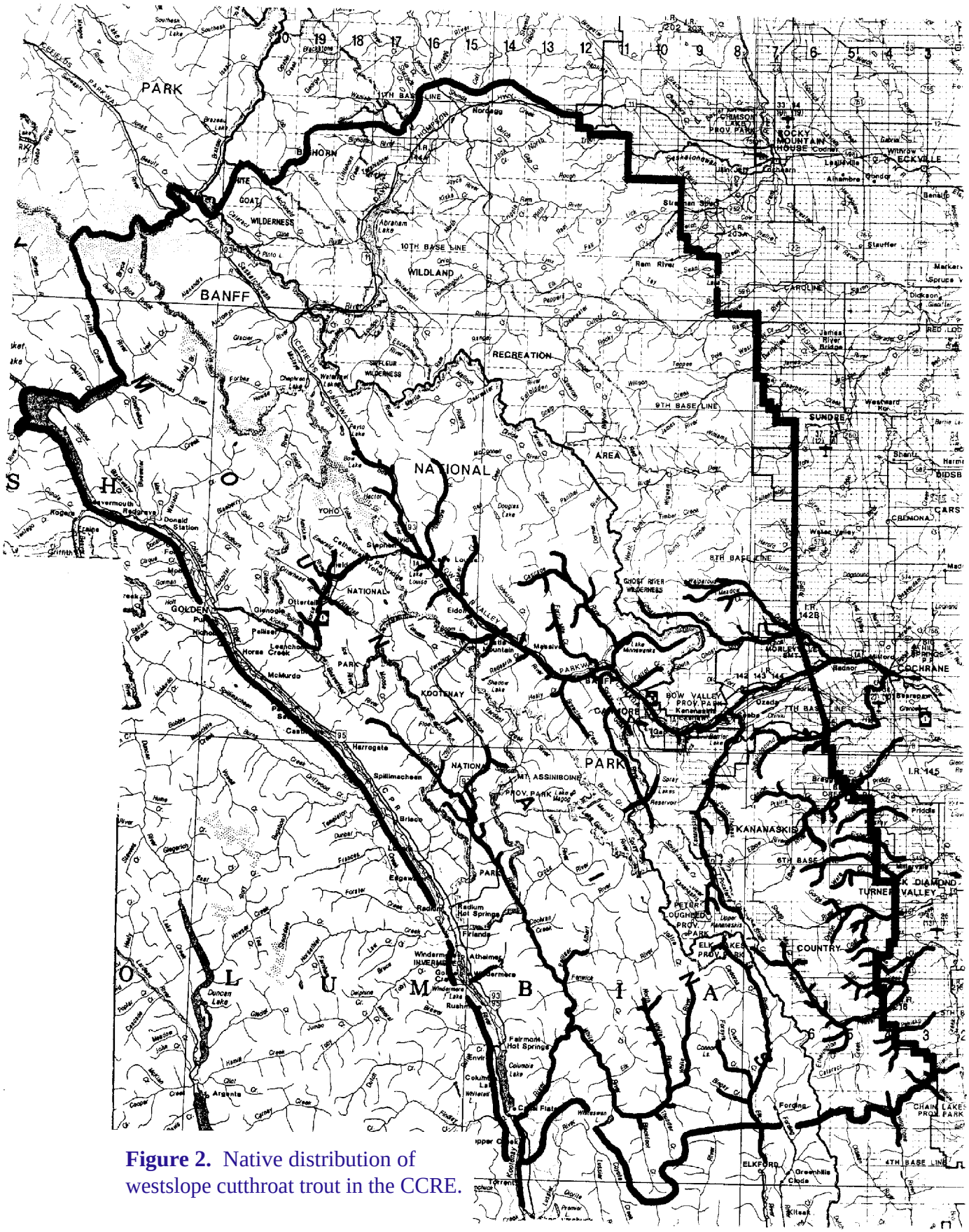

Figure 2. Native distribution of westslope cutthroat trout in the CCRE.

name "cutthroat" until 1884 (Behnke 1992:53), and certainly did not become widely known by it until much later (cf. Macoun 1905). Thus historical records of "rainbow trout" frequently referred to cutthroat trout, as indeed angler reports often do even today.

Westslope cutthroat trout are native to the CCRE in the Bow and Kootenay systems (Behnke 1992:78), and appear to have been native to certain Columbia River headwater tributaries in the vicinity of Columbia and Windermere lakes (e.g., Dutch and Toby creeks, Prince et al. 1912:38). The species probably is native to several other Columbia River tributaries upstream of Brisco, where it is the only black-spotted trout occupying several left bank tributaries according to one recent angler's report (Ambrosi 1987). Few of these have been shown on the map because I have been unable to find documentary evidence of cutthroats in most right-bank streams in that area. Elsewhere in the upper Columbia system the predominant native black-spotted trout is the rainbow, and native westslope cutthroats exist (or once existed) only as disjunct relict populations in a half-dozen locations, usually above barrier falls (Dymond 1932, Carl et al. 1959, Behnke 1992).

One of these disjunct stocks may have been native to the Kicking Horse drainage of Yoho National Park above Wapta Falls. "Trout" were native above Wapta Falls (Hector 1863, cf. Erasmus 1984), "three kinds" apparently providing good fishing in or near Emerald Lake in 1892 (McArthur 1893). One, a "small grey trout" (bull trout?), was abundant in the lake in 1887 (McArthur 1888). "Rainbow trout" were common in the Emerald Lake area and possibly Porcupine Creek at an early date, attaining sizes of over 6 pounds (Henshaw 1906). Henshaw included in her article a photograph of a square-tailed "rainbow" of over twelve pounds from an undisclosed location. After noting that "rainbow trout or cut-throat trout (*Salmo mykiss*)" was the black-spotted trout of the Rocky mountain waters of the Bow and Oldman drainages, Macoun (1905) reported that "passing the summit" of the Rockies and descending to the Columbia, "another black-spotted species is met with, named Steel-head or Gairdner's trout (*Salmo gairdneri*)." It is not clear whether this statement is intended to mean that *S. gairdneri* is found in addition to or in place of *S. mykiss*, but the former alternative would account for McArthur's third kind of trout. I have mapped cutthroat trout as native above Wapta Falls in the Kicking Horse drainage so that due attention will

be given to conserving what may be a rare, possibly unique native stock.

The westslope cutthroat has been widely transplanted within its native Bow and Kootenay systems, as well as into the Red Deer, North Saskatchewan and Kicking Horse drainages in the CCRE (Rawson 1947, Ward 1974, McAllister et al. 1981, Nelson and Paetz 1992:258). There is some limited evidence of transplantation of cutthroats (subspecies unknown) into the Columbia mainstem drainage of the CCRE as well. A rainbow/cutthroat hybrid swarm is reported to exist in Whitepine Creek, and there is some minimal evidence of cutthroat genetic introgression into the Willowbank Creek rainbow population (Triton Environmental Consultants Ltd. 1992). Although these populations may be naturally introgressed (given the existence just mentioned of some native cutthroat stocks in the upper Columbia drainage), rainbow and cutthroat trout rarely hybridize where they occur together naturally (Carl et al. 1959:70; Trotter 1991:248; Behnke 1992:80-81, 86).

The earliest recorded introduction of cutthroat trout in the CCRE was made in 1915 into Boom, Louise and Moraine lakes (Ward 1974), where there appear to have been extant native populations (Wilcox 1900). Earlier unrecorded stocking of exotic fishes, and transplanting of native fishes into naturally fishless waters, may have begun with the arrival of the Canadian Pacific Railway (CPR) in the mid-1880s in the Bow drainage (Mayhood 1992a) as well as in the upper Kicking Horse drainage, both of which lie along the CPR main line. Nearly all locality records for trout in these drainages of the CCRE date from after that time, so there will always be some doubt about the precise limits of the native distributions of fishes in them.

Figure 3 shows the present distribution of cutthroat populations within the CCRE insofar as I have been able to determine it from the recent records available to me. It shows the distribution of populations of black-spotted trout bearing the typical red slashmarks under the jaw characteristic of cutthroat trout; thus it includes any remaining native populations, as well as introgressed, transplanted and exotic stocks. The distributions in the Bow River drainage, the upper Kicking Horse drainage and the Kootenay drainage within KNP were mapped from actual locality records, and most of the gaps between them are real. The distributions in the remaining drainages have been mapped by others to show ranges of distribution;

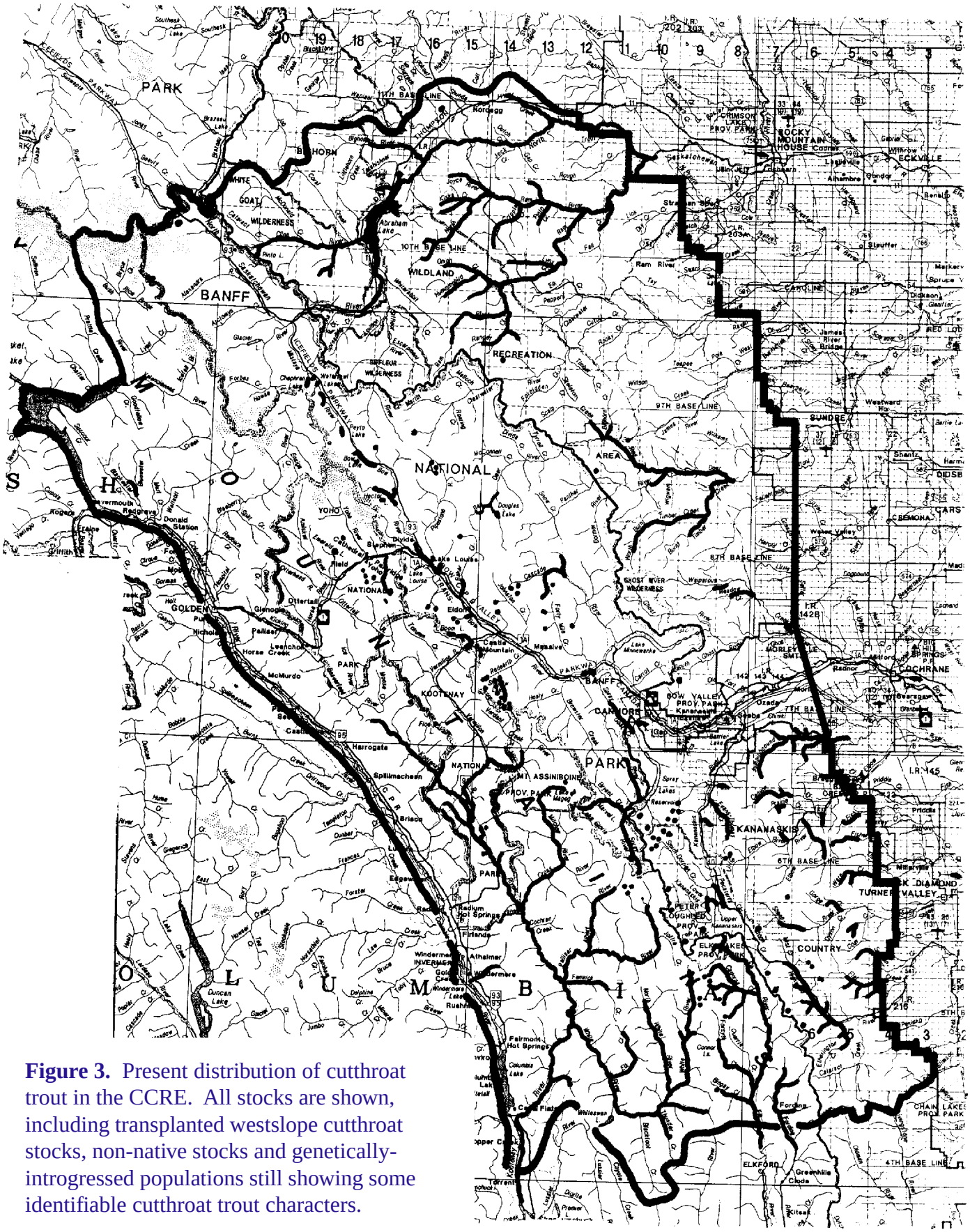

Figure 3. Present distribution of cutthroat trout in the CCRE. All stocks are shown, including transplanted westslope cutthroat stocks, non-native stocks and genetically-introgressed populations still showing some identifiable cutthroat trout characters.

actual occupancy of these drainages may be much more fragmented than that shown.

Even when all nominal cutthroat populations are included, it is obvious from a comparison of Figures 2 and 3 that the species has been decimated throughout most of its native range in the CCRE. This is especially true in the Bow drainage, where cutthroat trout of any description are now absent from vast reaches of the drainage basin where once they were abundant. The species is virtually extirpated from the mainstem Bow River below Lake Louise, and from nearly all of its tributaries, including the entire Kananaskis River and virtually all of its tributaries. Only a few fragmentary, highly isolated populations remain in the Bow basin. Renowned stocks of westslope cutthroat trout that once supported high quality indigenous and sport fisheries in the Spray and Lower Kananaskis lakes eventually disappeared some time after these waters were converted into hydroelectric reservoirs and their waters were stocked with rainbow trout (e.g., Vick 1913, Miller and Macdonald 1950; cf. Nelson 1965; Crosby 1990a, 1990b).

The westslope cutthroat trout is officially recognized as a species of special concern in Idaho and Montana, but is not so designated in British Columbia and Alberta (Johnson 1987). It does not have a conservation status designation from the American Fisheries Society (Williams et al. 1989) or COSEWIC (Campbell 1993). Nevertheless, uncontaminated indigenous stocks in their native habitats are extremely scarce at best in Alberta, and need to be immediately recognized as endangered in that province (Mayhood 1989, 1991). This is particularly the case for stream stocks, of which none have been unequivocally identified as genetically-pure natives to date.

The situation for truly native stocks in British Columbia is less clear, but the wide overlap in the distributions of native cutthroat and introduced rainbow trout, combined with the deliberate production and stocking of rainbow-cutthroat hybrids in the Kootenay drainage (Dymond 1932, Carl et al. 1959) strongly suggest that introgression is pervasive and pure native stocks are rare. Any remnant native populations should be flagged as of exceedingly high value for preservation.

Genetically-pure transplanted stocks appear to be widespread in the study area. Most of these represent only one or two common genetic lines (Spray-Marvel-Job and Connor stocks) the individual populations of which require no special protection. The remainder, representing isolated distinctive stocks, should each be treated as endangered due to their uniqueness, high value for conservation, and their relatively high risk of extinction due to their isolation.

Rainbow trout — This species is native in the CCRE only to the Columbia mainstem and its direct tributaries (Macoun 1905, Behnke 1992:166). There is evidence that rainbows are native to the Kicking Horse drainage above Wapta Falls (see Cutthroat trout, above). Whether anadromous stocks of this species (steelhead) once ascended the Columbia as far as the study area is a matter of conjecture, but several other anadromous species did so, and steelhead ascend a similar distance from the sea in the adjacent Fraser River system (Carl et al. 1959). Barrier falls on the Kootenai (Kootenay) River just below the Libby dam in Montana excluded rainbows from the Kootenay drainage in the CCRE (Behnke 1992:171). Rainbow trout have been introduced into all major drainages of the study area (Ward 1974, Nelson and Paetz 1992, SHIP Environmental Consultants Ltd. 1991).

The present documented distribution in the study area is shown in Figure 4. Populations introduced into lakes in which natural recruitment probably is negligible have been omitted. Lake populations of rainbow trout that reportedly have natural recruitment (Ward 1974:Appendix C) have been included. The present status of most populations requires confirmation. Populations in the Bow mainstem within the CCRE, and in the Kananaskis River, are known to be very sparse (Nelson 1965, Howes 1976, Thompson 1977). Dams on the Columbia have extirpated any anadromous stocks, or have created landlocked populations.

Coho salmon — Lee et al. (1980:94) show a locality record for this species in the Kootenay drainage within the CCRE. This portion of the study area is inaccessible to anadromous stocks due to barrier falls in Montana (Behnke 1992:171). If the record is accurate the population must have been introduced.

Sockeye salmon & kokanee — Neither anadromous sockeye salmon nor kokanee (landlocked sockeye) are believed to be native to the CCRE.

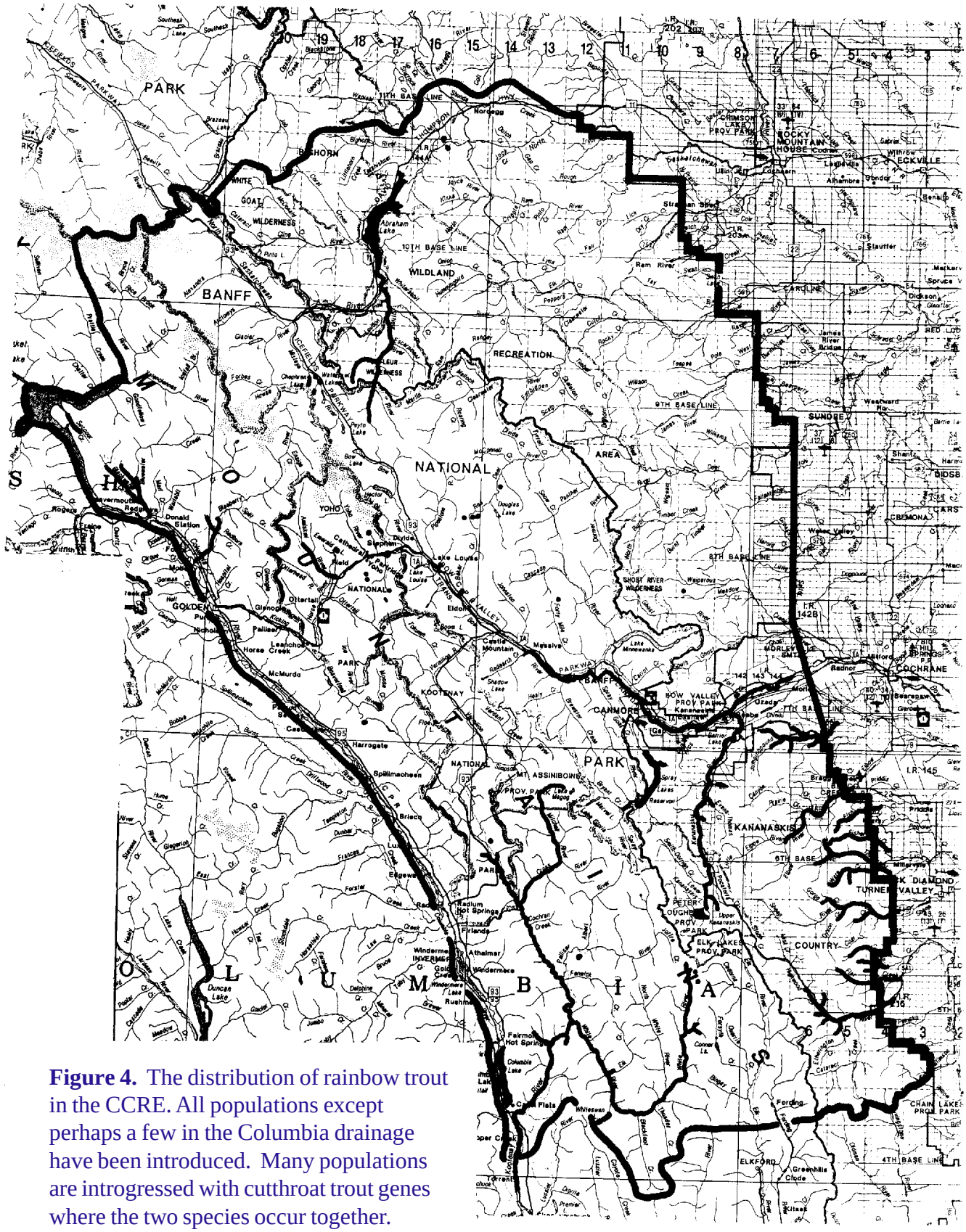

Figure 4. The distribution of rainbow trout in the CCRE. All populations except perhaps a few in the Columbia drainage have been introduced. Many populations are introgressed with cutthroat trout genes where the two species occur together.

Kokanee populations are thought to have been derived from anadromous ancestors, and anadromous sockeye apparently did not ascend the Columbia much above the Arrow lakes even before the building of the numerous dams on the mainstem (Nelson 1968). This view, however, is contradicted by Macoun (1905), who asserted that sockeye "… are found in suitable localities … in the Columbia, all around the Big Bend." Although Nelson (1968) notes that river piracy (drainage capture) may be the origin of kokanee in lakes of southeastern BC, the nearest indigenous populations to the CCRE mapped by him are in the St. Mary and Moyie drainages of the Kootenay system, west and southwest of Cranbrook, respectively. Introduced populations now existing in Windermere and Columbia lakes may be derived from introductions into Kinbasket reservoir as part of the Mica dam mitigation work (RL & L Environmental Services Ltd. 1993, W. Westover, BCME, personal communication). Kokanee from Kinbasket reservoir also use for spawning many right bank tributaries of the Columbia within the CCRE (Fielden et al. 1992, Triton Environmental Consultants Ltd. 1992). In the Kootenay system, recent spawning runs of introduced kokanee reached at least as far upstream as Mount Wardle in KNP (Brian Sheehan, KNP Warden Service, personal communication). These fish originated in Koocanusa reservoir behind Libby dam (Montana), more than 230 km downstream.

Chinook salmon — Historical records of salmon in the mainstem headwaters of the Columbia at Windermere and Columbia lakes (e.g., De Smet 1847, Lees and Clutterbuck 1888), 1900 km from the sea, almost certainly refer to this species. Eigenmann (1895) identified chinook salmon from the Columbia River at Golden. A major spawning area appears to have been in the gravelly midchannel shallows below Windermere Lake, where the redd-digging activities of these large fish were said to pose a significant impediment to river navigation (Lees and Clutterbuck 1888:102). Numerous dams on the Columbia, especially the Grand Coulee dam which was built without any fish passage facilities (Ebel et al. 1989:211), have since extirpated these stocks, and the species no longer occurs in the CCRE.

Atlantic salmon — Atlantic salmon, sometimes identified as the landlocked form (ouananiche), were introduced into Sawback Creek, Cuthead Lake, the Cascade River, Lake Minnewanka and an isolated gravel pit in BNP, all in the Bow drainage; and possibly into Sherbrooke

Lake in the Kicking Horse drainage. All introductions were apparently unsuccessful (Ward 1974, Anderson and Donald 1978, Nelson and Paetz 1992, M. J. Pole, personal communication 1991).

Brown trout — This European native has been widely introduced into the Bow, Red Deer and North Saskatchewan drainages, where it is largely confined to streams of the outer foothills. Within the CCRE it penetrates deeply into the study area only in the mainstems of the Bow, lower Kananaskis and Clearwater rivers, and the lower reaches of a handful of their lower tributaries (Figure 5).

Arctic charr — The *marstoni* (Quebec red trout) form of this species once was introduced, without any subsequent evidence of natural recruitment, into two of the Block lakes and Lake Louise, Bow drainage, and "in several areas already containing [bull trout] populations" (Ward 1974). Eggs of "red trout," presumably this form, were shipped from Quebec to the Banff hatchery as early as 1914-15, but the disposition of these eggs was not reported (Fisheries Branch 1917:312, cf. 340). The *marstoni* form is considered part of *S. a. oquassa*, a disjunct, relict subspecies confined to southern Quebec, New England and New Brunswick. Certain native New England populations are considered threatened (Williams et al. 1989). COSEWIC currently is reviewing the status of this subspecies in Canada (Campbell 1993:398).

Whether this species is capable of introgressive hybridization with native bull trout appears to be unknown. If it is, native bull trout populations in the drainages in which it was introduced may have been contaminated with the genes of this species.

Bull trout — The bull trout is native to all major drainages in the CCRE, on both sides of the Continental Divide (Cavender 1978, Haas and McPhail 1991). There are many historical records of this fish that provide evidence of its former great abundance and exceedingly large sizes attained throughout the study area.

Figure 6 presents an interpretation of the native range within the CCRE based on historical records, present distribution and stream accessibility. Bull trout have been excluded by impassable falls from extensive portions of the CCRE. The most notable examples are in the Ram and Siffleur

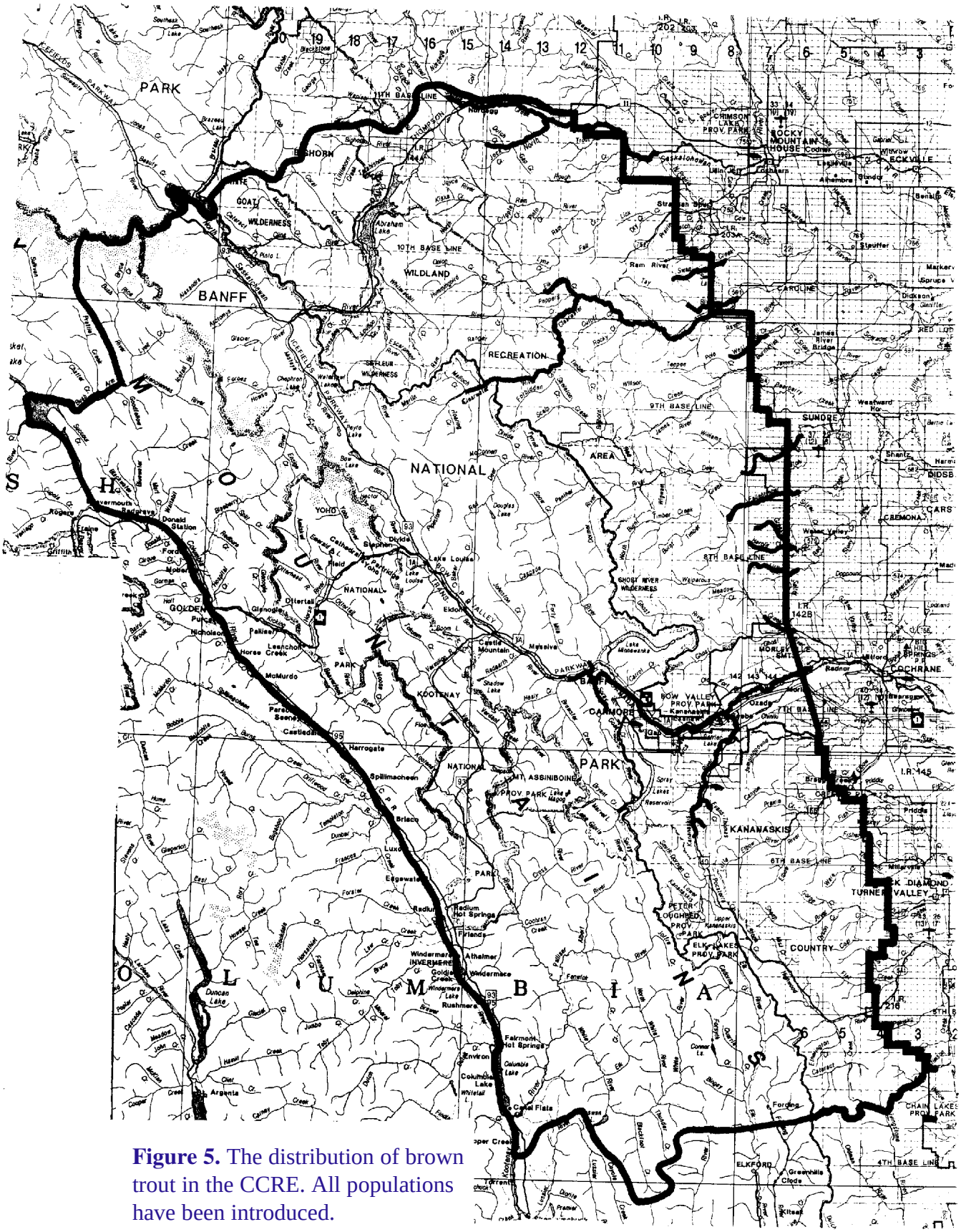

Figure 5. The distribution of brown trout in the CCRE. All populations have been introduced.

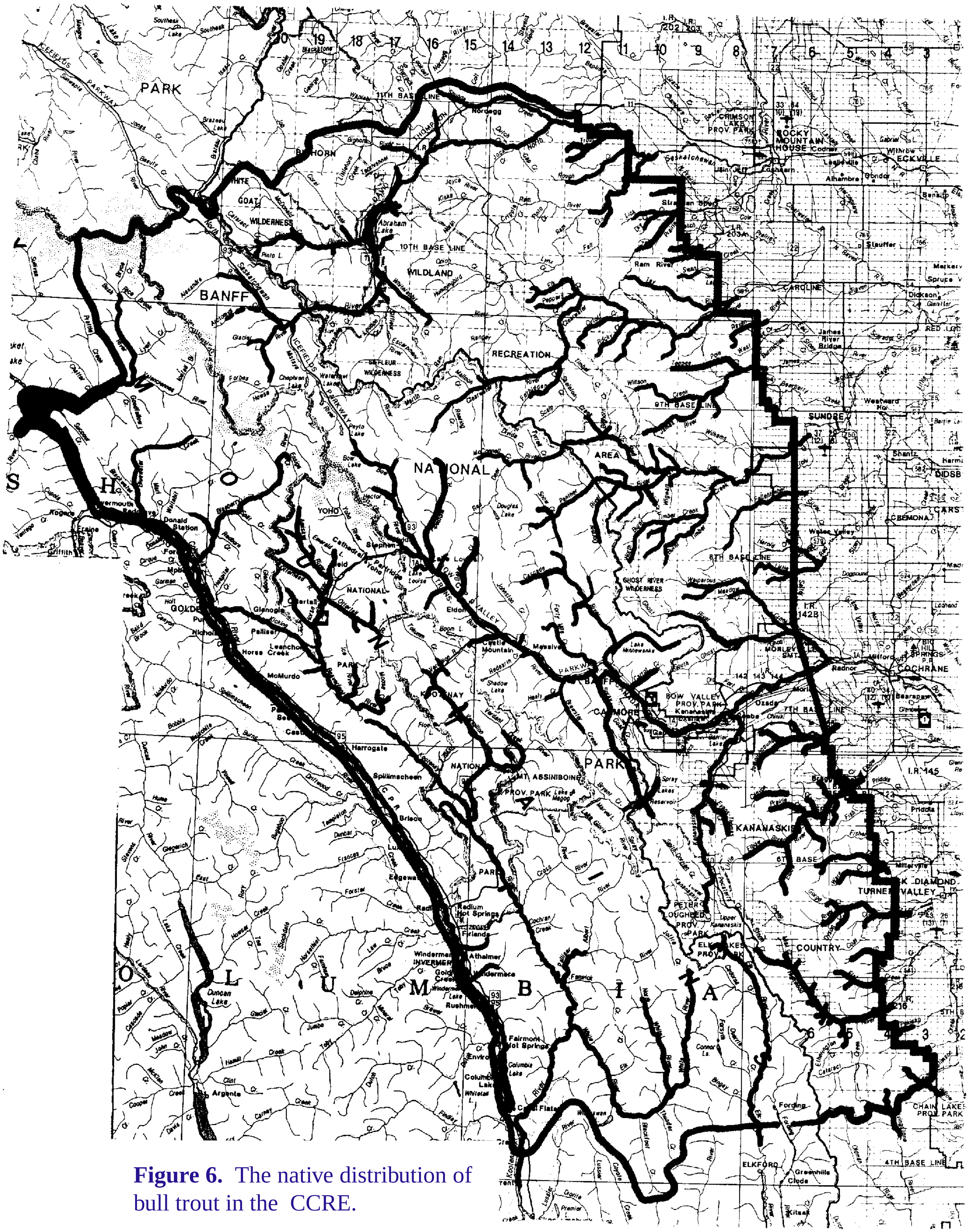

Figure 6. The native distribution of bull trout in the CCRE.

rivers, North Saskatchewan drainage; and in the Cross, upper Palliser and upper Fording rivers, Kootenay drainage. On the other hand, bull trout appear to be native above several present-day barriers to migration. Examples are Pinto Lake, Cline-North Saskatchewan drainage (Schäffer 1911:48, Carl et al. 1989); above Wapta Falls in the upper Kicking Horse drainage, YNP (see Discussion); and in the upper Blaeberry drainage above Blaeberry Falls, Columbia drainage (Triton Environmental Consultants 1992).

Figure 7 illustrates the present distribution of bull trout in the CCRE as documented since 1974, when this fish was last described as generally abundant in the study area (Ward 1974:8). In many of its native waters the species is scarce but still extant (e.g., Bow River drainage above Bow Falls; Mayhood et al. 1976:56-57, Mayhood and Paczkowski 1993). Exceptions include complete losses from Bow and Hector lakes, apparently due to displacement by lake trout (Donald and Alger 1993), and from Spray Lakes after it was converted into a hydroelectric reservoir and stocked with lake trout (Wilcox 1900, Vick 1913, Miller and Macdonald 1950; cf. Crosby 1990b). Bull trout also are virtually absent from their former habitat in the mainstem Bow River below Bow Falls at Banff, and from the Kananaskis River mainstem (Nelson 1965, Howes 1976, Thompson 1977). Other apparent differences between the present and native ranges are certainly due to lack of recent sampling in many drainages, especially in remote areas. There can be little doubt, though, that bull trout are much less abundant in the study area now than formerly, to the extent that the species has virtually disappeared from much of its former habitat in the CCRE.

The bull trout is internationally recognized as vulnerable throughout its range (Williams et al. 1989), and an application for listing it for protection under the Endangered Species Act has been made in the USA. Its status in Canada has been under review by COSEWIC since at least 1988 (Campbell 1988:84, 1993:398). Alberta has recently implemented a special management and recovery plan for bull trout (Berry 1994).

Brook trout — Native to eastern North America, brook trout have been introduced into every major drainage of the CCRE (Figure 8). They have become widely established in all drainage basins in the study area, with the possible exception of the Columbia mainstem and its immediate

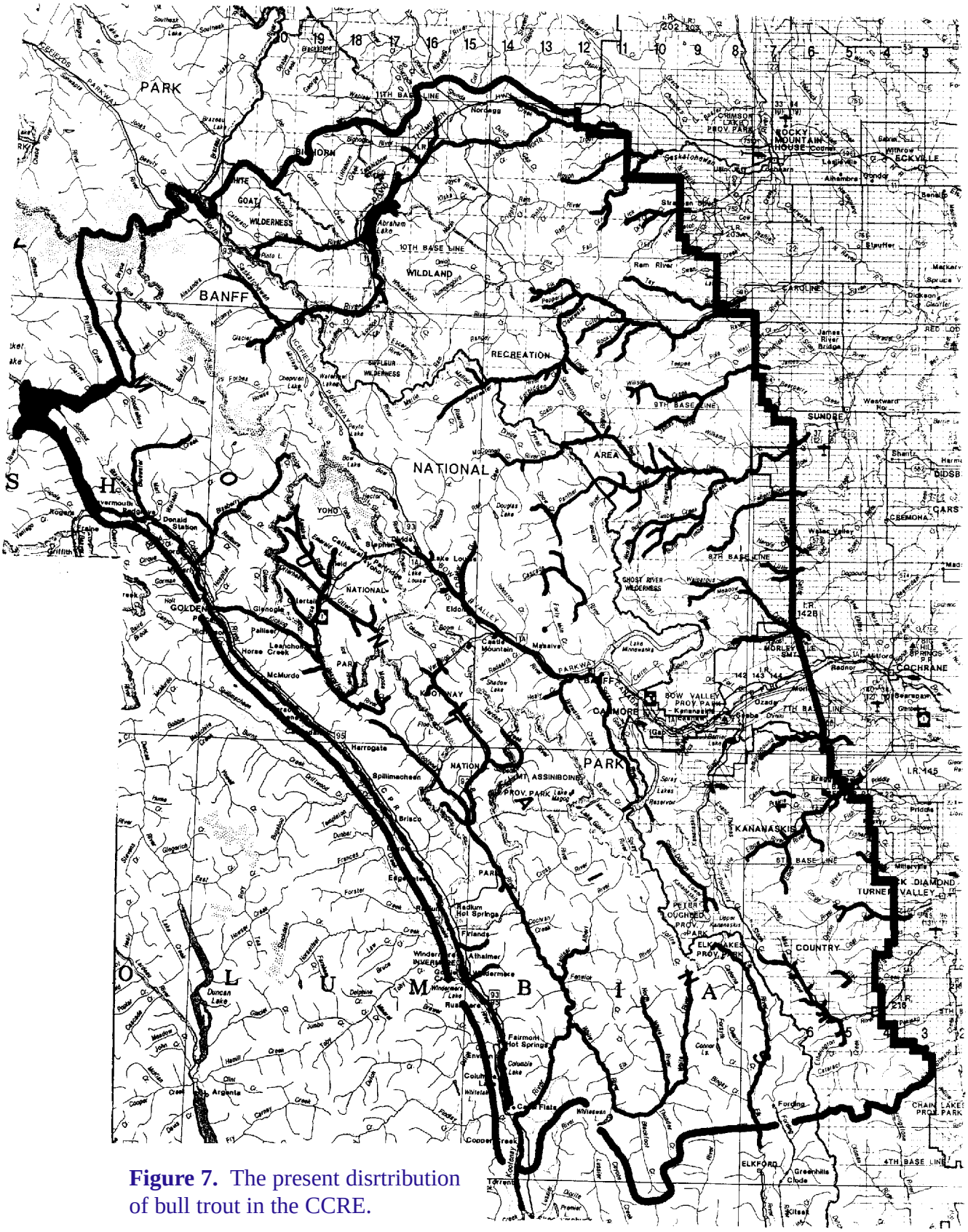

Figure 7. The present disrtribution of bull trout in the CCRE.

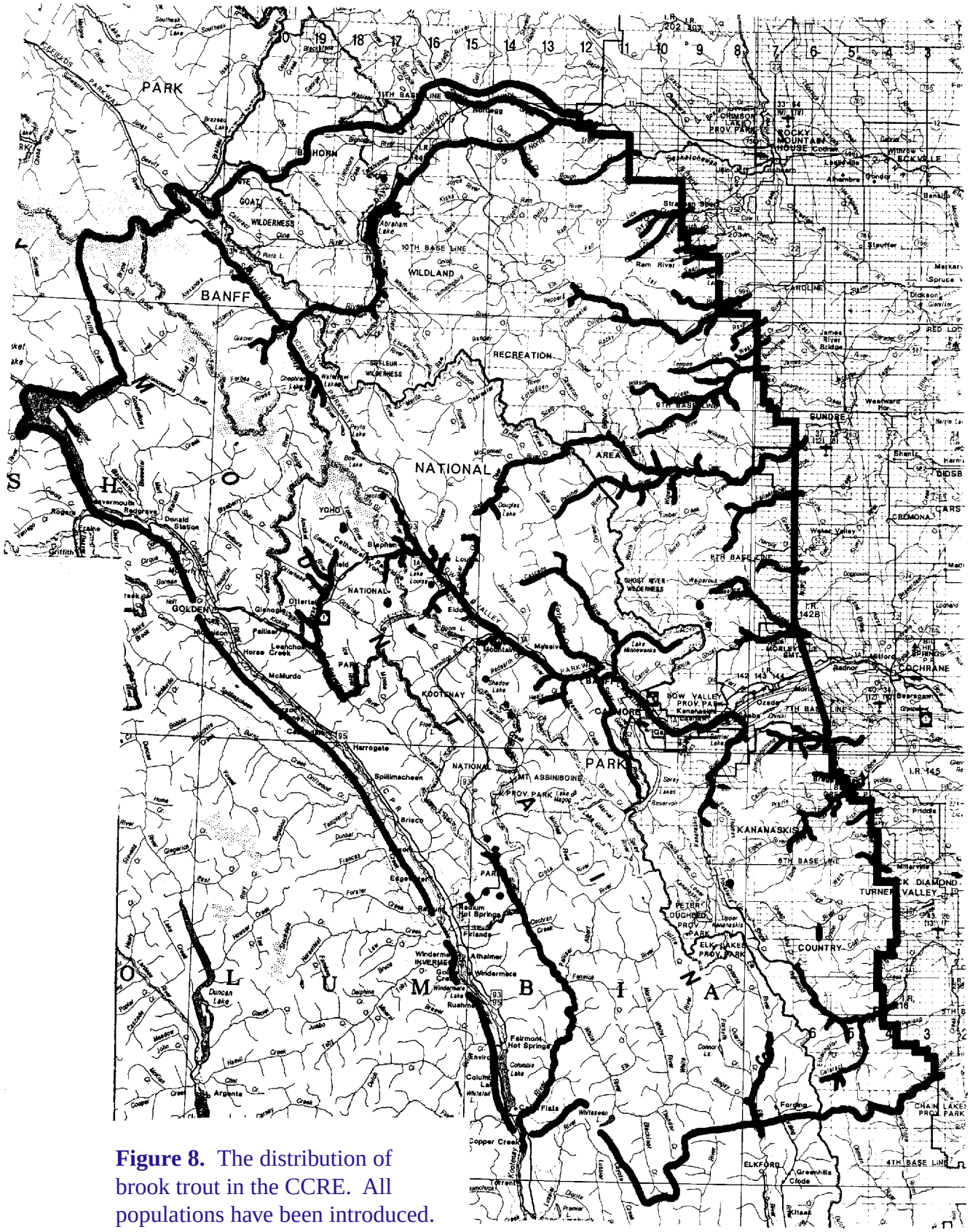

Figure 8. The distribution of brook trout in the CCRE. All populations have been introduced.

tributaries, where the only specimen record I encountered was for Succour Creek (Fielden et al. 1992). Brook trout constitute a threat to weakened bull trout populations where the two occur together by producing hybrids with that species that rarely reproduce (Leary et al. 1983, 1993).

Dolly Varden — True Dolly Varden charr (as opposed to misidentified bull trout) occur within the CCRE in just one location: Chester Lake, in the extreme headwaters of the Kananaskis drainage[1], Bow River basin. According to Nelson and Paetz (1992), who discussed the origin of this stock at length, these fish were introduced in 1974, and are the northern form of the species.

Dolly Varden and bull trout can hybridize and produce viable offspring (Cavender 1978, Haas and McPhail 1991). Chester Lake has a permanent outlet that could easily allow individuals of this stock to escape downstream to Smuts Creek via Mud Lake reservoir, and from there ultimately to the rest of the Spray drainage and to the Bow River. There already are in fact credible angler reports of northern Dolly Varden in the upper Smuts Creek drainage (Jim Stelfox, Alberta Fish and Wildlife, personal communication 1994). A failure of the Mud dam, diversions by the utility company or angler releases would allow access to Smith-Dorrien Creek. Once there, Dolly Varden would pose a threat to the genetic integrity of the trophy native bull trout stock presently being restored in Smith-Dorrien Creek. In the worst case, this exotic species eventually could genetically contaminate all remaining native bull trout stocks in the Bow River watershed not presently protected above barriers to dispersal. These include essentially all those below Bow Falls (Bow River at Banff) and the Glenmore dam (Elbow River at Calgary), as well as virtually all remaining stocks in the Highwood drainage (possibly exclusive of those in the upper Highwood River above a barrier below the CCRE boundary).

Lake trout — Lake trout are believed to be native to a small number of lakes and associated rivers on the east slopes within the CCRE, in the North Saskatchewan (Glacier, Outram, Clearwater, Swan lakes, North Saskatchewan and Alexandra rivers) and Bow (Minnewanka) drainages (Ward 1974, Nelson and Paetz 1992, Donald and Alger 1993). The species

[1] This is the natural drainage. A dam on Mud Lake at the height of land now causes Chester Creek to drain to Smuts Creek, Spray River drainage, Bow basin.

has been introduced into Bow and Hector lakes, and Spray Reservoir, all in the Bow drainage; and into the Kicking Horse drainage in Wapta and Sherbrooke lakes (Donald and Alger 1993). A record of a single lake trout from Moraine Lake (Mayhood and Anderson 1976, Mayhood 1978) was in fact a splake (Mudry and Anderson 1977:26): there is no record of lake trout being stocked there (Ward 1974). Non-native lake trout stocks have been introduced into waters with native lake trout stocks in Lake Minnewanka (BNP stocking records) and possibly in Swan Lake (Steve Herman, Alberta Fish and Wildlife, personal communication). It is presently not known whether introduced and native lake trout stocks have introgressed where they have come into contact, although the potential clearly exists for it. Native bull trout have been displaced by lake trout introduced into Bow and Hector lakes, although native stocks of each species continue to coexist in two relatively pristine CCRE lakes (Glacier and Clearwater, Donald and Alger 1993).

Splake — This hybrid of lake trout and brook trout was produced for many years in the Banff hatchery (Stenton 1950, 1952; Solman et al. 1952; Ward 1974). The hybrid is both viable and highly fertile, capable in turn of producing viable, fertile offspring in matings with other splake or with either parental species (Stenton 1950, 1952; Buss and Wright 1956, 1958; Berst et al. 1980). In this sense it may be considered a hybrid species. Spawning and natural recruitment in the wild occurs (Goldberg et al. 1967, Berst et al. 1980:878-880), and if continued ultimately would produce an introgressed hybrid swarm in which it would be visually impossible to distinguish certain hybrids from the parental species (cf. Berst et al. 1980:843).

Splake were stocked into several CCRE lakes in BNP (Agnes, First Block, Second Block, Boulder, Hector, Herbert, Louise, Minnewanka, Moraine, Mosquito, Turquoise and Two Jack lakes, Bow drainage; Sunwapta Lake, North Saskatchewan drainage), YNP (Duchesnay, Summit and Wapta lakes) and KNP (Kootenay Pond) (Ward 1974). The Agnes Lake population reproduced successfully in 1954 after its introduction in 1951 (Goldberg et al. 1967, Ward 1974), and persisted until at least 1975, although it apparently was very small then and in 1976 (Mayhood and Anderson 1976:14). The reproductive success and continued existence of most other populations is unknown, although the populations in Hector, Minnewanka and Turquoise lakes are thought to be naturally reproducing

(Ward 1974:Appendix C, but cf. Ward 1974:12).

Because many of these populations have access via lake outlets to lake trout, brook trout and other splake populations, it is conceivable that lake trout-brook trout genetic introgression has spread beyond the original stocking sites. This is particularly true in the Bow drainage, where splake, brook trout and lake trout introductions have been numerous and where brook trout are widespread and often abundant. All populations of lake trout and brook trout that are or were accessible to splake populations should be considered potentially contaminated with the genes of brook trout or lake trout, respectively.

Cisco — Ciscoes of Great Lakes origin were successfully introduced into Lake Minnewanka (Bow drainage) in 1916-17 (Ward 1974). A stock introduced into the Spray reservoir in 1953, though initially successful, now appears to be declining toward extirpation (J. Stelfox, Alberta Fish and Wildlife Service, personal communication; Nelson and Paetz 1992). The locality record of cisco in the headwaters of the North Saskatchewan given by Scott and Crossman (1973:238) requires confirmation. Although the species is under review by COSEWIC for possible listing as endangered (Campbell 1993:398), this evidently refers only to populations in lakes Ontario and Erie (cf. Campbell 1992:4). The Great Lakes stock in Lake Minnewanka thus might have special value for preservation if it was derived from either of these lakes.

Lake whitefish — Lake whitefish were introduced unsuccessfully into Lake Minnewanka (Bow drainage) in 1953-58 (Ward 1974:22). Nelson and Paetz (1992:239) suggest, however, that this introduction may have given rise to a lake whitefish population now existing downstream in Ghost reservoir on the Bow mainstem.

Pygmy whitefish — The Kicking Horse River at Field is the type locality for the pygmy whitefish (Eigenmann and Eigenmann 1892, Eigenmann 1895). The Columbia mainstem drainage within the CCRE harbours it as well: it has been recorded from Kinbasket Lake and the Blaeberry River (McCart 1970). The pygmy whitefish has not been reported from any of the other major drainages of the CCRE. The type locality at Field has been repeatedly abused by construction activities and poor sewage disposal practices (M. Pole, personal communication 1991). The impact of these abuses on the the originally-described population is not known.

Mountain whitefish — Like bull trout, mountain whitefish are widespread in all major drainages in the CCRE (Figure 9). Most stocks appear to be intact. Mountain whitefish do seem to have disappeared from Jumpingpound Creek within the study area sometime between the mid-1960s and the late 1970s, however (Cunningham 1961, 1962, 1964; cf. Tripp et al. 1979, Nibourg 1985). In addition the Bow Lake population may have declined markedly since the 1930s, judging from catch-per-unit-effort comparisons (Donald 1987:551, Donald and Alger 1993:242).

Arctic grayling — Arctic grayling were recently introduced into the CCRE: in Big Iron Lake and Bear Pond, close together in the extreme headwaters of the Willow Creek drainage, Oldman River system. The Big Iron population is reproducing, and is expected to maintain itself (J. Stelfox, Alberta Fish and Wildlife Service, personal communication).

Trout-perch — This species has been recorded near or in the CCRE in Jumpingpound Creek, and near the study area in Threepoint, Fish and Fisher creeks, Bow drainage; and near or in the CCRE in the James River drainage, Red Deer system (Henderson and Peter 1969, Monenco Consultants Limited 1982). The species might occur within the study area in these and other streams on the east slopes (Nelson and Paetz 1992:299).

Burbot — Burbot are known to occur within the CCRE in the Bow, Red Deer and North Saskatchewan drainages (Henderson and Peter 1969, Nelson and Paetz 1992, Alberta Fish and Wildlife Service file data), and in the mainstem Columbia (Eigenmann 1895, Carl et al. 1959:142). The species does not appear to occupy the upper Kootenay drainage (Scott and Crossman 1973, Lee et al. 1980, Alger and Donald 1984), nor are there records for the Kicking Horse drainage above Wapta Falls (M. J. Pole, personal communication).

Western mosquitofish — This species was introduced in 1924 into the Cave and Basin hotsprings to control mosquitoes, and now is thriving there (McAllister 1969, Nelson 1983). It has been cited as one of several exotic fishes possibly contributing to the extinction of the Banff longnose dace endemic to this site (Renaud and McAllister 1988). It may not be able to successfully reproduce in the cold waters of the Bow drainage beyond the immediate hotsprings area, although it has been reported under the ice

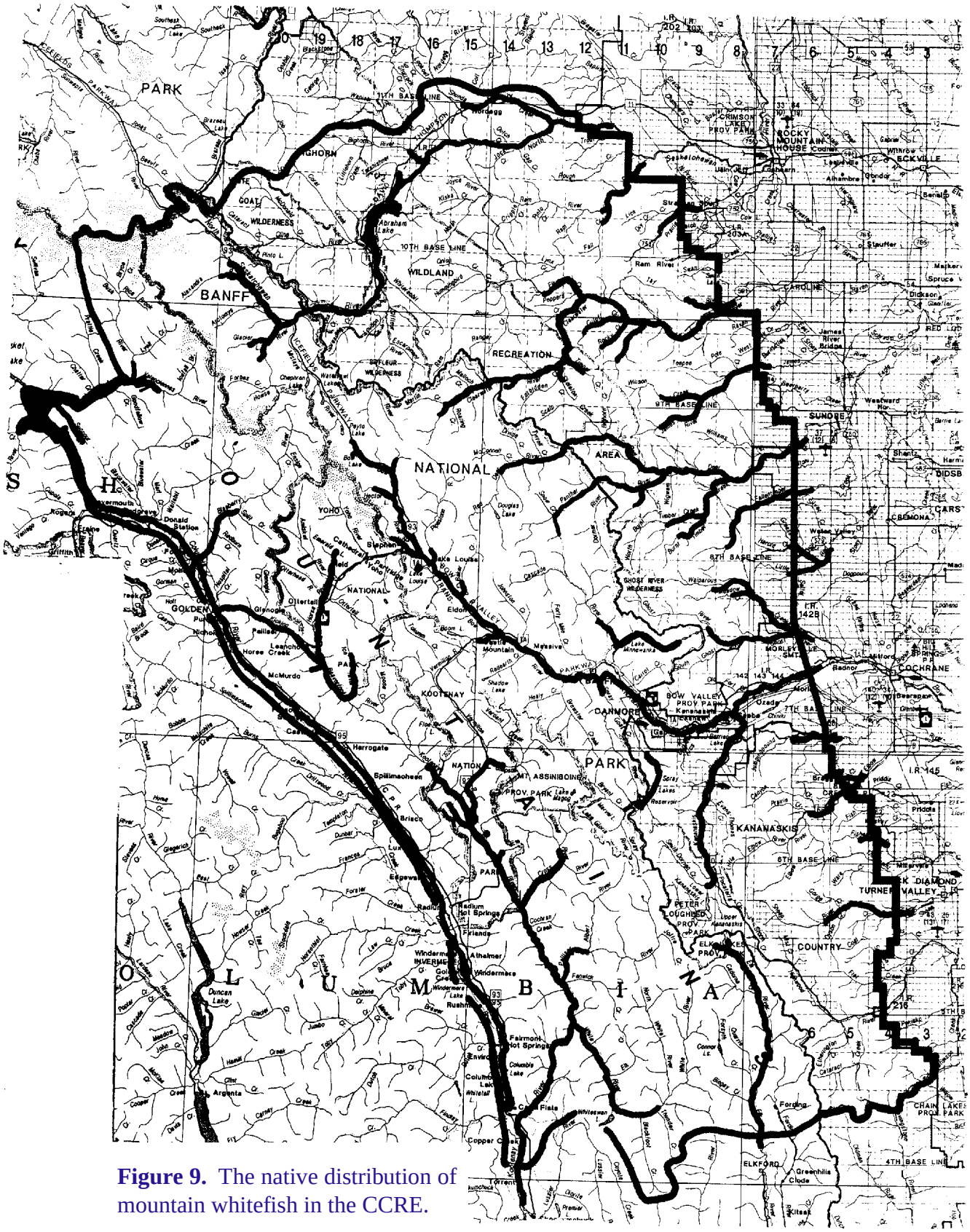

Figure 9. The native distribution of mountain whitefish in the CCRE.

of the Cave and Basin marsh in winter (Nelson and Paetz 1992). Mosquitofish once were found in the warm spring across the Bow River at Third Vermilion Lake (Ward 1974), but this population has not been seen for some time (Sentar 1992). The mosquitofish is found nowhere else in the CCRE.

Sailfin molly — This tropical species was introduced into the Cave and Basin hotsprings marsh at Banff in 1960 by a local aquarist (Nelson and Paetz 1992). It has since established a self-sustaining population there, but probably cannot survive beyond the immediate vicinity of the hotspring waters. The sailfin molly has been cited as one of several exotic fishes possibly contributing to the extinction of the Banff longnose dace endemic to this site (Renaud and McAllister 1988).

Guppy — Guppies introduced by local aquarists into the marsh at the Cave and Basin hotspring and the warm spring at Third Vermilion Lake have not survived (Ward 1974:31, Nelson and Paetz 1992:382, Sentar 1992).

Green swordtail — This tropical fish initially was successfully introduced by aquarists into the marsh at the Cave and Basin Hotsprings, but has subsequently disappeared (Ward 1974, Nelson and Paetz 1992).

Brook stickleback — Brook sticklebacks occupy the Bow, Red Deer and North Saskatchewan watersheds in the CCRE (Henderson and Peter 1969, Nelson and Paetz 1992, L. Rhude, personal communication). The species does not occur west of the Continental Divide in our area (Carl et al. 1959, Lee et al. 1980).

Mottled sculpin — Fielden et al. (1992) reported finding this species in one or more unspecified tributaries to Kinbasket Lake. Some of their study streams were within the CCRE. The record needs confirmation. This is a taxonomically difficult and variable species in need of revision, being readily confused with the shorthead sculpin, *Cottus confusus* (Peden et al. 1989), recognized by COSEWIC as a threatened species (Campbell 1993). If the identification is correct, it marks a major range extension of more than 300 km above the closest previously-identified population in the Columbia system (Peden et al. 1989).

Slimy sculpin — This widespread sculpin is absent from east slope streams within the CCRE (Nelson and Paetz 1992). It is known west of the divide from the mainstem Columbia, Kootenay and Kicking Horse drainages, including the latter drainage above Wapta Falls (Eigenmann and Eigenmann 1892, Eigenmann 1895, Carl et al. 1959, Ward 1974, Alger and Donald 1984).

Torrent sculpin — The torrent sculpin has been reported from just outside the CCRE in the Columbia mainstem at Kinbasket Lake, and in the Kootenay drainage from the Canal Flats area (Lee et al. 1980). The only records for the species within the CCRE, however, are in Emerald Lake and Ice River, above Wapta Falls in the Kicking Horse drainage (M. J. Pole, personal communication 1991; Pole 1991 cited in Triton Environmental Consultants Ltd. 1992). Torrent sculpins are not known to occupy streams east of the Continental Divide anywhere within their range (Lee et al. 1980:822).

Spoonhead sculpin — There are records of this species in the study area in the North Saskatchewan and Red Deer drainages, but the nearest records for the Bow drainage are downstream from Cochrane and in lower Threepoint Creek (Henderson and Peter 1969, Ward 1974, Nelson and Paetz 1992). The spoonhead sculpin has not been found anywhere in the Pacific drainage (Lee et al. 1980).

Sunfish (unidentified) — RL & L Environmental Services Ltd. (1993) reported collecting young centrarchids of the genus *Lepomis* in Columbia Lake, on the mainstem Columbia River. This population clearly has resulted from an introduction.

Smallmouth bass — Ward (1974:2), citing a "memo on old National Park files," reported the introduction of this species to Lake Minnewanka in 1901-02. This is undoubtedly the failed introduction to this lake of "some 500 parent Black Bass and some 3,000 fingerlings" referred to by the Dominion Alberta and Saskatchewan Fisheries Commission of 1910-11 "some ten years ago" (Prince 1912:48). The term "black bass" was commonly used for both this and the following species (Prince et al. 1912:48-49).

Largemouth bass — Windermere Lake, on the Columbia River mainstem, is said to hold this introduced species (W. Westover, personal communication). Prince et al. (1912:38) did not believe that introducing bass to this lake would be successful, but raised a concern that if successful the species might spread elsewhere in the system "where they were not desired."

Convict cichlid — the convict cichlid, a tropical species, was introduced without success into the marsh at Cave and Basin Hotsprings, BNP (Bow drainage) by local aquarium hobbyists (Nelson and Paetz 1992:385).

African jewelfish — This is another of the many tropical species that have been introduced into Cave and Basin hotsprings in BNP (Nelson and Paetz 1992). The African jewelfish probably is not capable of surviving outside the confines of the marsh fed by the hotsprings.

Freshwater angelfish — Nelson and Paetz (1992:385) state that this tropical species, once introduced into the marsh at the Cave and Basin Hotsprings, BNP (Bow drainage) has not been seen since 1968, and probably did not survive for long.

Discussion

Faunal Loss: Causes and Consequences

Native fish stocks have not fared well in the CCRE. Of the 33 species believed to be native to the study area or adjacent connected waters, at least 10 have suffered impacts of significant conservation concern (Table 3). Only four native species could be considered to have benefitted overall from human intervention. It is worth elaborating on some of the more significant concerns, emphasizing two of the most prominent species.

Westslope Cutthroat Trout

Westslope cutthroats like other interior subspecies have been decimated throughout their range by the cumulative effects of overexploitation, habitat damage, displacement by introduced species and genetic introgression from introduced black-spotted trout stocks (e.g., Nelson 1965; Reinitz 1977; Bjornn and Liknes 1986; Allendorf and Leary 1988; Liknes and Graham 1988; Trotter 1991; Behnke 1992). Of these, introgressive hybridization with introduced rainbow trout and non-native cutthroat stocks is often considered to have been the factor most responsible for the destruction of this subspecies.

An exotic subspecies, the Yellowstone cutthroat, has been widely introduced in the national parks of the CCRE, exposing many native westslope cutthroat populations to introgression (McAllister et al. 1981). A genetically-pure population of Yellowstone cutthroats still exists in Taylor Lake (Bow drainage, BNP, McAllister et al. 1981), and probably also in several other park lakes. Cutthroats from the state of Washington, possibly coastal cutthroats, also were stocked in the Bow drainage for several years (Techman Ltd. 1980).

But I believe by far the most serious hybridization problem arose from the introduction of rainbow trout, widely, persistently and in large numbers, into waters that had been depleted of their native cutthroat stocks, with the results described in this report. Complaints of widespread overfishing and wanton destruction of trout populations by almost every conceivable

Table 3. Summary of the status of native fishes in the CCRE. Designations refer to the study area only unless stated otherwise. Only species of some conservation concern are included.

Species	Status
Pacific lamprey	probably extirpated, but conceivably a landlocked stock still exists
white sturgeon	status unknown: no longer anadromous, stock may be extirpated
chiselmouth	rare at best, COSEWIC review re possible status as vulnerable in BC
lake chub	range expanded through introductions, commonly hybridizes with longnose dace in reservoirs
longnose dace	range expanded through introductions, commonly hybridizes with lake chub in reservoirs
Banff longnose dace	extinct
leopard dace	possibly not in study area; uncommon, vulnerable to effects of dams
longnose sucker	several suspected introductions into non-native waters; commonly hybridizes with white sucker in reservoirs
white sucker	some suspected introductions into non-native waters; commonly hybridizes with longnose sucker in reservoirs
largescale sucker	some suspected introductions into non-native waters
westslope cutthroat trout	most native stocks destroyed, all remaining native stocks in native habitats endangered
rainbow trout	any possible anadromous stocks destroyed; native status unknown & threatened by introgression from non-native stocks
sockeye salmon	any native anadromous stocks extirpated
chinook salmon	extirpated
bull trout	extirpated from some waters, severely depleted throughout area; threat of introgression from introduced Arctic charr & Dolly Varden?
lake trout	native stocks rare, 2 possibly introgressed with introduced stocks
pygmy whitefish	population of type locality threatened by continued abuse of habitat

means in the CCRE were voiced shortly after the arrival of the CPR in the mid-1880s, and prompted immediate demands for hatchery restocking (Whitcher 1887; McIllrie and White-Fraser 1983, re 1890; Prince et al. 1912). The hatcheries were built and trout both native and exotic, especially rainbow trout, were transplanted or introduced throughout the CCRE (Miller and Macdonald 1950, Ward 1974, Donald 1987, Mayhood 1992a:9-14). Obvious rainbow-cutthroat hybrids were widespread by at least 1947

(Miller and Macdonald 1950, Miller 1950).

As of this writing, only 12 existing cutthroat stocks in the CCRE have been demonstrated by reliable biochemical means to be genetically pure. These are in Upper Block, Elk, First Fish, Second Fish, Third Fish, Marvel, Mystic, Taylor, Lower Twin (all in BNP) and Picklejar #4 lakes (Bow drainage); Floe (KNP) and Connor lakes (Kootenay drainage) (McAllister et al. 1981, Leary et al. 1985, Carl and Stelfox 1989). The Marvel and Connor lakes stocks have been widely transplanted in Alberta and BC, respectively. While many of the populations arising from these transplants may remain genetically uncontaminated, they represent only two genetic lines, each of which is remarkably homogeneous (i.e., highly homozygous) (McAllister et al. 1981, Carl and Stelfox 1989).

At least four of these pure stocks certainly are not indigenous to the waters in which they are now found. As noted above, the Taylor Lake population is an exotic (non-Canadian) subspecies almost certainly derived from Yellowstone Lake, Wyoming (McAllister et al. 1981). The Marvel Lake population was transplanted from the nearby Spray Lakes (Rawson 1947, Techman Ltd. 1980). The Floe Lake population was not native to that lake, and almost certainly no longer exists due to lack of natural recruitment (Donald and Alger 1984). Floe Lake was last stocked with cutthroats from an unknown source in 1968 (BNP stocking records cited by Techman Ltd. 1980). The Upper Block Lake population is self-maintaining, but is known to have been stocked in 1957 (source unknown) and 1958 (Cranbrook hatchery) (Ward 1974, Techman Ltd. 1980). This lake lies over 300 metres above the valley floor at the top of a cliff, lacks a surface outlet, and certainly was inaccessible to colonizing native fish.

In addition to the above, there are reasonable concerns about whether some of the other genetically-pure populations are truly indigenous to the lakes in which they are found. For example, Lower Twin Lake does have a permanent surface outlet that would appear to be passable to fish, and a self-maintaining cutthroat population. This lake, however, was either stocked directly with cutthroats from an unrecorded source in 1953 (Ward 1974), or was accessible to cutthroats from an unrecorded source stocked in the upper Twin Lake that same year (Techman Ltd. 1980). Because unrecorded introductions were commonly made in lakes of the national parks for many years, at this time we cannot be entirely confident that *any*

of the known genetically-pure populations are actually native to the waters in which they are now found.

All or nearly all of the native stream populations in the Bow, Kootenay and upper Kicking Horse drainages have been exposed to introgression from introduced rainbow trout (Figure 2, cf. Figure 4), and sometimes from introduced cutthroat stocks. Most remnant populations throughout the mainstem Bow, Jumpingpound, Elbow, Sheep and Highwood basins show the effects of introgression with rainbow trout in their colouring, spotting patterns and morphology. Difficulties in distinguishing between introduced rainbow and native cutthroat trout in these drainages, evident at least by 1947-1949 (Miller and Macdonald 1950:41-44, Miller 1950), were almost certainly due to widespread introgressive hybridization.

The existing lake populations in the Bow and other CCRE drainages under Alberta jurisdiction are mostly introduced populations derived from a single, genetically-depauperate Spray Lakes stock via Marvel and Job lakes (Rawson 1947, Techman 1980, McAllister et al. 1981, Carl and Stelfox 1989). Introduced populations in the North Saskatchewan and Red Deer drainages have greatly expanded the range of westslope cutthroat trout in the CCRE. Isolation of transplanted westslope cutthroats above major falls in the Ram, Palliser and Fording river drainages may serve to protect at least two or three artificial stream stocks from genetic contamination in future, if in fact these populations originated from genetically uncontaminated stocks in the first place.

The westslope cutthroat trout is so genetically distinct from all other cutthroats that it should be treated as a separate species in its own right (Leary et al. 1987, Allendorf and Leary 1988). Given the widespread destruction of its stocks throughout its range, it is critical to preserve all remaining genetically-pure stocks of this fish.

A high proportion of the total genetic diversity of westslope cutthroat trout is represented by unique alleles existing at high frequency in isolated, genetically-uniform populations (Leary et al. 1987). This is particularly true of the remnant stocks in the Bow basin, which are especially divergent genetically among themselves and as a group from stocks elsewhere throughout the range of the subspecies (Leary et al. 1985). For this reason, preserving the remaining genetic integrity of this subspecies requires preserving as many local native populations as

possible (Leary et al. 1987, Allendorf and Leary 1988), those in the Bow drainage being especially important to protect in this respect.

Bull Trout

Almost everything about the biology of the bull trout makes it vulnerable to extirpation, so the possible causes for the decline of this species in the CCRE are numerous (Mayhood 1992b:186-205, Rieman and McIntyre 1993). Bull trout mature late, so become vulnerable to fishing mortality well before the age of first spawning. They seem to favour groundwater discharge areas, which usually have a limited distribution in most watersheds, as spawning and rearing habitat. Incubating bull trout embryos, early fry and juveniles are highly sensitive to silting and other bottom disturbances. Because many stocks home strongly to their native streams, a lost stock is not soon replaced. The adults are large (attracting angler interest), strongly predaceous and easily caught by angling. They are highly visible and easily poached in their tiny spawning streams. Adults undergo long spawning migrations in many stocks, and are therefore vulnerable to being isolated by dams from their spawning streams.

Depletion or complete loss of certain stocks in the Clearwater River appear to have been due to overexploitation rather than to habitat damage or displacement by exotics such as brown trout (Allan 1980). In contrast the nearly complete eradication of bull trout from the Kananaskis River system below Lower Kananaskis reservoir evidently had several contributory causes, including displacement by brown trout (which apparently were favoured in the widely fluctuating water levels of this hydroelectric dam-dedicated system) and overexploitation (Nelson 1965). It also seems likely that certain of the dams blocked spawning runs. Elsewhere depleted bull trout stocks have been linked to habitat disruption (especially siltation and increased bedload movement from disruptions in the watershed) and displacement by brook trout, which overwhelm bull trout populations by hybridizing with them to create offspring which fail to reproduce (Rieman and McIntyre 1993, Leary et al. 1993).

It is sometimes held or implied that overexploitation is the chief factor responsible for the decline of bull trout in Alberta (e.g., Roberts 1987, 1991, 1993; Palmer 1994). Clearly other factors are important in many cases. But more to the point, looking for a chief factor for population declines is misleading for future conservation efforts, because factors interact. For example, restoring a trout stock depleted by overfishing will be impossible if its critical habitat is not protected, or if introduced competitor stocks, now with the upper hand, occupy the habitat. Blocking access to spawning sites with a poor culvert or a dam will destroy the population whether it is fished or not. In managing, protecting or restoring fish stocks care must be taken to manage with the whole ecosystem in mind.

The losses and depletion of so many bull trout stocks in the CCRE is a serious threat to the continued existence of the species in the study area. Like westslope cutthroat trout, bull trout where they have been adequately studied show little within-population genetic variation, but significant genetic differences among populations (Leary et al. 1993). If the same is true of stocks in the CCRE, preserving the genetic diversity of bull trout here will require the continued existence of populations throughout the region.

Other Species

The causes of damage to the remaining native species adversely impacted by human activities in the CCRE are sometimes clearer to discern. Known or potential anadromous stocks of Pacific lamprey, white sturgeon, steelhead, sockeye salmon and chinook salmon have been destroyed (or possibly landlocked in some cases) by barrier dams on the Columbia River mainstem. Similarly, dams may now exclude lake sturgeon from entering East Slopes waters of the CCRE. Dams and impoundments have created favourable conditions for the invasion or introduction of many nonindigenous stocks (e.g., the spawning invasion of the upper Kootenay River in KNP by thousands of kokanee introduced into Koocanusa reservoir) and the extensive hybridization of several species (e.g., Nelson 1965, 1966, 1973).

The mechanism causing the extinction of the Banff longnose dace in Cave and Basin Hotspring is an example of how complex the causes of faunal

loss can be. Evidently introductions of several tropical species, periodic cessation of flows arising from the use of the hotspring as a public bath, periodic sewage spillage and introgressive hybridization of the weakened hotspring stock with another native subspecies all played a role in the demise of the subspecies (Renaud and McAllister 1988, Miller et al. 1989).

The New Fauna

In contrast to native fish stocks, many introduced stocks have done well in the CCRE. Of 21 species introduced to the study area or adjacent connected waters, 13 have managed to sustain populations somewhere within it (Table 2). At least eleven are of significant conservation concern (Table 4). None have produced significant new sport fisheries that could not have been provided by native or transplanted native stocks.

Table 4. Summary of the status of introduced fishes in the CCRE. Only species of some conservation concern are listed.

Species	Status
Yellowstone cutthroat trout	introduced widely into Bow drainage westslope cutthroat range, some introgression identified
kokanee	widespread, abundant, invades Kootenay National Park in large numbers
brown trout	introduced & expanding range in east slopes mainstems
Arctic charr	introduction apparently unsuccessful; some stocks possibly introgressed with native bull trout stocks
brook trout	widespread & well-established exotic in all major drainages; competitive threat to native cutthroat and bull trout
Dolly Varden	1 population, hybridization threat to 1 remnant bull trout population
lake trout	introduced stocks displaced bull trout in at least 2 lakes
splake	status unknown, introgression threat to some introduced lake & brook trout
cisco	1 introduced stock, potentially valuable for future reintroduction into native Great Lakes waters where stocks may be endangered
western mosquitofish	exotic contaminant of a unique hotspring habitat, possible contributor to extinction of Banff longnose dace
sailfin molly	exotic contaminant of a unique hotspring habitat, possible contributor to extinction of Banff longnose dace
African jewelfish	exotic contaminant of a unique hotspring habitat

The losses of so many native fish stocks, and the successful introduction and transplantation of non-native stocks, has transformed the fish fauna of the CCRE. The bull trout and cutthroat trout assemblage characteristic of the Bow drainage has been replaced by a trout fauna in which brook trout predominate above Bow Falls. Below Bow Falls brown and brook trout have completely replaced the native cutthroat and bull trout. The same native trout fauna of the lower Bow tributaries of Jumpingpound Creek and the Elbow, Sheep and Highwood rivers is now largely replaced by exotic brook and hybrid rainbow-cutthroat trout. The unique Cave and Basin microecosystem has been transformed into little more than a tropical fish pond.

Introduced cutthroat trout dominate the formerly fishless Ram River drainage above the barrier falls, and are widespread in the upper North Saskatchewan drainage. Brook trout are pervasive almost everywhere except the Columbia River mainstem and its direct tributaries, and introduced rainbow trout occupy large portions of the Kootenay drainage. The Columbia has lost its anadromous stocks of chinook salmon that so impressed the first European travellers. The native fish fauna of the upper Kicking Horse appears to have all but vanished, replaced by brook trout, and introduced rainbow and cutthroat stocks. Introduced brook and cutthroat trout occupy many dozens of formerly fishless mountain lakes. Several sucker and minnow species are expanding their ranges through illegal introductions. In almost every drainage the abundant supplies of large native trout reported by early anglers have been replaced by large reaches of empty stream habitat.

In short, the present fish fauna of the CCRE is overwhelmingly artificial, depauperate and dominated by exotic stocks. The native fauna has been largely obliterated; only tiny fragments remain.

Realistic Response: Ecosystems for Fish Conservation & Management

The pervasiveness of the changes in the fish fauna of the CCRE summarized above make it clear that the ecological integrity of the study area has already been lost. The question is no longer one of maintaining

ecological integrity of the region, but of retaining whatever remnants we can, perhaps restoring to some limited extent some small portion of the CCRE. The situation is analogous to a battle that has been decisively lost with appalling casualties, and the approach must be one of triage.

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triage: 1 the act of sorting according to quality. **2** the assignment of degrees of urgency to decide the order of treatment of wounds, illnesses, etc. — Concise Oxford Dictionary, 8th edition, 1990

Because the damage is so widespread and profound, and because related damage to other biota and habitats exists throughout the CCRE, it would prove futile to rely solely on the population-based approaches of traditional fishery biology to address the problems. An ecosystem-based approach is needed. But is the current conception of the Central Canadian Rockies Ecosystem suitable for dealing with the ecological disintegration of its fish stocks?

The Continental Divide separates two distinct native fish faunas within the CCRE. Of 33 species that are believed to be native to the CCRE or its immediate surroundings, 13 are native exclusively to waters on the west slopes, and 13 are native only to the east slopes. Just seven (lake chub, longnose dace, longnose sucker, westslope cutthroat trout, bull trout, mountain whitefish and burbot) occupy waters on both sides, but three of these (lake chub, longnose dace and burbot) are represented by different morphotypes or subspecies on either side of the divide (McPhail and Lindsey 1970:244, 1986:628-629; Renaud and McAllister 1988:108-110). Thus only 11% of the native fish fauna (four of 36 distinguishable types) is common to waters on both sides of the divide in the CCRE.

It is thus obvious that the Central Canadian Rockies Ecosystem as presently demarcated does not comprise an appropriate unit ecosystem for fish conservation and management. At the very least a useful natural ecosystem for such purposes should include all waters within which natural genetic interchange among aquatic populations is possible. It should also be functionally integrated such that the physical, chemical and biological elements and processes with which the fish stocks interact are

included within their ecosystem boundaries, while those with which there is little or no interaction are excluded. The fishes of the North Saskatchewan drainage, for example, do not interact with those in the Kootenay drainage. The physical, chemical and biological elements and processes of the Red Deer basin are not an integral part of the ecosystem of fishes in the Columbia drainage. What *is* of direct and intimate relevance to the Red Deer drainage fish stocks are the physical, chemical and biological elements and processes of the Red Deer basin. The North Saskatchewan basin fishes interact among themselves, and not with those on the far side of the Continental Divide.

For these reasons discrete drainage basins are especially useful natural ecosystem units for conserving and managing aquatic organisms and their habitats (Hynes 1975, Lotspeich 1980, Stanford and Ward 1992). Watershed ecosystems are inherently organized hierarchically, with related basins being nested together within common larger basins, a useful management arrangement. Several such watershed ecosystems incorporating the presently-defined CCRE have been used to organize the data for this report: the North Saskatchewan, Red Deer, Bow, Kootenay and Columbia rivers. The upper Kicking Horse drainage is a natural ecological subunit of the Columbia, with unique yet related features to those in the larger basin. Likewise the Ram drainage is a unique but integral part of the larger North Saskatchewan drainage.

Banff, Yoho and Kootenay national parks taken together can be thought of as the core area supporting the conservation of ecological integrity in the larger CCRE. Yet they would far better serve the purpose for fish conservation if managers organized their activities around watersheds as the unit ecosystems. For example the Kootenay drainage basin within Kootenay National Park should be thought of as a protected area of the greater Kootenay River Ecosystem. Somewhat similarly the upper Kicking Horse watershed within Yoho and Kootenay national parks is in fact a protected area for conserving as a whole this isolated unit ecosystem, a unique part of the Greater Columbia River Ecosystem. In fact, the major watersheds within these three national parks are headwater protected areas for no fewer than six regional ecosystems. In addition to the two just mentioned, these are the regional ecosystems of the North Saskatchewan, Clearwater, Red Deer and Bow river catchments. Similar roles can readily be perceived for the several provincial protected areas in the region.

The proposed regional watershed ecosystems and their headwater protected areas within the national parks are illustrated in Figure 10. Downstream boundaries are not shown for most, acknowledging the fact that sharp, ecologically-meaningful boundaries do not exist at the outlets of drainage basins except at barrier waterfalls.

The open-ended nature of these ecosystems forces us to view our aquatic conservation problems in a much more realistic context than the present enclosed, sharp and entirely arbitrary boundaries of the CCRE allow us to do. Instead of thinking of the CCRE as a tidy patch of landscape that we might eventually be able to control, we see it as vast open area from which everything we do within the region unavoidably leaks out. The national parks are shown in their true context, not as the centre of the regional ecosystem, but as rather small, marginal, out-of the-way adjuncts to much larger unit ecosystems.

The open-ended watershed model of the CCRE makes it clear that the parks can play only a limited role in protecting the regional aquatic ecosystems. Certainly the headwater areas within the national parks must be managed in such a way that the ecological integrity of the downstream watershed is not compromised. But most ecosystem protection must take place primarily outside the parks. In such ways as this, the watershed ecosystem view of the aquatic ecosystems of the CCRE will help us to conduct triage realistically.

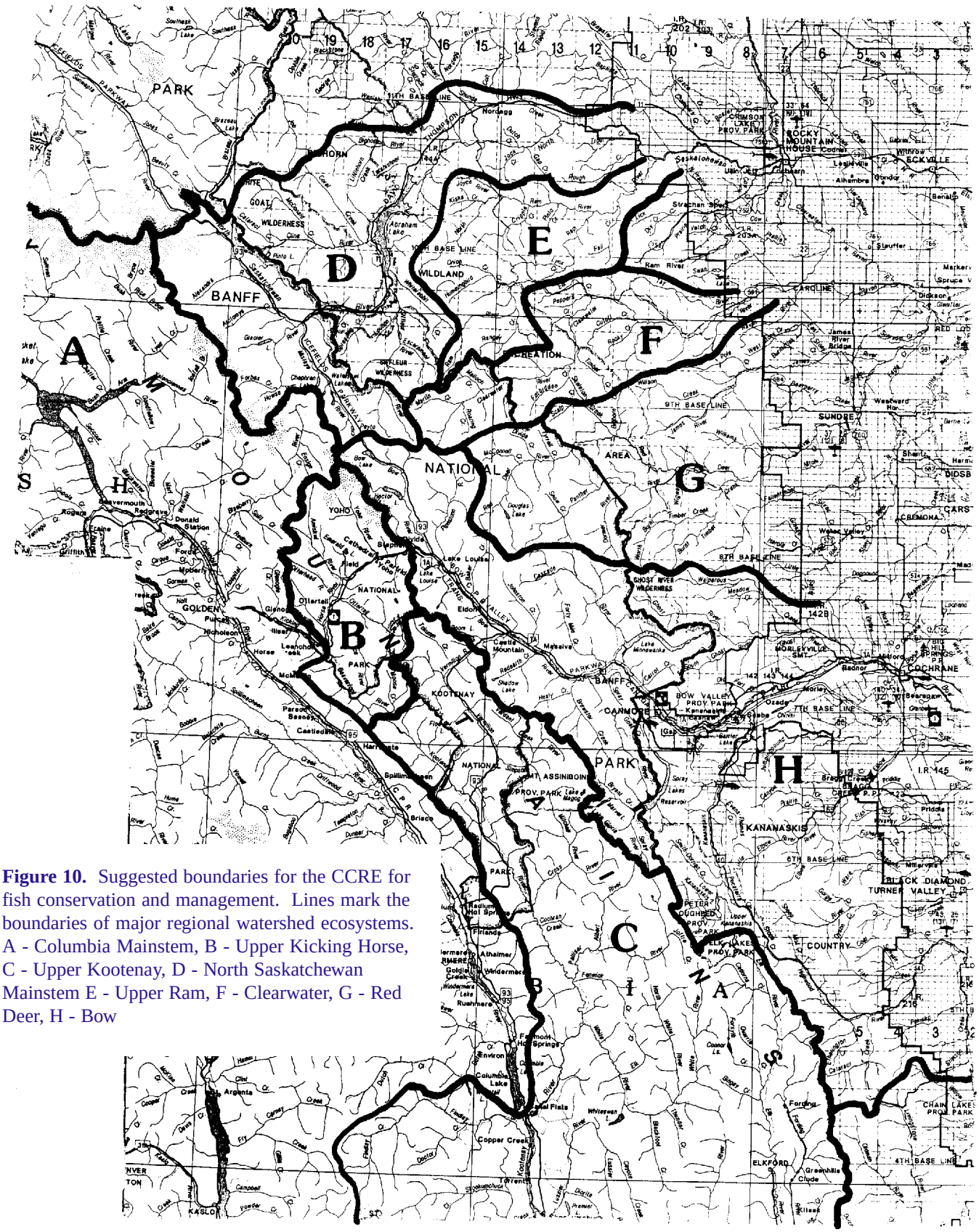

Figure 10. Suggested boundaries for the CCRE for fish conservation and management. Lines mark the boundaries of major regional watershed ecosystems. A - Columbia Mainstem, B - Upper Kicking Horse, C - Upper Kootenay, D - North Saskatchewan Mainstem E - Upper Ram, F - Clearwater, G - Red Deer, H - Bow

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