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WILDLIFE CONSERVATION SOCIETY CANADA

PROTECTING AND CONNECTING HEADWATER HAVENS

VITAL LANDSCAPES FOR VULNERABLE FISH AND WILDLIFE SOUTHERN CANADIAN ROCKIES OF ALBERTA

John L. Weaver

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SUMMARY

Some of the best-known and most-cherished mountains on Earth are set in the Canadian Rockies of Alberta and adjoining British Columbia. Indeed, the mention of Banff, Jasper, Kootenay or Yoho National Parks evokes images of snow-capped peaks, thundering falls and turquoise waters, numerous natural wonders and majestic wildlife. Waterton Lakes National Park in Alberta and Glacier National Park in Montana – brought together in 1932 as an International Peace Park by the respective Rotary Clubs – exemplify international cooperation and wilderness and wildlife without borders. All of these parks have been designated as *World Heritage Sites* in recognition of their outstanding natural importance to the common heritage of humanity.

In the midst of international acclaim over the past century for these spectacular Parks, however, the area between them has been overlooked by all but a few. Known as the Southern Canadian Rockies (or the Eastern Slopes in Alberta), much of this intervening landscape rivals the others in terms of sky-piercing mountains and verdant forests. Here are the headwaters of rivers that provide precious water for all life – including people on the ranches and towns below. It supports one of the most diverse communities of big wildlife anywhere in North America – including grizzly bears and wolverines, mountain goats and bighorn sheep. For many years, the Southern Canadian Rockies enjoyed 'de-facto' protection due to few roads, local economies, and modest levels of mining and logging. That situation, however, began changing in the 1950s as extraction of oil & gas and timber expanded. The network of accompanying roads spread throughout the Southern Canadian Rockies, eventually penetrating all major valleys and into most tributary valleys.

Now, the melting glaciers of Glacier-Waterton Lakes National Park signal changes in climate that may become even more pronounced in coming decades. Climate scientists project that there will be warmer winters and hotter summers, decreasing snowpack and earlier melting in spring, declining stream flows and warmer streams, and longer wildfire season with more severe fires. In response, animals will need room to roam as they try to track the shifting location of their habitats. The problem for vulnerable species, of course, is that the landscape has been fractured by roads and developments – leaving few safe havens and safe passages. The challenge now is to match the spectacular beauty and wildlife/

water treasures of the Southern Canadian Rockies in Alberta with appropriate stewardship by charting new directions.

The purpose of this report is to inform discussions and decisions about land and resource management in the proposed South Saskatchewan River Land Use Plan. The goal is to assess the conservation value of 6,452 km^2 (2520 mi^2) along the Eastern Slopes south of Kananaskis Country to the US border for a suite of vulnerable fish and wildlife species: bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki lewisi*), grizzly bear (*Ursus arctos horribilis*), wolverine (*Gulo gulo*), mountain goat (*Oreamnus americanus*), and Rocky Mountain bighorn sheep (*Ovis canadensis*). In this conservation assessment, I (1) identify and map current and future key areas for these species using empirical data and models, (2) assess options for connectivity across Highway 3 and Continental Divide, and (3) recommend conservation lands such as Wildland Provincial Parks.

Bull trout and westslope cutthroat trout exhibit high vulnerability. They are adapted for cold waters – especially for spawning and rearing. Bull trout populations are impacted by non-native lake trout and brook trout, whereas westslope cutthroat trout can be hybridized by non-native rainbow trout. Although adult bull trout can move long distances, human fragmentation of streams can have acute impacts on connectivity. Bull trout and westslope cutthroat trout are vulnerable to several detrimental effects associated with roads such as increased sedimentation to streams. Finally, climate change may warm lower-elevation waters past their tolerance. Important elements in the conservation of these native trout include: (1) reduction of non-native trout and/or placement of barriers that keep them separate, and (2) protection of large patches of cold-water habitat. Regional strongholds for populations of bull trout are found in the Castle River, upper Oldman River, and upper Highwood River drainages. Populations of westslope cutthroat trout with intact genetic integrity occur in the upper Oldman and Livingstone River drainages, upper Castle and Carbondale River drainages, South Racehorse Creek, and tributaries to the upper Highwood River. These populations represent the last remnant pure populations of this threatened species in Alberta.

Although resourceful in finding food and habitat, **grizzly bears** have high vulnerability due to low demographic or population resiliency. Bears have very low reproduction and cannot quickly compensate for excessive mortality. Young females do not disperse very far, which makes bear populations susceptible to landscape fragmentation. Roads with even modest traffic volume can displace bears from key habitats and expose them to greater risk of human-caused mortality. Protection of large areas of productive habitats with security from human disturbance and mortality are key conservation measures.

About 62% of the area has very-high and high habitat value for grizzly bears, and another 20% has attractive habitat but low security. Very-high quality habitat occurs in the foothills region (much on private ranchlands) and also in the headwater basins of the upper Castle and Carbondale Rivers, upper Racehorse Creek, and upper Highwood River. (Adjacent to the Castle River, the Flathead River in B.C. sustains the highest density of grizzly bears recorded thus far for non-coastal populations in North America.) Intensive motorized recreation (ATVs) occurs extensively throughout the Southern Canadian Rockies of Alberta – with scant safe havens from higher mortality risk and displacement associated with the vast network of open roads. Along with other conservation measures, strategic management of access in the following basins would be especially important for grizzly bear recovery: upper Carbondale and Castle River, upper Racehorse and Dutch Creek, upper Oldman River, and west of Hwy 40/940 in the upper Highwood River.

Wolverines have high vulnerability. Although they have a broad foraging niche, wolverines select areas characterized by persistent snow cover during spring for their reproductive habitat, summer habitat, and dispersal routes. Wolverines have very low reproductive rates, too. Consequently, they cannot sustain high mortality rates, which can be exacerbated by trapping pressure. Wolverines appear sensitive to human disturbance near maternal sites. Due to their adaptation for snow environments, wolverines will be particularly susceptible to reductions in suitable habitat as a result of projected climate change. About 50% of the higher country of the Southern Canadian Rockies in Alberta appears suitable as habitat for the rare wolverine. (In the future, this may diminish to 30% as a result of warmer conditions – a decrease of 40%). Only 8% of the area appears suitable for critical maternal habitat. Key areas include all of the Castle and upper Carbondale River basins, upper Oldman River basin (including Racehorse-Dutch-Oldman-Cabin Ridge), and west of Hwy 40/940 in the upper Highwood River.

Mountain goats have high vulnerability. They are constrained to live on or near steep cliffs that provide escape terrain from predators and more accessible forage in winter. Female goats have very low reproduction rates and cannot quickly compensate for excessive mortality (notably hunting). Goats (primarily males) do disperse modest distances, which may provide some connectivity among proximal populations. Mountain goats are especially sensitive to motorized disturbance and access. Suitable habitat for mountain goats is rather limited in southwest Alberta – about 9% of the area appears suitable as summer habitat; and only 2% as suitable habitat for the critical winter period. Goat habitat occurs in a narrow strip all along both sides of the Continental Divide from Waterton Lakes National Park north to Highwood Pass and also along the crest of the Livingstone Range. Recent surveys have tallied 250-300 goats on Provincial lands.

Bighorn sheep exhibit moderate vulnerability. They need cliffs for escape terrain, too, but have a narrower feeding niche on grasses. Female sheep have low to moderate reproduction, but wild sheep are highly susceptible to outbreaks of disease (some carried by domestic sheep) that can decimate a herd quickly. Because Rocky Mountain bighorn sheep have strong fidelity to chosen sites, they do not disperse very readily and have a low capacity for re-colonizing vacant habitats. Bighorn sheep appear less sensitive to motorized disturbance than goats. Warming winter climate could enable elk to range higher and compete with bighorn sheep. Thirteen herds totaling 650-700 bighorn sheep spend the winter on 11-13 winter ranges along the eastern slopes of the Southern Canadian Rockies in Alberta. Winter range comprises about 13% of the area and summer habitat 16%. Key areas include: Prairie Bluff-Yarrow,

Table Mountain, and Barnaby Ridge north of Waterton Lakes National Park; Sentry-McLaren Mountain south of Crowsnest Pass, South Livingstone Range, Cabin Ridge and Pasque Mountain in the upper Oldman River basin; Mount Livingstone; and Plateau Mountain, Cataract Creek, and portions of Mount Head and Opal range in the upper Highwood.

To sum up: A ***composite*** score represents the sum of conservation value for all 6 species for each 1-km^2 grid cell across the study area. Although the maximum tally for a cell could be 18 (6 species x highest score of 3), the highest realized score was 14. Overall, the top 50% of composite values (scores 8-14) were located on 25% (1,639 km^2) of the study area, whereas the top 75% (4-14) occurred on 62% (3,471 km^2). Key areas in the top 50% composite score include: (1) nearly all of the Castle Special Place, [including upper Carbondale River basin], (2) headwater basin of Crowsnest River south of Crowsnest Pass, (3) headwater basins of Racehorse Creek and Dutch Creek, (4) upper Oldman and Livingstone basins, (5) South Livingstone Range, and (6) headwater basins of upper Highwood River. In some places, the composite score might be rather low, but the site may be important for at least one of the vulnerable species. Very high values for ***species importance*** (score = 3) occur on 45% of the area, whereas high values (score = 2) were found on another 26% of the area. **Thus, most (71%) of the Southern Canadian Rockies of Alberta has high-very high value for 1 or more vulnerable species.**

Roads and settlements have fragmented habitats for all of these vulnerable species across the Southern Canadian Rockies in Alberta. Such fracturing can reduce population and genetic exchange, and impede movements of animals to track shifting climatic conditions. Consequently, many wildlife scientists recommend landscape linkages to facilitate current and future movements. Highway 3 (and associated railroad) is a major east⇔west transportation route across the Southern Canadian Rockies, which fractures north⇔south connectivity. Based upon habitat mapping and field reconnaissance, I identified and mapped 4 **potential linkages across Highway 3** (in order of decreasing importance for these vulnerable species): (1) Crowsnest Lakes, (2) West Crowsnest, (3) Iron Ridge, and (4) East Blairmore. Based upon data and knowledge of local naturalists, we identified 14 **mountain passes that provide important connectivity** for wildlife across the Continental Divide between Alberta and British Columbia. Some of the key passes include: Elk/Tobermory, Weary Gap and Fording in the Highwood River basin; Tornado, Racehorse, and Deadman in the Oldman River basin; Tent and Ptolemy south of Crowsnest Pass; and North Kootenay, Middle Kootenay, Sage and South Kootenay at the head of the Castle River.

Various surveys of residents in southwest Alberta have found that local people value the following: (1) reliable supply of clean water, (2) habitat to sustain diverse wildlife, (3) open space and traditional rural lifestyle, (4) clean air, (5) sustainable production of foods, (6) low-impact recreation, (7) aesthetic landscapes, and (8) ethic of stewardship. The Southern Foothills Community Report states:

> "Residents call for coordinated land-use and water planning, with proactive, long-term, integrated plans based on sound science and local consultation. They strongly urge watershed protection as the highest

> priority for land-use planning and management. Similarly, they call on land managers to foster connected, functioning landscapes, which in turn will help maintain healthy ecosystems and the region's traditional economy and culture."

Protecting and connecting the headwater havens of the Southern Canadian Rockies in Alberta is central to these values strongly held by local residents and visitors alike.

Waterton Lakes National Park comprises about 8% of the total study area and accounts for 13% of the top 50% Composite Values and about 11% of the top 75% Composite Values. Along the Great Divide north of Waterton Lakes National Park in Alberta, however, there is no adequate protection of the headwaters for 177 km. Existing *Wildland* Provincial Parks (WPP) – principally the Don Getty and Elbow-Sheep WPP in the upper Highwood – comprise 8% of the study area and protect only 16% of the top 50% CV and 13% of the top 75% CV for these vulnerable species. These WPP are too small and too isolated to provide adequate protection and connectivity. Thus, 71% of the top 50% CV and 76% of the top 75% CV remain unprotected. Hence, there is a mis-match between current protection of valuable fish and wildlife habitat and multiplying threats. The challenge, then, is to provide a higher level of committed stewardship commensurate with these remarkable treasures of native fish and wildlife and headwaters.

What options are available for conserving these headwater havens at adequate landscape scales? Currently, there are 7 various designations in Alberta (from most protective to least protective): (1) Wilderness Area, (2) Ecological Reserve, (3) Wildland Provincial Park, (4) Heritage Rangelands, (5) Provincial Park, (6) Natural Area, and (7) Provincial Recreation Area. Each has particular purposes, accompanied by varying restrictions on commercial and recreational activities.

Although the 'Wilderness Area' and 'Ecological Reserve' designations provide the most stringent protection, they also prohibit *any hunting and fishing* in addition to industrial activity. This provision contrasts notably with the Wilderness Act in the United States, which has protected millions of acres with the support of hunting and fishing constituencies. 'Ecological Reserves' typically are very small areas to protect discrete features such as wetlands and do not serve large, wide-ranging animals adequately. 'Heritage Rangeland' applies specifically to grasslands and does not restrict mineral leasing (interestingly, it does prohibit off-highway vehicles). 'Provincial Parks' and 'Natural Areas' do not restrict any commercial or other activity by legislation; the responsible Minister may proscribe certain protections in an accompanying management plan or regulations. 'Provincial Recreation Areas' provide the least protection because they are not really designed to protect Nature.

I concluded that the category of 'Wildland Provincial Parks' offers the best option for protecting wide-ranging, vulnerable species in the Southern Canadian Rockies of Alberta. Wildland Provincial Parks are a type of Provincial Park established in 1996 specifically to protect natural heritage over large areas and provide opportunities for back country recreation.

Designation of additional *Wildland* Provincial Parks is necessary to provide conservation stewardship appropriate to the *world-heritage and local values* of fish and wildlife in this region. Therefore, I strongly recommend designation of 257, 065 ha of Crown land as **Wildland** Provincial Parks. This recommendation is based upon a bottom-up, scientific analysis of the important areas for vulnerable fish and wildlife – rather than an arbitrary number. These Wildland Provincial Parks would protect and connect the following places:

- Castle Special Place as recommended by the citizen's initiative,
- lands on both the south and north side of Crowsnest Pass,
- Livingstone Range,
- headwaters of the Oldman River which has a concentration of high values for these vulnerable species, and
- headwater basins of the Highwood River.

These new Wildland Provincial Parks would protect 66% of lands containing the top 50% of the composite scores on just 40% of the assessment area. They would encompass the following proportions of the very-high conservation scores (percent within National Park/existing Provincial Wildland Park in parens): bull trout 70.1% (19.7), westslope cutthroat trout 81.2% (3.0), grizzly bear 46.5% (20.3), wolverine 59.2% (37.1), mountain goat 58.9% (37.0), and bighorn sheep 69.0% (23.2). Hence, these new Provincial Wildland Parks would bring a high return-on-investment in terms of conservation gains for land area. Such Wildland Provincial Parks, however, would need better management of access to serve the role of safe havens. Accordingly, I recommend designation of 'wild zones' within these Parks to protect habitats and provide security for vulnerable species.

In conclusion, the spectacular landscapes of the Southern Canadian Rockies of Alberta provide some of the best remaining strongholds for a suite of vulnerable fish and wildlife species. Expanding human developments and roads, however, have fractured the landscape – with few safe havens for security or safe passages for options in the face of changing climate. In an arena of competitive pressures for resource development, successful conservation will depend upon a strong commitment to truly protect this rich heritage of fish and wildlife and tower of clean water. Designation and stewardship of new Wildland Provincial Parks will demonstrate that Alberta recognizes and safeguards these values for people today and generations yet to follow.

RESUME

Beaucoup des montagnes les plus celèbres et aimées sur Terre se trouvent dans les Rocheuses Canadiennes de l'Alberta et de la Colombie Britanique adjacente. La simple mention des Parcs Nationaux de Banff, Jasper, Kootenay ou Yoho suffit à évoquer des images de sommets enneigés, de cascades tumultueuses et d'eaux turquoises, un grand nombre de merveilles naturelles et une faune majestueuse. Le Parc National de Waterton Lakes en Alberta et le Parc National des Glaciers dans le Montana – unis en 1932 sous la forme d'un Parc International pour la Paix par leurs Rotary Clubs respectifs – illustrent la coopération internationale et les étendues et la faune sauvages sans frontières. Ces parcs ont été placés sur la *Liste du Patrimoine Mondial* en reconnaissance de leur contribution naturelle remarquable à l'héritage commun de l'humanité.

Cependant, les acclamations internationales reçues par ces parcs spectaculaires au cours du siècle précédent masquent le fait que les terres situées *entres eux* ont été négligées par presque tous. Connue sous le nom des Rocheuses Canadiennes du Sud (ou des Versants Est en Alberta), la majorité du paysage y rivale celui de sites plus célèbres en terme de montagnes immenses, de larges vallées et de forêts verdoyantes. C'est ici que se trouve l'amont des rivières à l'origine de l'eau précieuse à toute vie – y compris celle des habitants des ranchs et des villes en aval. Cette zone supporte l'une des communautés de carnivores et d'ongulés les plus diverses d'Amerique du Nord – comprenant l'ours grizzly, le glouton, la chèvre des montagnes et le mouflon. Des années durant, les Rocheuses Canadiennes du Sud ont eu droit à une protection "de facto" due à la paucité des routes, à l'économie locale, et à de faibles niveaux d'extraction minière et de coupes forestières. Cette situation a cependant commencé à changer dans les années 50 suite à l'expansion des extractions forestières et minières. Le réseau routier s'est étendu au travers des Rocheuses Canadiennes du Sud, pour finalement pénètrer toutes les vallées majeures et la plupart des vallées tributaires.

Les glaciers fondants du Parc National des Glaciers sont de nos jours le signe d'un changement climatique qui risque de s'aggraver au cours des décennies à venir. Les climatologues prédisent des hivers plus doux et des étés plus chauds, une réduction du manteau neigeux et une fonte des neiges plus précoce, une réduction du flux des rivières et une augmentation de leur température, ainsi qu'une plus longue saison d'indendies accompagnée de feux de forêt plus intenses. Pour répondre à ces changements, la grande faune aura besoin d'espace lui permettant de suivre la localisation changeante de son habitat. Le problème pour les espèces vulnérables est bien entendu la fracturation du paysage par routes et agglomérations – ce qui laisse peu de refuges et de passages sans dangers. Le défi actuel consiste à égaler la beauté spectaculaire et les trésors faunistiques des Rocheuses Canadiennes du Sud en Alberta avec un niveau de gestion proactive approprié, en proposant de nouvelles orientations.

Le but de ce rapport est d'informer les discussions et décisions concernant la gestion du territoire et des ressources naturelles dans le Plan d'Utilisation des Terres des Rivières du Saskatchewan Sud. L'objectif est d'évaluer la valeur de conservation de 6,452 km^2 (2520 mi^2) des Versants Est s'étendant du sud du Pays Kananaskis à la frontière des Etats-Unis, pour un groupe d'espèces vulnérables : omble a tête plate (*Salvelinus confluentus*), truite fardée des versants de l'ouest (*Oncorhynchus clarki lewisi*), ours grizzly (*Ursus arctos horribilis*), glouton (*Gulo gulo*), chèvre des montagnes (*Oreamnus americanus*), et mouflon des Montagnes Rocheuses (*Ovis canadensis*). Dans cette évaluation de la conservation, j'ai : (1) identifié et cartographié les sites clés présents et futurs pour ces espèces à l'aide de données empiriques et de modèles, (2) évalué les options de connectivité pour traverser l'autoroute 3 et la Ligne de Partage des Eaux, et (3) recommandé la mise en place de sites de conservation tels que les Parcs Provinciaux Wildland.

L'omble à tête plate et la truite fardée présentent une vulnérabilite élevée. Elles sont adaptées à l'eau froide – particulièrement pour la ponte et l'élevage. Les populations d'omble à tête plate sont menacées par les truites exotiques telles que l'omble du Canada et la truite mouchetée, tandis que les population de truite fardée peuvent s'hybrider avec la truite arc-en-ciel. Bien que les ombles adultes soient capables de se déplacer sur de longues distances, la fragmentation humaine des rivières peut avoir un impact grave sur la connectivité. Les ombles et truites fardée sont vulnérables à plusieurs effets préjudiciables liés au reseau routier, tels que l'augmentation de la sédimentation dans les rivières . Enfin, le réchauffement climatique pourrait causer une augmentation de la témperature des eaux des rivières de basse altitude en-deça de leur tolérance. Protèger de larges segments de rivières froides et réduire la présence d'espèces non-natives sont deux éléments importants de la conservation des truites natives.

On trouve des bastions régionaux de populations d'omble a tête plate dans les bassins versants des rivières Castle, Oldman supérieure, et Highwood supérieure. Des populations de truite fardée à l'intégrité génétique intacte ont été recensées dans les bassins versants des rivières Oldman, Livingstone, Castle supérieure et Carbondale, dans la rivière South Racehorse, et dans les rivières tributaires de la rivière Highwood supérieure. En Alberta, ces populations représentent les dernières populations résiduelles pures de cette espèce menacée.

Bien que doués pour dénicher nourriture et habitat, les **ours grizzly** ont une vulnérabilité élevée en raison d'une faible résilience démographique. Les ours ont un taux de reproduction faible et ne peuvent pas contrebalancer rapidement une mortalité excessive. Les jeunes femelles ne se dispersant pas loin, les populations d'ours sont sensibles à la fragmentation du paysage. Même avec un faible volume de circulation, les routes peuvent faire fuir les ours d'habitats-clé et les exposer à de plus grands risques de mortalité liée à l'homme. La protection de larges étendues d'habitats productifs, à l'abrit des dérangements et des causes de mortalité humaines, est une mesure de conservation clé.

Environ 62% de la zone d'étude présentent une valeur tres élevée ou élevée pour l'ours grizzly, avec 20% supplémentaires sous forme d'habitat attrayant mais à flaible sécurité. L'habitat de très haute qualité se situe dans la region des piémonts (en grande partie sur des ranch privés) ainsi que dans la partie amont des bassins des rivières Castle supérieure, Carbondale, Racehorse supérieure, et Highwood supérieure. (Adjacente à la riviere Castle, la rivière Flathead en Colombie Britanique supporte la plus grande densité d'ours grizzly enregistrée à ce jour parmi les populations non-cotières d'Amerique du Nord). La récréation motorisée intensive (ATVs) est présente extensivement au travers des Rocheuses Canadiennes du Sud de l'Alberta – avec peu de refuges face au risque de mortalité élevée et aux déplacements associés au large réseau de routes ouvertes a la circulation. En sus d'autres mesures de conservation, la gestion stratégique de l'accès aux bassins suivants serait particulièrement importante pour la sauvegarde l'ours grizzly: Carbondale, Castle supérieur, Racehorse supérieur, Dutch, Oldman supérieur, ainsi que Highwood supérieur à l'ouest de la route 40/940.

Les **gloutons** ont une vulnérabilité élevée. Bien qu'ayant une large niche alimentaire, les gloutons sélectionnent comme sites de reproduction, d'estivage et de routes de dispersion des milieux caractérisés par un manteau neigeux permanent au printemps. Ils ont aussi un taux de reproduction très bas et ne peuvent par conséquent pas absorber des taux de mortalité élevés, lesquels peuvent être exacerbés par la pression de trappage. Les gloutons paraissent sensibles au dérangement humain des sites maternels. En raison de leur adaptation au milieu enneigé, ils seraient particulièrement sensibles à une réduction de leur habitat résultant d'un réchauffement climatique.

Environ 50% des hautes terres des Rocheuses Canadiennes du Sud en Alberta possèdent l'habitat requis par le rare glouton. (Dans le futur, des conditions climatiques plus chaudes pourraient faire descendre ce chiffre à 30% – une réduction de 40%). Seuls 8% de la zone semblent adaptés à l'habitat maternel critique. Les sites-clé comprennent la totalité des bassins versants Castle, Carbondale supérieur, Oldman supérieur (y compris Racehorse-Dutch-Oldman-Cabin Ridge), ainsi que Highwood supérieur à l'ouest de la route 40/940.

Les **chèvres des montagnes** ont une vulnérabilité élevée. Elles sont contraintes de vivre sur ou à proximité des falaises qui leur permettent d'échapper aux predateurs et leur fournissent un fourrage plus accessible en hiver. Les femelles ont un taux de reproduction très bas et ne peuvent pas compenser rapidement un taux de mortalité élevé (en particulier lié à la pression de chasse). Les chèvres (surtout les males) se dispersent sur de modestes distances, ce qui peut être source de connectivité entre les populations proches. Les chèvres des montagnes sont particulièrement sensibles à l'accès et aux dérangements motorisés.

L'habitat adapté aux chèvres des montagnes est plutôt limité dans le sud-ouest de l'Alberta, cette zone ne comprenant que 9% d'habitat estival et seulement 2% d'habitat hivernal critique. L'habitat des chèvres forme une bande étroite de chaque côté de la ligne de partage des eaux, depuis le Parc National de Waterton Lakes jusqu'au col Highwood, ainsi que le long de la crête de la chaîne Livingstone. Des recensements récents ont denombré 250-300 chèvres sur les terres Provinciales.

Le **mouflon** présente une vulnérabilité moyenne. Il a besoin de falaises pour échapper aux predateurs et sa niche alimentaire est étroite et liée aux herbages. Les femelles ont un taux de reproduction faible à moyen, mais les mouflons sauvages sont hautement sensibles aux épidemies (certaines transmises par les chèvres domestiques) qui peuvent rapidement décimer un troupeau. Fortement attachés à leurs territoires, les mouflons des Montagnes Rocheuses ne se dispersent pas facilement et ont une faible capacité de recolonisation des habitats vacants. Ils semblent moins sensibles au dérangement motorisé que les chèvres. Le réchauffement hivernal pourrait permettre aux cerfs d'hiverner en plus haute altitude et d'être en compétition avec les mouflons.

Treize troupeaux comprenant 650-700 mouflons passent l'hiver sur 11-13 aires d'hivernage qui composent environ 13% des versants est des Montagnes Rocheuses du Sud en Alberta; l'habitat estival compose 16% de cette zone. Les sites-clé comprennent: Prairie Bluff-Yarrow, Mont Table, et Barnaby Ridge au nord du Parc National de Waterton Lakes; le Mont Sentry-McLaren au sud du col Crowsnest, le sud de la chaîne Livingstone, Cabin Ridge et le Mont Pasque dans le bassin versant de la rivière Oldman supérieure; le Mont Livingstone; et le Mont Plateau, Cataract Creek, et des sections de Mont Head et de la chaîne Opal dans le bassin versant de la rivière Highwood supérieure.

Pour résumer: un score ***composite*** représente la somme des valeurs de conservation pour les 6 espèces dans chaque cellule d'1km^2 de la grille couvrant la zone d'étude. Bien que le score maximum d'une cellule puisse être 18 (6 espèces multiplié par le score maximum de 3), le plus haut score réalisé est 14. Dans l'ensemble, les <u>50% supérieurs</u> des valeurs composites (scores 8-14) couvrent 25% de la zone d'étude (1,639 km^2), tandis que les <u>75% supérieurs</u> (4-14) en couvrent 62% (3,471 km^2). Les zones-clé dans les 50% supérieurs comprennent: (1) pratiquement tout Castle Special Place [y compris le bassin versant de la rivière Carbondale], (2) l'amont du bassin de la rivière Crowsnest au sud du col Crowsnest, (3) l'amont des bassins de Racehorse Creek et Dutch Creek, (4) les bassins Oldman et Livingstone supérieurs, (5) la chaîne Livingstone sud, et (6) l'amont du bassin de la rivière Highwood supérieure. En certains endroits, le score composite peut être bas, mais le site peut être important pour au moins l'<u>une</u> des espèces vulnérables. Les valeurs <u>très élevées</u> pour ***l'importance d'une espèce*** (score = 3) occupent 45% de la zone d'étude, tandis que les valeurs <u>élevées</u> (score = 2) en couvrent 26% supplémentaires. **Ainsi, la plupart (71%) des Rocheuses Canadiennes du Sud de l'Alberta presente une valeur élevée-très élevée pour une ou plusieurs espèces vulnérables**.

Les routes et agglomérations ont fragmenté les habitats de toutes ces espèces vulnérables à travers les Rocheuses Canadiennes du Sud en Alberta. Une telle fracture peut réduire les populations et les échanges génétiques, et gêner les mouvements d'animaux cherchant à répondre à des conditions climatiques changeantes. Par conséquent, de nombreux scientifiques étudiant la faune sauvage recommandent la mise en place de liens paysagers pouvant faciliter ses mouvements actuels et futurs.

L'autoroute 3 (et la voie ferrée associée) est un axe de transport majeur d'est en ouest à travers les Rocheuses Canadiennes du Sud, qui fracture la connectivité nord-sud. En me basant sur la cartographie de l'habitat et des reconnaissances de terrain, j'ai identifié et cartographié **4 zones de liaison potentielles en travers de l'autoroute 3** (en ordre d'importance décroissante pour les espèces vulnérables): (1) Crowsnest Lakes, (2) West Crowsnest, (3) Iron Ridge, and (4) East Blairmore. En me basant sur les données et connaissances des naturalists locaux, j'ai identifié **14 cols de montagne qui fournissent une connectivité importante** pour la faune en travers de la ligne de partage des eaux entre l'Alberta et la Colombie Britanique. Parmi ces cols on trouve: Elk/Tobermory, Weary Gap et Fording dans le bassin de la rivière Highwood; Tornado, Racehorse, et Deadman dans le bassin de la rivière Oldman; Tent et

Ptolemy au sud do col Crowsnest; et North Kootenay, Middle Kootenay, Sage et South Kootenay à l'amont de la rivière Castle.

Plusieurs sondages des residents du sud-ouest de l'Alberta montrent que la population locale attache de la valeur aux choses suivantes: (1) un approvisionnement fiable en eau pure, (2) un milieu naturel pouvant supporter une faune diverse, (3) des espaces ouverts et un mode de vie rural traditionnel, (4) un air pur, (5) une production de nourriture durable, (6) des modes de récréation à faible impact, (7) des paysages esthétiques, et (8) une éthique d'intendance. Le rapport Southern Foothill Community déclare:

> "Les résidents réclament une gestion coordonnée de l'utilisation des terres et de l'eau, avec des plans proactifs à long terme basés sur de solides études scientifiques et une consultation locale. Ils exhortent fortement à donner la priorité à une planification et une gestion des terres visant la protection des bassins versants. De même, ils appellent les gestionnaires des terres à favoriser des paysages connectés et fonctionnels, qui en retour aident à maintenir des écosystèmes sains ainsi que l'économie et la culture traditionnelles de la région".

Protéger et assurer la connectivité des refuges amonts des Rocheuses Canadiennes du Sud en Alberta est au centre de ces valeurs dont l'importance est cruciale aux résidents tout comme aux visiteurs.

Le Parc National De Waterton Lakes couvre environ 8% de la zone d'étude et est responsable de 13% des 50% supérieurs des valeurs composites et d'environ 11% des 75% supérieurs des valeurs composites. Cependant, 177 km de l'amont le long du Great Divide au nord du Parc en Alberta ne disposent pas de protection adéquate. Les Parcs Provinciaux *Wildland* (PPW) existants – principalement les PPW Don Getty et Elbow-Sheep dans l'Highwood supérieur – couvrent 8% de la zone d'étude et ne protègent que 16% des 50% supérieurs des valeurs composites et 13% des 75% supérieurs des valeurs composites des espèces vulnérables. Ces PPW sont trop petits et trop isolés pour fournir une protection adéquate et une connectivité suffisante. Ainsi, 71% des 50% supérieurs des valeurs composites et 76% des 75% supérieurs des valeurs composites demeurent sans protection. Il existe donc un désaccord entre le niveau actuel de protection de l'habitat de la faune et les menaces qui s'y multiplient. Le challenge consiste en l'application d'un niveau supérieur de gestion engagée, commensuré avec ces trésors faunistiques remarquables.

Quelles sont les options disponibles pour conserver ces refuges amonts à une échelle paysagère adéquate? Pour l'instant, il existe 7 désignations en Alberta (du plus au moins protégé): (1) Zone Wilderness, (2) Réserve Ecologique, (3) Parc Provincial Wildland, (4) Rangeland Héritage, (5) Parc Provincial, (6) Aire Naturelle, et (7) Zone de Récréation Provinciale. Chacune a un but particulier et s'accompagne de diverses restrictions des activités commerciales et récréatives.

Bien que les désignations 'Zone Wilderness' et 'Réserve Ecologique' fournissent la protection la plus rigoureuse, en sus des activités industrielles elles interdisent toute forme de chasse et de pêche. Cette clause est en contraste avec l'Acte Wilderness des Etats-Unis, qui a protégé des millions d'acres avec le support des électeurs chasseurs et pêcheurs. Les 'Réserves Ecologiques' sont typiquement de très petites zones visant à protéger des sites bien définis telles que des zones humides, et ne protégeraient pas de façon satisfaisante la grande faune mobile. Les 'Rangeland Héritage' s'appliquent spécifiquement aux prairies et ne restreignent pas les baux minéraux (il est intéressant de noter que les véhicules hors-routes y sont interdits). Les 'Parcs Provinciaux' et les 'Aires Naturelles' n'ont pas de législation limitant les activités commerciales ou autres; le ministre responsable peut prescrire certaines mesures de protection en accompagnement, dans un plan de gestion. Les 'Zones de Récréation Privinciales' fournissent le niveau de protection le plus faible car leur but n'est pas de protéger la nature.

J'en conclue que la catégorie des 'Parcs Provinciaux Wildland' présente la meilleure option pour protéger les espèces vulnérables à grands déplacements dans les Rocheuses Canadiennes du Sud de l'Alberta. Les Parcs Provinciaux Wildland sont un type de Parc Provincial établi en 1996 spécifiquement pour protéger l'héritage naturel sur de larges étendues et fournir des possibilités de récréation dans l'arrière-pays.

La désignation de Parcs Provinciaux Wildland supplémentaires est nécessaire pour fournir une gestion de conservation convenant aux *valeurs de l'héritage mondial* des espèces faunistiques dans cette région. De ce fait, je recommande vivement la désignation de 257,065 ha de terres de la Couronne sous la forme de **Parcs Provinciaux Wildland**. Cette recommandation n'est pas un chiffre arbitraire mais se base sur une analyse scientifique du bas-en-haut des sites importants pour les espèces de mammifères et de poissons et de leurs habitats. Ces Parcs Provinciaux Wildland protègeraient et relieraient les endroits suivants:

- ✔ Castle Special Place recommandé par l'initiative des citoyens,
- ✔ Les terres au sud et au nord du col Crowsnest,
- ✔ La chaîne Livingstone,
- ✔ L'amont du bassin de la rivière Oldman qui présente une concentration de hautes valeurs pour les espèces vulnérables, et
- ✔ Les bassins amonts de la rivière Highwood.

Ces nouveaux Parcs Provinciaux Wildland protègeraient 66% des terres contenant les 50% supérieurs des scores composites, sur seulement 40% de la zone étudiée. Ils comprendraient les proportions suivantes des scores de conservation très élevés (pourcentages a l'intérieur du Parc National et des PPW existants entre parenthèses): omble à tête plate 70.1% (19.7), truite fardée 81.2% (3.0), ours grizzly 46.5% (20.3), glouton 59.2% (37.1), chèvre des montagnes 58.9% (37.0), et mouflon 69.0 (23.2)%. Ces nouveaux Parcs Provinciaux Wildland fourniraient ainsi un haut retour-sur-investissement en terme de gains de conservation par unité de terrain. Cela dit, une meilleure gestion des accès à ces Parcs Provinciaux Wildland serait nécessaire pour qu'ils servent de refuges. En conséquence, je recommande la désignation de "zones sauvages" au sein de ces Parcs pour protéger les habitats et assurer la sécurité des espèces vulnérables.

En conclusion, les paysages spectaculaires des Rocheuses Canadiennes du Sud de l'Alberta fournissent parmis les meilleurs bastions restants pour une suite de mammifères et de poissons vulnérables. L'expension des développements humains et des routes a cependant fracturé ces paysages – laissant peu de refuges sécurisés et peu d'options de passages sûrs face a un climat changeant. Dans l'arène des pressions compétitives pour le développement des ressources naturelles, le succès de la conservation dépendra d'un engagement fort visant à réellement protéger ce riche héritage faunistique et ces sources d'eau pure. La désignation et la gestion de nouveaux Parcs Provinciaux Wildland prouvera que l'Alberta reconnait et sauvegarde ces valeurs, pour la population actuelle et les générations à venir.

1. SOUTHERN CANADIAN ROCKIES OF ALBERTA

A Spectacular Landscape, Rich in Wildlife

Some of the best-known and most-cherished mountains on Earth are set in the Canadian Rockies of Alberta. Indeed, the mention of Banff and Jasper National Parks evokes images of snow-capped peaks, thundering falls and turquoise waters, numerous natural wonders and majestic wildlife. More than nine million people visit the Canadian Rockies each year.

About 200 km (125 mi) further south along the Continental Divide are set other jewels of the Crown of the Continent Ecosystem: Waterton Lakes National Park in Alberta and Glacier National Park in Montana. More inspiring beauty splashed from prairie to peak, accompanied by tremendous diversity of plants and animals and fountains of clean water for the rest of the continent. Brought together in 1932 as the Waterton – Glacier International Peace Park as petitioned by the Rotary Clubs of Montana and Alberta, they exemplify international cooperation and wilderness and wildlife without borders. These parks have been designated as *World Heritage Sites* in recognition of their outstanding natural importance to the common heritage of humanity.

In the midst of international acclaim over the past century for these spectacular Parks, however, the area *between* them has been overlooked by all but a few. Known as the *Southern* Canadian Rockies (or the Eastern Slopes in Alberta), much of this intervening landscape rivals the others in terms of sky-piercing mountains, beautiful river valleys, and verdant forests. Here are the headwaters of rivers that provide precious water for all life – including people on the ranches and towns below. One of the most diverse communities of big wildlife anywhere in North America – including grizzly bears and wolverines, mountain goats and bighorn sheep – roams these mountains. Of course, the indigenous people of the Blackfoot, Piegan, and Blood tribes have long hunted, fished, and gathered foods and medicinal plants throughout this, their traditional territory. Pioneering naturalists like Andy Russell hunted here and wrote glowingly of the wildlands and wildlife, rivers and native fish. Small-scale mining and logging and a few roads did not seem to have much impact on wildlife or rural lifestyles.

Figure 1. Location of the trans-border Crown of the Continent Ecosystem in Alberta, British Columbia, and Montana. The Alberta boundary of the Southern Canadian Rockies for this conservation assessment is delineated in dark purple. It covers 6,452 km2 (2,520 mi^2). Map courtesy of the Miistakis Institute.

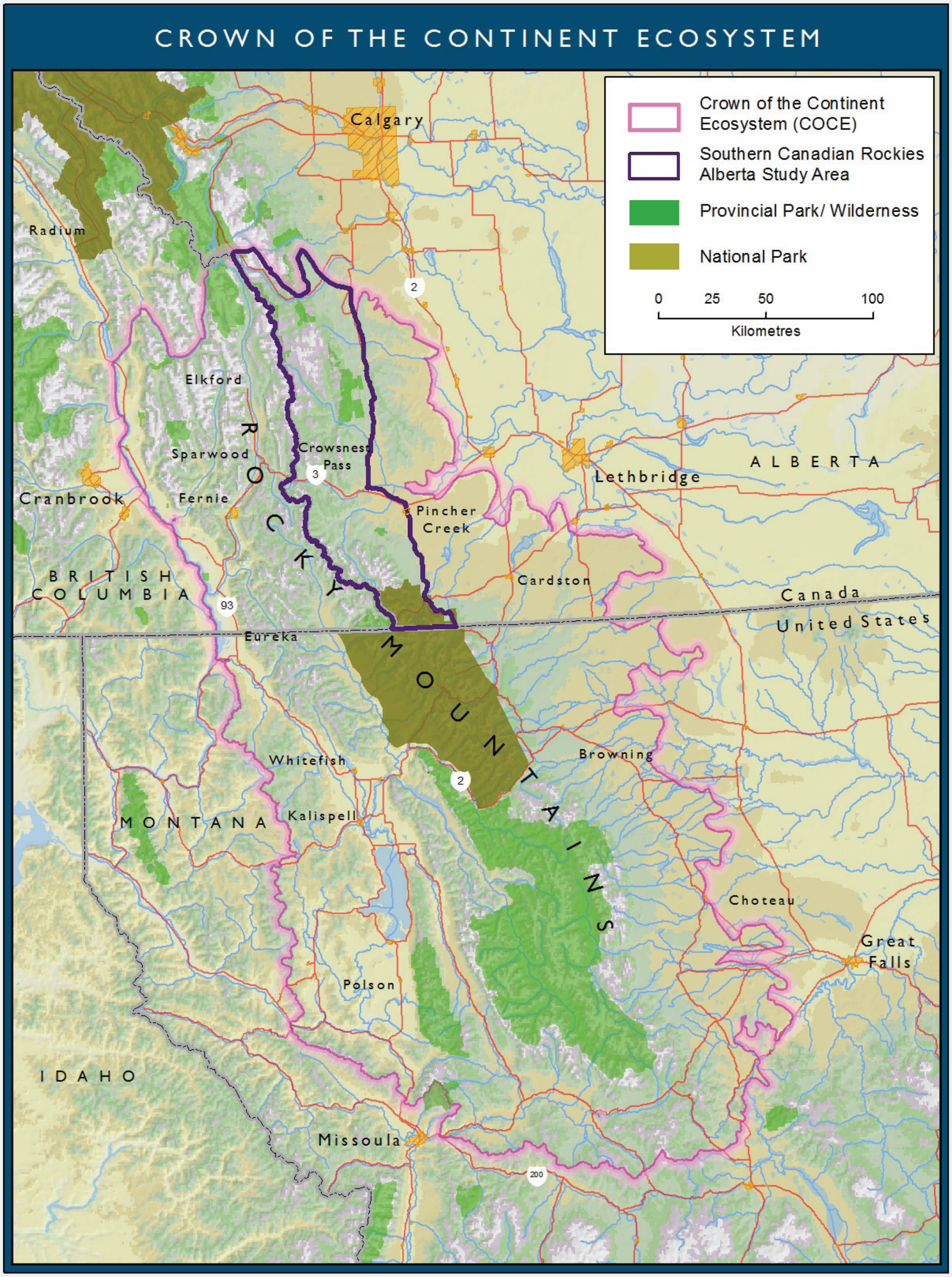
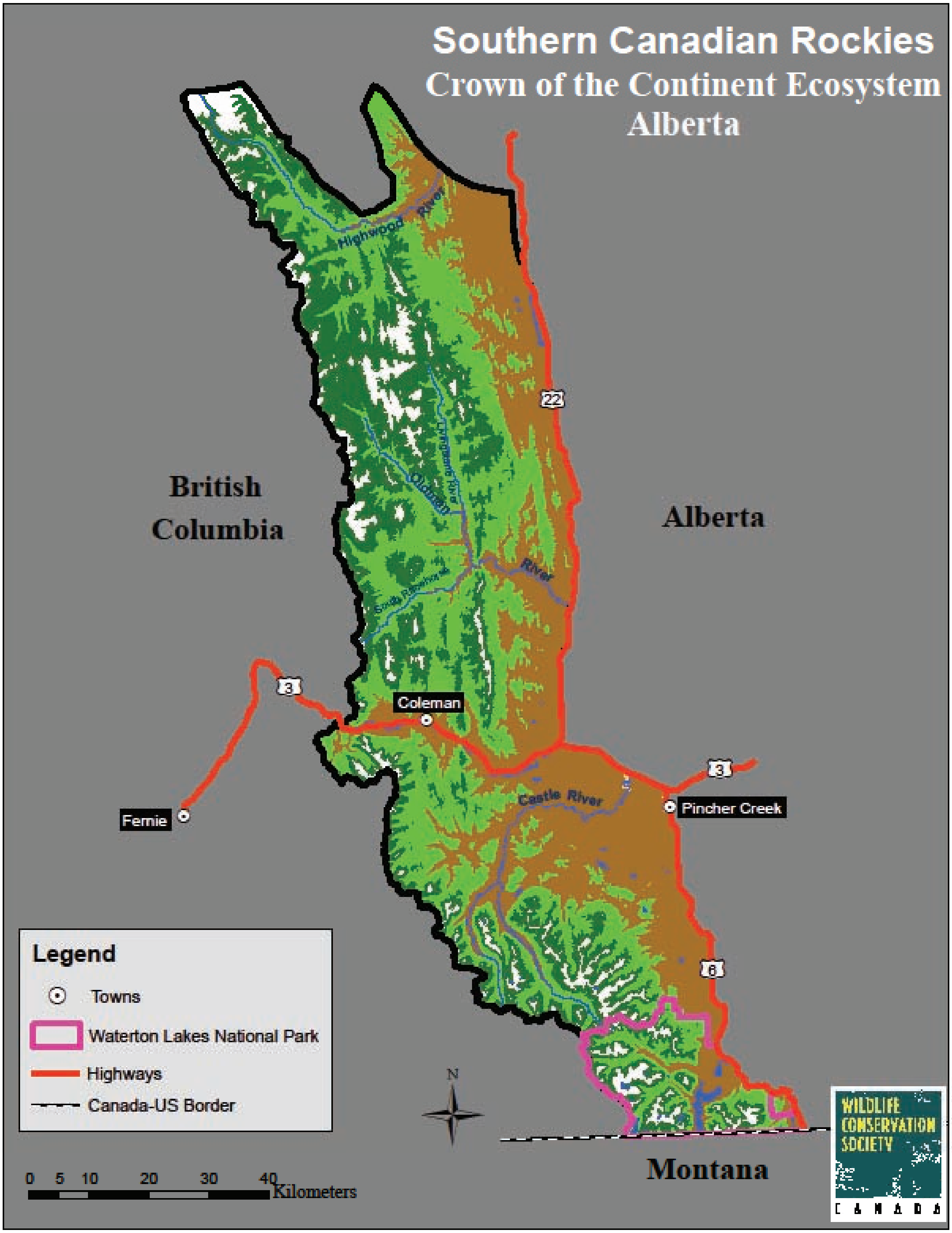


Figure 2. Topography, towns, and major highways of the Southern Canadian Rockies, Alberta. See Figure 5 for map of extensive network of other roads.



That situation, however, began changing in the 1950s as resource extraction of oil & gas and timber expanded. The network of accompanying roads spread throughout the Southern Canadian Rockies, eventually penetrating all major valleys and into most tributary valleys. More recently, prosperous regional (globalized) economies have lead to burgeoning outdoor recreation, facilitated by advances in 4-WD and ATVs. The result has been more and more human activity penetrating deeper into the backcountry… and the cumulative effect of all this disturbance has been rough on the populations of wildlife and native fish.

Now, the melting glaciers of Glacier National Park signal changes in climate that may become even more pronounced in coming decades. Climate scientists project that there will be warmer winters and hotter summers, perhaps more extreme events, decreasing snowpack and earlier melting in spring, declining stream flows and warmer streams, and longer wildfire season with more severe fires. In response, animals will need room to roam as they try to track the shifting location of their habitats. The problem for vulnerable species, of course, is that the landscape has been fractured by roads and developments – leaving few safe havens and safe passages.

The challenge now is to match the spectacular beauty and wildlife treasures of the Southern Canadian Rockies of Alberta with stronger stewardship. But where are the key remaining places for wildlife and native fish? Where are the linkages across busy highways and mountain passes that will enable wildlife to move to meet both short-term and long-term needs? What land management options will protect these headwater havens?

Figure 3. The juxtaposition of spectacular landscapes and industrial/recreational development exemplifies the challenges of conserving the headwater havens in the Southern Canadian Rockies of southwest Alberta.

John Weaver

Threats to Fish and Wildlife Values

Overarching Threat of Climate Change

One challenge facing conservation of wildlife and wildlands over the past century has been the ever-expanding footprint of humans – urban and rural sprawl, superhighways and forest roads, dams and diversions. But scientists are alerting us to a new challenge for the next century: climate change. What changes in climate can we anticipate over the next 50-100 years? What will be the ecological consequences? What might comprise thoughtful responses to this new challenge?

Over the past 100 years, a new array of instruments has enabled climate scientists to measure trends and variability in temperature, precipitation, snowpack and other climate variables with greater accuracy and better geographic representation. This has provided a strong empirical record for many areas, including the Crown of the Continent Ecosystem.

Attempting to predict *future* climate conditions, though, is a daunting but important endeavor. Projecting climate change depends, of course, upon the (1) assumed scenario of greenhouse gas (GHG) emissions and (2) variables and relationships used to build any specific climate model. The empirical record of past climate change helps scientists better understand the performance of a model. In an attempt to develop robust projections, researchers increasingly are using ensembles of different climate models to examine implications of different GHG scenarios.

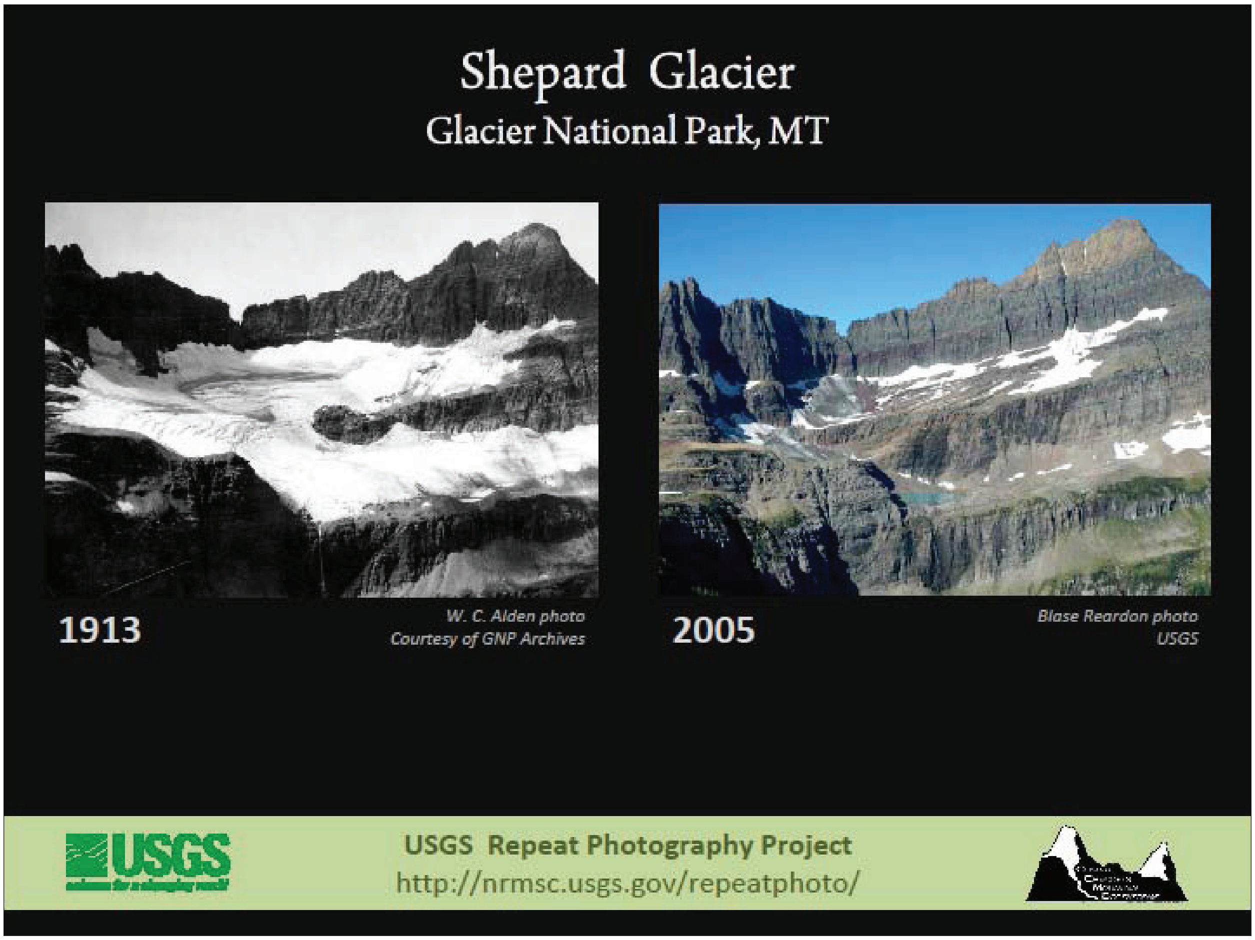
In this report, I examined patterns and trends reported by a diverse set of investigators in several recent climate assessments encompassing the Crown of the Continent Ecosystem. The key references (in alphabetical order) include: Graumlich and Francis (2010), Gray and Hamann (2013), Hebda (2010), Mbogga et al. (2009), McWethy et al. (2010), Murdock and Werner (2011), Pederson et al. (2010), and Wang et al. (2012). The authors represent several university/agency climate research groups (University of Alberta, University of British Columbia, University of Victoria, University of Montana, Montana State University, USGS, and NPS). These studies used empirical weather-station data for the past 100 years and multi-model ensembles with regional downscaling to develop future projections. Taken together, these represent some of the best available analyses and projections of future climate conditions for the Crown of the Continent. There is strong agreement among the assessments, too. Although there is still considerable uncertainty in climate projections (especially for complex environments like mountains), climatologists expect that patterns and trends in climate over the past 50-100 years will continue and perhaps accelerate under even moderate GHG scenarios.

Here, I synthesize the major findings from recent research to describe climate patterns over the past 100 years as well as projected changes over the next 40 years (2011-2050). This lays the foundation for anticipating changes in future environmental conditions that vulnerable fish and wildlife may encounter.

△ Disappearing glaciers

Perhaps the most iconic impact of climate change in the Crown has been the disappearance of glaciers from Glacier-Waterton Lakes National Parks (Figure 4). Of 150 glaciers in Glacier Park in1850 (covering 99 km^2 total), only 25 (<16 km^2 total) remain today. Increasing temperature during the critical spring and summer melting season has accelerated the retreat of glaciers. If trends continue, scientists expect glaciers will disappear from Glacier Park by 2030 (Hall and Fagre 2003, McWethy et al. 2010).

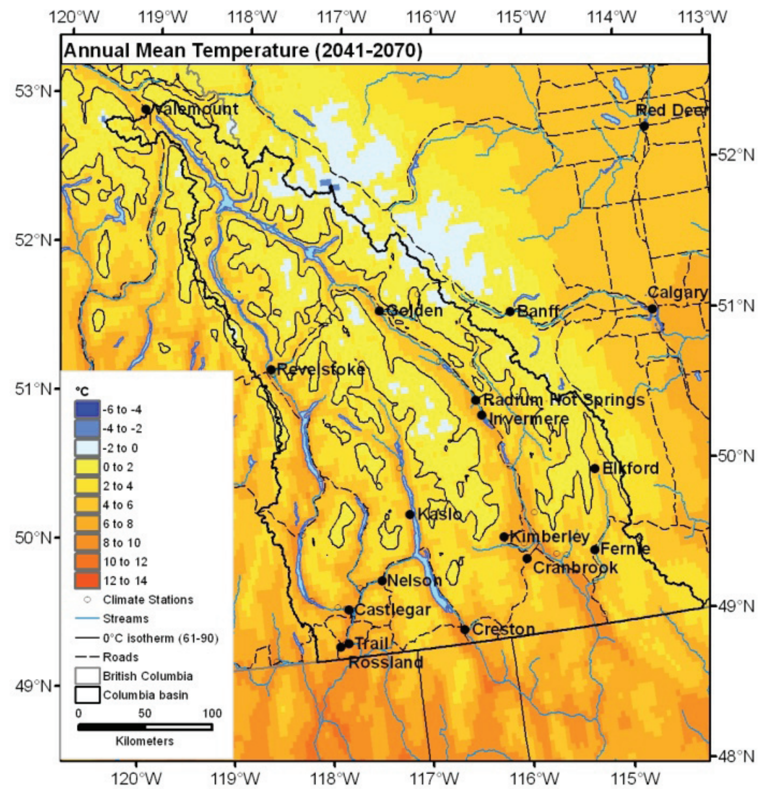
Figure 4. Melting of glaciers in Glacier National Park signals an era of changing climate.

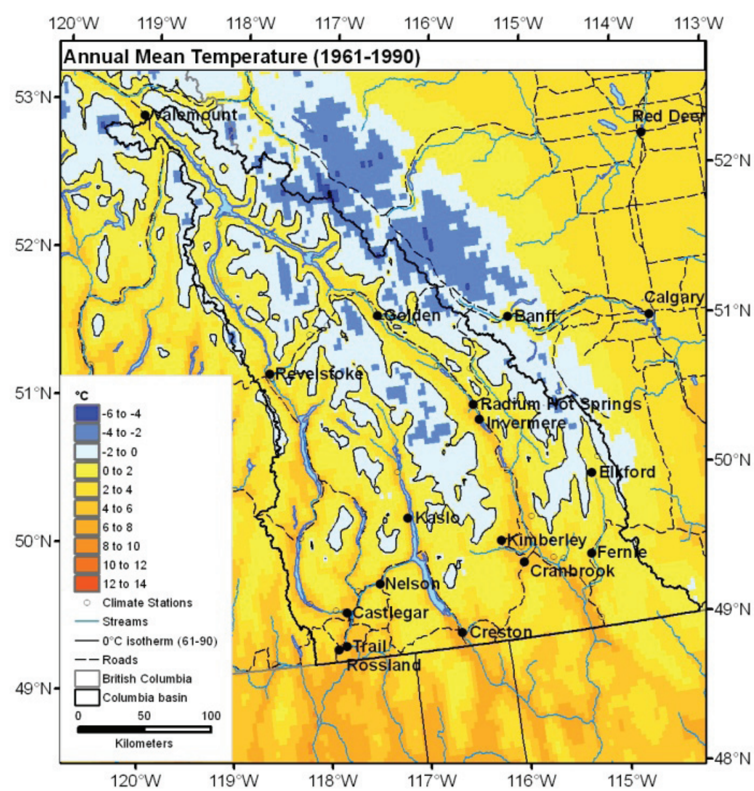


△ Warmer winters and hotter summers

Over the past 100 years, mean annual temperature (MAT) in western Montana has increased 1.3° C (2.3° F), nearly twice the rise in global temperature (Pederson et al. 2010). In the Columbia River basin of southeast British Columbia, MAT has increased by 0.7°-1.7° C over past 100 years (Murdock and Werner 2011). The largest increase has taken place in winter, when minimum temperatures rose +2.4° C and maximum temperatures +1.8° C (Murdock and Werner 2011). The average number of days below-freezing in winter has dropped from 186 days to 170 days, due mostly to warmer days in early spring (Westerling et al. 2007). Temperatures have warmed dramatically since the early 1980s and hot temperatures have occurred longer through the summer

Figure 5. Projected change in mean annual temperature during 2041-2070 (top) compared to mean annual temperature during 1961-1990 for Eastern Slopes of Alberta and adjoining areas of British Columbia and Montana. Source: Climate WNA from Murdock and Werner (2011).





(McWethy et al. 2010, Pederson et al. 2010). This increase in summer temperature has been 3x greater at higher elevations. Such accelerated warming at high elevations has been reported from many areas across the globe (Pepin and Lundquist 2008).

Climatologists project that by 2050, annual temperatures will be 1.4° – 3.1° C warmer in southern Alberta than now (Mbogga et al. 2009, McWethy et al. 2010, Murdock and Werner 2011, Pederson et al. 2010) (Figure 5). Both winters and summers will become warmer, with intense heat waves in summer becoming more common and longer in duration. There will be fewer, shorter, and less intense episodes of really cold weather in winter. For example, in the Montana portion of the Crown of the Continent, major river valleys will have average daily maximum temperature in winter above 0° C (32° F) by 2020s, tributary valleys by 2040s, and many mid to high-elevation sites by 2080s (S. Running and J. Oyler, University of Montana, *in prep.*). There still could be large variability (1.0° – 1.8° C) in temperatures between years and decades due to ENSO and PDO events (Murdoch and Werner 2011).

△ Variable precipitation patterns

During the 20th century, there have been periods of drought and periods of greater precipitation in southern Alberta. Indeed, the high variability in seasonal, annual, and decadal patterns of precipitation overrides any strong century-long trends (Selkowitz et al. 2002). Precipitation patterns are more difficult to predict than temperature, especially in the complex terrain of mountains. Summers are likely to become even hotter and drier, which could increase evapotranspiration. Various models suggest a slight increase or decrease (-10% → +10%) in annual precipitation in the Crown region, characterized by perhaps slight increases in winter (0% → +10%) and slight decrease in summer (0% → -10%) (Mbogga et al. 2009, Murdock and Werner 2011). The climate record suggests a trend toward more intense precipitation events (Groisman et al. 2005).

△ Decreasing snowpack and earlier melting in spring

Annual snowpack level (indexed by April 1 Snow Water Equivalent, SWE) has declined by 15 to 30 percent throughout the Rocky Mountains during the second half of the 20th century (Hamlet et al. 2005, Mote et al. 2005, Pierce et al. 2008) and by approximately 20% in the Crown (Pederson et al. 2011). More of the winter precipitation in the western United States has been falling as rain rather than snow – especially at lower elevations – due to significant increases in number of days when temperatures are above freezing (Knowles et al. 2006, McWethy et al. 2010). Rain-on-snow events have become more frequent at low to mid-elevations, increasing the prospects for winter flooding (Hamlet and Lettenmaier 2007). Over the past 50 years, warmer temperatures have led to earlier runoff in the spring (by 1-4 weeks) and reduced base-flow of streams in the summer and autumn across western United States (Stewart et al. 2005, Hildago et al. 2009). In the Crown of the Continent Ecosystem, for example, average snowmelt advanced about 8 days earlier in the spring between 1969 and 2006 than previously (Pederson et al. 2011).

For the future, climatologists project that, due to warmer temperatures during winter, there will be more rain and less snow falling at low and mid elevations (Knowles et al. 2006). This will result in less snowpack, shorter snow season, and earlier melt in spring (Mote et al. 2005, Pederson et al. 2011). Most areas in the Montana section of the Crown will experience 10-40% decrease in April 1 SWE by 2050s.

△ Declining stream flows and warmer streams, particularly by late summer

Approximately 60-80% of surface water flow in the interior Mountain West is governed by the amount of snowpack (Barnett et al. 2005). Over the past 50 years, there has been a general decline in stream flows associated with reduced snowpack (Barnett et al. 2008). (Rood et al. 2005, Rood et al. 2008). In the Northern Rockies, for example, water flow in August decreased by an average of 31% (range 21-48%) during 1950-2008 (Leppi et al. 2010). The decline in snowpack has reduced recharge of aquifers, making less water available for groundwater flow into streams and decreasing the base flow during the key summer period – especially along the Eastern Slopes in Alberta (Rood et al. 2005, Rood et al. 2008). In some areas, increased precipitation during spring may have buffered the annual streamflow from more severe declines due to decreased snowpack alone (Pederson et al. 2011). With warmer air temperatures, loss of shading cover along streams due to wildfire, and lower stream flows by August, stream temperatures have also increased (Isaak et al. 2010, Arismendi et al. 2012). Moreover, both the year-to-year variability in stream flow (Pagano and Garen 2005) and multi-year duration of drought conditions are increasing (McCabe et al. 2004). Researchers project that these trends in stream flows will continue in the future, with negative consequences for cold-water native trout and other biota (Shepard et al. 2010, Jones et al. 2013).

△ Longer season of wildfire, with severe fires across more of the landscape

Wildfires, of course, have long been a feature of landscapes and driver of ecological processes across western North America. Beginning in the mid- 1980s, large forest fires have become more frequent and much more severe than in previous decades (Running 2006). Compared to the 1970-1985 period, for example, there has been a 6-fold increase in number of acres burned each year and the fire season is about 78 days longer (Westerling et al. 2006). Notably, much of the increased fire activity has occurred in forests at higher elevations (5500 to 8500 feet), where snowpack levels normally keep wildfire activity low. More intense fires have swept across streams, and the loss of critical shading has exacerbated warming of streams (Dunham et al. 2007, Pettit and Naiman 2007). As temperatures continue to climb in the future accompanied by earlier snowmelt and hotter, drier summers, there will likely be a longer fire season with severe fires across more of the landscape (Spracklen et al. 2009, McWethy et al. 2010, van der Kamp and Bürger 2011).

△ Spread of insects, invasive weeds, and non-native fish

In the wake of milder winter temperatures, populations of mountain pine beetle have exploded in recent years across western North America (Nordhaus

2009). In addition, warmer summers with longer droughts have stressed many coniferous tree species, enabling bark beetles to expand to higher elevations and new host species – such as the whitebark pine (Logan et al. 2003). Along with warmer temperatures and prolonged droughts, wildfire and land alterations have promoted spread of invasive plant species such as cheatgrass and spotted knapweed (Bradley 2009) and non-native rainbow and brook trout to the detriment of native, cold-water trout (Dunham et al. 2003, Rahel and Olden 2008). Climate change may alter the transport and establishment of new invasive species, distribution and impact of existing species, and effectiveness of control strategies (Hellmann et al. 2008).

△ Shifting distribution of plants and animals

As conditions become warmer and more arid in the future, different plant species will become stressed and will need to shift in response to changes in temperature and soil moisture (Rehfeldt et al. 2006). At lower elevations, forests will decline in density and extent, and some may transition to shrub-dominated sites and grasslands (Fagre 2007). In the middle sections of mountain slopes, the structure and composition of forest communities will change as different species shift mainly upward or to different aspects. With warming and longer growing seasons at higher elevations, trees could fill-in alpine meadows more over time (Klasner and Fagre 2002).

During warming episodes in past millennia, distribution of animals in North America generally shifted north in latitude and upward in elevation, too (Pielou 1991). In the mountains, various mammals shifted distribution upward in elevation or perhaps to a different aspect and consequently did not have to shift as far north as those in flatter areas (Guralnick 2007, Lyons et al. 2010). Of course, there were no roads and other human infrastructure back then that posed barriers to shifts by species in response to climate change. In recent years, researchers have documented similar shifts northward and upward (Parmesan 2006, Moritz et al. 2008). But, there may be niche or physiological constraints to such adaptive movements. As alpine animals like pikas shift upward, they may find temperatures too warm even on mountaintops (Beever et al. 2011).

△ Implications of Climate Change for Conservation in the Southern Canadian Rockies

From this litany of past and projected changes in climate, there appears to be strong consensus that the Crown of the Continent Ecosystem will continue to get warmer. It's sobering to see how relatively small changes in average temperature (1°- 2° C) and snow-rain thresholds already have resulted in large ramifications for water resources such as snowpack and summer stream flow.

Projected changes in climate will set many ecological changes cascading into motion, putting increasing pressure upon plants and animals to adapt their niche or move to track preferred environmental conditions. Although species' responses to environmental change differ, their primary response to large climatic changes during the Quaternary period was to shift their geographical distributions, albeit at much slower pace than will be required under most climate change scenarios (Huntley 2005). Scientists are already documenting changes in species distribution over recent decades (e.g., Parmesan 2006). Furthermore, because species respond individualistically, composition and structure of ecosystems will change in the future as novel assemblages come together (Williams and Jackson 2007). Complex ecological interactions may affect species beyond simply changes in their climatic 'envelope'.

More people may move into the Southern Canadian Rockies as a response to more intense climate change (heat, drought, sea rise) elsewhere. Resource development pressures may intensify and expand as humans scramble for dwindling fossil-fuel and water resources (Turner et al. 2010). Ever-increasing numbers of people across the landscape would only exacerbate current challenges of habitat fragmentation and mortality risk. What does all of this imply for conservation strategies to maintain species, ecosystems, and the critical services they provide society?

One key conservation concept involves *resilience* thinking (Walker and Salt 2006). 'Resilience' can be defined as the capacity of species or system to withstand disturbance and still persist (sensu Holling 1973). Plants and animals evolved in ecosystems where natural disturbances varied in frequency, intensity, duration, and extent – thereby resulting in different spatial and temporal patterns of change (Pickett et al. 1989, Folke et al. 2004). Over millennia, animals developed important behaviors and ecological traits that imbued them with resilience to certain kinds and levels of disturbance (Weaver et al. 1996, Lavergne et al. 2010). But as human activities accelerate rates of disturbance across a greater extent of the landscape, the combination of rapid change and simplification can undermine the evolved resiliency of species and render their populations more fragile.

Importantly, the resilience framework does not require an ability to precisely predict the future, but only a qualitative capacity to devise systems that can withstand disturbance and accommodate future events in whatever surprising form they may take. *One of the key messages of resilience thinking is to keep future options open through an emphasis on ecological variability across space and time,* rather than a focus on maximizing production over a short time (Walker and Salt 2006).

This kind of resilience thinking is reflected in several 'climate-smart' strategies identified by scientists and managers from around the world (Hannah and Hansen 2005, Heller and Zavaleta 2009, Graumlich and Francis 2010, Hansen et al. 2010, Davison et al. 2012). A broad consensus has emerged on the following actions to enhance resiliency in the face of climate change:

- ✔ Protect large landscapes with high topographic and ecological diversity
- ✔ Enhance connectivity among such key landscapes
- ✔ Reduce other pressures on species and ecosystems

In an ever-changing world where impacts of habitat loss and fragmentation, invasive species, and climate warming are accelerating, vulnerable species will persist longer with well-designed networks of core refugia ('safe havens') and connectivity ('safe passages') that offer ecological options (Carroll et al. 2009, Hodgson et al. 2009).

Multiple Effects of Roads and Human Access on Fish and Wildlife

One challenge facing conservation of wildlife and wildlands over the past century has been the ever-expanding footprint of humans – urban and rural sprawl, superhighways and forest roads, dams and diversions. Roads, vehicle traffic, and associated human activity can have a variety of substantial effects upon species and ecosystems (see reviews of research findings by Olliff et al. 1999, Trombulak and Frissell 2000, Gucinski et al. 2001, Forman et al. 2003, Coffin 2007, Fahrig and Rytwinski 2009, Beckman et al. 2010 and *hundreds* of references therein). These authors concluded that roads and associated human activities often have negative effects on behavior and abundance of animals and ecological processes. High-speed highways and backcountry ('forest') roads have different characteristics, problems, and solutions. Here are some of the principal effects that roads, vehicle traffic, and human activity can have on ecosystems and fish and wildlife. Subsequent chapters will provide more detail on (1) effects of forest roads on conservation of the 6 vulnerable fish and wildlife species, and (2) management of backcountry roads for wildlife security and for landscape connectivity across Highway 3.

★ ***Road construction kills sessile or slow-moving organisms and high-speed roads increase collisions and mortality.*** Road construction destroys soil biota, plants and slow-moving organisms within the road alignment. With >1 million km of roads in Canada, this is not a trivial matter. Collisions with vehicles along roads kill many animals every year – including large and small mammals, birds, amphibians and reptiles, and countless insects. Vehicle mortality is a serious concern for amphibians, which are declining due to multiple factors. Mortality from vehicles may be nonselective in terms of age, sex, or condition of the animal. In general, mortality increases with traffic volume and speed. Wide clearing of vegetation along roads can either increase or decrease likelihood of collisions. Recent modifications such as wildlife underpasses and overpasses have reduced mortality and facilitated passage (see Safe Passages: Highways, Wildlife, and Habitat Connectivity by Beckman et al. 2010 for recent examples and innovations).

★ ***Road placement can have long-term and long-distance impact on the structure and function of aquatic ecosystems.*** Placement of roads and crossings can re-route surface water or shallow groundwater – thereby changing the flow of water, sediments, and nutrients. These changes can undermine stability of adjacent slopes and trigger mass slumping, downcutting of new gullies, and erosion. Such effects may not show up until years later and/or miles downstream when an infrequent but intense rainstorm occurs. In particular, roads in the floodplain of a river or stream can interfere substantially with the natural dynamics that promote the diversity of these habitats. During the road construction phase, fine sediments may be deposited in adjacent waters, which can kill aquatic organisms and impair aquatic productivity. Road crossings commonly act as barriers to passage by fish and other aquatic organisms. Bull trout and westslope cutthroat trout are especially vulnerable to these barriers. Some of these impacts can be mitigated effectively by proper design and construction of roads, culverts, and bridges.

★ ***Road maintenance and vehicles introduce chemical contaminants that degrade air and water.*** Many chemicals are introduced into the local environment due to road maintenance and vehicles. For example, a variety of heavy metals are deposited from gasoline additives and de-icing salts. These contaminants can pollute nearby soils, plants, and waterways. Ungulates such as mountain goats and bighorn sheep are attracted to salt applied to highways and are killed in vehicular collisions. On some gravel roads, dust mobilized by vehicles can impact nearby vegetation.

★ ***Roads facilitate spread of invasive plants (weeds) and introduction of nonnative fish.*** Road construction inevitably disturbs soils, which can stress or eliminate native plants and favor establishment of nonnative 'weeds'. Nonnative plants, spores of exotic diseases, and mollusks can 'hitchhike' on vehicles and spread to new sites. All-terrain vehicles (ATVs) can be the extending vector spreading weeds when the people drive them off roads or penetrate deeper into the backcountry on 4-WD roads. Indeed, such unwitting spread of nonnative species is one of the biggest problems in contemporary conservation. Roads into remote areas also facilitate unsanctioned introduction of nonnative fish into lakes and streams, leading to profound effects on native fish such as bull trout and westslope cutthroat trout and aquatic ecosystems.

★ ***Roads reduce available habitat due to direct removal or displacement.*** Roads are typically built for extraction of commodity resources such as oil and gas development or logging, which often removes or alters habitats for variable periods of time. The loss of habitat depends upon the type and extent of the development. Some wildlife species avoid roads and associated human activity during both the extraction phase and subsequent use of open roads by people. Depending upon the type, volume of traffic, and duration of traffic, animals can be displaced from 100 m to 2 km from a road or facility. This displacement results in the loss of available habitat, which can result in less productivity in some cases. Some animals can habituate to road traffic that is predictable in space and time. Even when animals are not displaced from roadside habitats, human activity/vehicles on roads can elevate their metabolic rate and costly expenditure of energy.

★ ***Roads reduce security for wildlife and increase risk of human-caused mortality.*** New roads open up access into remote areas, which can lead to increased mortality from poaching, incidental killing, and excessive harvest. Grizzly bears, wolverines, mountain goats, and bighorn sheep are especially vulnerable to the effects of new access and inadequate regulations. If excess harvest of fish remains chronic, this can give rise to public demand for artificial stocking to compensate for unsustainable harvest … at the further expense of native trout populations and ecosystem integrity.

- ★ ***Snowmobiling activity along roads can affect behavior, habitat use, health and inter-specific relationships among wildlife.*** The noisy activity of snowmobiles or helicopters can displace animals from their selected habitats in winter, which can negatively affect their energy balance – especially if it occurs in late winter which is a critical time period for ungulates like bighorn sheep and mountain goats. This is also the denning period for wolverines (Feb-April) which have their dens in snowy terrain at high elevations. Trails packed by snowmobiles may facilitate new access into areas of deep snow usually avoided by predators like wolves and coyotes.

- ★ ***Road access leads to un- natural wildlife behavior, with more habituation and greater likelihood of getting accustomed to food/garbage left by people.*** Habituation along roadways can result in loss of wariness for species like grizzly bears, or the animals become conditioned to receiving rewards of available food or garbage at campgrounds. This prompts managers to capture and relocate them to more remote areas (but the bears often return to the original site) or kill the animal after repeat episodes.

- ★ ***Roads fracture connectivity for population and genetic exchange.*** Roads may pose an impermeable barrier to some small organisms, and a partial barrier to larger species. Depending upon density of roads and traffic volume, this can impact an animal's movements on a daily or seasonal basis in response to severe weather events or a shortfall in key foods. Fragmentation of the larger landscape fractures natural connections, resulting in less opportunity for animals from 1 area to move into another area and boost the recipient population. This can result in smaller populations and greater isolation, which increases the risk of local extirpation. Finally, landscape fragmentation reduces the genetic exchange between populations, which can adversely affect longer-term viability. Species like grizzly bears with limited population resiliency and dispersal are particularly vulnerable to landscape fragmentation. Roads fracture landscapes into smaller patches at an exponential rate rather than a linear rate; hence, even a single major road can have substantial fragmentation effect. Loss of habitat and landscape fragmentation is another one of the major and ever-expanding issues in contemporary conservation of biodiversity.

- ★ ***Roads can restrict freedom for animals to move in response to climate change.*** As climate changes in the future, fish and wildlife will need to move to find new sites for sustaining their ecological needs. Because the exact location of new habitats will be difficult to predict, animals will need room to roam in their search. Providing for such connectivity is one of the smartest strategies for promoting resiliency of many species in the face of climate change.

- ★ ***At the larger scale of landscapes, increasing road density can lead to cumulative effects of multiple human activities.*** A single road arguably may have little detrimental effect upon fish and wildlife populations. But a spidery, expansive network of many roads can result in substantial and cascading <u>cumulative</u> effects upon animal populations and ecological processes. This has been called the 'tyranny of small decisions' whereby the total impact of seemingly insignificant, single decisions combine to cause substantial cumulative effects.

The expansive literature on roads leads to several key conclusions:

★ The physical imprint of a road itself can have impacts, particularly on fish and aquatic ecosystems due to sedimentation and barriers to passage – *regardless of the level of traffic or human behavior*.

★ Risk of mortality from direct shooting (legal hunting or poaching) and spread of invasive species increases as access expands – *regardless of traffic volume*.

★ Increasing levels of traffic volume on backcountry roads and secondary highways reduces amount of useable habitat via displacement (or shifts to nighttime use) and reduces permeability of roads to wildlife crossing.

Some of the detrimental effects of roads can be mitigated with proper design and management (such as permanent or seasonal closure), and some effects (such as mortality of food-conditioned bears) can happen at backcountry sites, too. Yet – in the big picture – vulnerable populations of fish and wildlife will have a better chance to prosper and persist in large, secure roadless areas. Hence, as a greater proportion of the natural landscape continues to be modified by human infrastructure and activities, protected wildlands become even more critical and valuable.

In the Southern Canadian Rockies of Alberta, roads proliferated dramatically starting in the 1950s. The initial purpose of these new roads was to enable extraction of timber and energy resources such as oil and gas. Over time, however, they became accustomed access for other uses such as summer and/or winter recreation. With recent improvements in the capability of ATV vehicles and snow machines to access more difficult terrain and recent prosperity in the regional economy, recreational access into the backcountry has exploded across the Southern Canadian Rockies.

Today, there are thousands of kilometres of primary and secondary forest roads across the region (Figure 6). <u>Every major river valley and nearly every tributary valley throughout the Southern Canadian Rockies of Alberta has a road in it</u>. As human populations and affluence increase in the region, the importance of managing proliferating roads and human access will become ever more critical.

Purpose, Goal and Objectives, and Organization of the Report

The purpose of this report is to inform discussions and decisions about land and resource management in the South Saskatchewan River basin of Alberta. The goal is to assess the conservation value of 6, 452 km^2 (2520 mi^2) of the Southern Canadian Rockies (Eastern Slopes) in Alberta for a suite of vulnerable fish and wildlife species. Specific objectives are to: (1) compile and critically examine the latest scientific information about conservation needs of these species and contemporary threats of climate change and road access, (2) identify current

Figure 6. Location of the road network across the Southern Canadian Rockies, Alberta.

and future key areas for these species using empirical data and models, (3) assess options for connectivity across Highway 3 and Continental Divide, and (4) make recommendations for various levels of conservation such as Wildland Provincial Parks. The approach involves synthesis of available spatial data into maps of conservation value for vulnerable species and a geographical narrative to draw attention to key areas.

The Wildlife Conservation Society has woven together several lines of contemporary thinking about planning for wildlife conservation into a concept called 'landscape species' (Sanderson et al. 2002). It is based on the notion that species which use large, ecologically diverse areas can serve as useful 'umbrellas' or surrogates for conservation of other species. Importantly, a suite of species is chosen considering area requirements, heterogeneity of habitats, ecological functionality, and socioeconomic significance. For assessing the conservation value of the Southern Canadian Rockies, I selected the following suite of fish and wildlife species: bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki lewisi)*, grizzly bear (*Ursus arctos horribilis*), wolverine (*Gulo gulo*), mountain goat *(Oreamnus americanus*), and Rocky Mountain bighorn sheep (*Ovis canadensis*). These are the same species I used in a previous conservation assessment in the B.C. portion of the Crown (Weaver 2013).

In Chapter 2, I introduce a framework for assessing the *vulnerability* (or lack of resiliency) of a species using 5 factors (following Weaver et al. 1996). For each focal species, I provide a vulnerability profile based upon its ecology, demography, and behavior. Next, I describe my method for scoring conservation importance (current and future) of lands or waters for the species. Based upon results of that mapping, I identify and discuss key conservation areas for each species by watershed. Finally, I combine maps of important areas for individual species into a composite or overall map of conservation values. Considerable spatial information about these species and key areas is captured in the series of maps.

In Chapter 3, I synthesize the findings to highlight core areas for these species. We map key linkages or corridors across Highway 3 (Crowsnest Hwy) that would facilitate connectivity across the larger landscape of the Southern Canadian Rockies. Lastly, we identify and map key mountain passes through the Continental Divide between British Columbia and Alberta, which are also quite important for regional connectivity.

In the closing Chapter 4, I sum up the critical importance of the Southern Canadian Rockies of Alberta for long-term conservation of these vulnerable fish and wildlife species. I recommend a network of new Wildland Provincial Parks to connect Albertan values and places.

2. SENTINELS OF THE HEADWATERS: VULNERABLE FISH AND WILDLIFE SPECIES

Introduction

For each of the 6 focal species of fish and wildlife, I provide a profile of its vulnerability based upon its ecology and behavior. Next, I describe the methods for scoring areas of conservation value for that particular species. Lastly, I provide GIS-based maps of the distribution of key conservation areas for the species, as well as a table summarizing the amount of area (ha) in each conservation value. For the two native fish, the tabulations are provided for each of the 5 major watersheds. For the 4 species of terrestrial mammals, tabulations are provided for each side of Highway 3, which may be a semi-permeable or complete barrier to movements.

Framework for vulnerability profiles

Vulnerability refers to the susceptibility of species to disturbances of various kinds. Over millennia, species have persisted by a variety of mechanisms that buffered environmental disturbance at various spatial and temporal scales. Yet some species seem more vulnerable than others. What factors contribute to their vulnerability?

The concept of *resilience* can guide our thinking about vulnerability. Resilience can be defined as the capacity of species to withstand disturbance and still persist (*sensu* Holling 1973, Folke et al. 2004). Species can be considered as nested hierarchies of individuals, populations, and meta-populations in which the higher levels provide context for mechanisms at lower levels. Persistence may be accomplished by 'spreading the risk' (e.g., separate small herds of bighorn sheep will be less vulnerable than a single large herd to spread of a virulent disease). Because disturbances occur at different spatial and temporal scales, no single level of organization can respond adequately to all disturbances (Pickett et al. 1989).

Following Weaver et al. (1996), I postulate a basic mechanism of resistance or resiliency at each of three hierarchical levels: individual, population, and metapopulation. At the individual level, an animal can exhibit physiological tolerance to variability in an environmental condition (temperature), or behavioral flexibility in food acquisition and selection of habitat. For example, in the face of environmental change, an individual may substitute one resource for another in its diet, thereby ameliorating flux in food availability.

At the population level, native fish may have little resistance to invasion by nonnative fish and are vulnerable to hybridization and/or competition. Some mammals compensate for excessive mortality with increased reproduction and/or survivorship, thereby mitigating demographic fluctuations. High survivorship and longevity of adult females typically is critical to the continued well-being of many mammal populations.

At the metapopulation level, dispersal enables animals to augment an existing population or re-colonize an area where a population has been extirpated. Dispersal usually refers to movements by juvenile animals when leaving their natal range after reaching the age of independence (adults occasionally disperse, too). Dispersal is successful only if the individual survives, establishes a home range, finds a mate and reproduces. In landscapes fragmented by human disturbance, successful dispersal is the mechanism by which declining populations are supplemented, genes are shared across the landscape, and functional connectivity of meta-populations is established (Gilpin and Hanski 1991).

In reference to human disturbance, niche flexibility addresses the problem of loss or change in habitat conditions. Capacity for greater productivity enables populations to compensate for overexploitation or to come through a genetic 'bottleneck' more quickly. Dispersal addresses the problem of habitat fragmentation at a landscape scale. Resiliency, however, have definite limits. <u>As human activities accelerate rates of disturbance across a greater extent of the landscape, the combination of rapid change and simplification can undermine the evolved resiliency and render their populations more fragile.</u> Cumulative effects can accrue that threaten their persistence. One of the key messages of resilience thinking is to *keep future options open through an emphasis on ecological variability across space and time*, rather than a focus on maximizing production over a short time (Walker and Salt 2006).

In this section, I use this framework of resilience to assess vulnerability for 6 species of native fish and wildlife. Each profile addresses the following factors: (1) niche flexibility, (2) resistance to hybridization (fish) or reproductive capacity and mortality risk (mammals), (3) dispersal and connectivity, (4) sensitivity to human disturbance, and (5) response to climate change.

Methods for Scoring Conservation Importance

To assess the relative importance of areas across the Southern Canadian Rockies of Alberta, I developed a scoring system to quantify the conservation values for vulnerable fish and wildlife species. The scoring system comprised 3 relative ranks: *Moderate* Importance = score of 1; *High* Importance = score of 2; and *Very High* Importance = score of 3. The scoring system started with moderate importance (rather than low importance) for two reasons: (1) the Crown of the

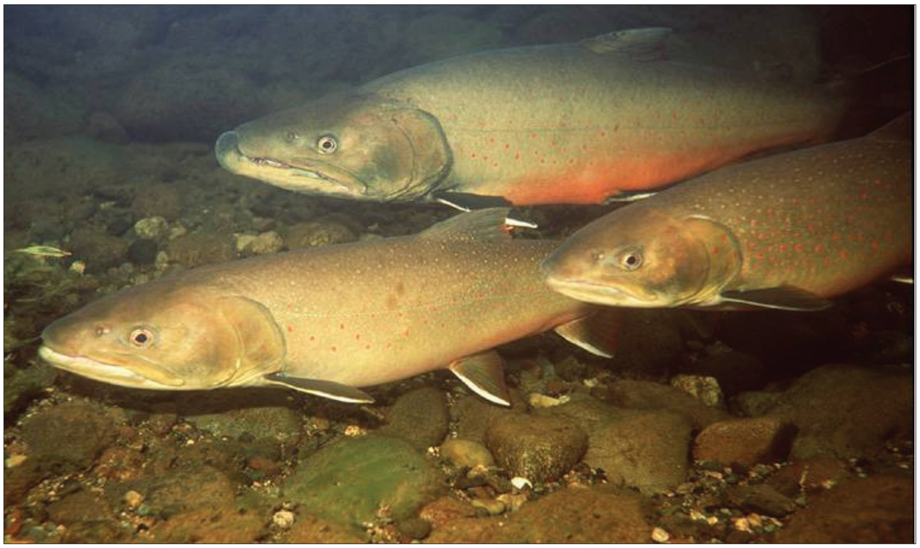
Continent Ecosystem is one of the most ecologically intact and important areas for native fish and wildlife and will likely serve as a large refugia as climate changes, and (2) each of the vulnerable species has national and/or Provincial/State importance due to federal or provincial listing (e.g., bull trout, westslope cutthroat trout, grizzly bear, wolverine) and/or iconic prominence (mountain goat, bighorn sheep).

I customized the scoring criteria for each vulnerable species to reflect attributes that are important to the long-term persistence of that species. In several cases, a higher score incorporates either direct assessment or consideration of future habitats under warming climate – with the intent of providing some future options for that species. For example, in the case of wolverines, places where snow cover persists during a critical spring period are a critical element of their distribution and population ecology. I assigned a higher score to areas where such snow cover is likely to remain until the year 2050 under different climate-change scenarios. Details of the scoring system are provided under each species.

Description of Key Areas of Conservation Value

I used the scored maps to identify key conservation areas for each species. In addition, I summarized the scores in 2 complementary ways. First, I added scores across all species to derive a *composite* score for each 1-km^2 grid cell across the study area (max potential score = 18, 6 species x highest score of 3). I also mapped *species importance* whereby a grid cell with a *very high* or *high* score for any species was highlighted. Although I conducted field studies here during an earlier project 2002-2003 (Apps et al. 2007), I made additional reconnaissance during 2012-2013.

Bull Trout


US Fish and Wildlife Service

Vulnerability Profile

Status: Prior to European settlement, native bull trout were common in the streams, rivers, and lakes along the Eastern Slopes of Alberta (Alberta SRD 2012). The *Provincial* fish of Alberta, the bull trout's range extended from the mountains and foothills out to the prairie as far as Calgary and Lethbridge (Rodtka 2009). Bull trout still occur in all of the major watersheds of the Eastern Slopes of Alberta, but have experienced significant reductions in both range (decrease of 33%) and numbers. Of 128 subpopulations of bull trout in 51 core areas, 11 have been extirpated. About 78% of the core areas have been ranked as *high risk* or *at risk*, 16% as *potential risk* and 6% as *extirpated*. The greatest declines have occurred in the Southern Canadian Rockies of southwest Alberta in the Oldman, Crowsnest, and Castle Rivers of the Oldman River watershed (Fitch 1997). Numerous populations in mountain lakes have been extirpated, too (Donald and Alger 1993). Bull trout have declined due to cumulative effects of over-fishing and catch-and-release mortality, degradation of habitat from industrial and recreational activities, impacts from nonnative fish (competition with lake trout and hybridization by brook trout), and loss of stream connectivity due to dams on larger rivers. Warmer stream temperatures from climate change will degrade bull trout habitat over time (Jones et al. 2013)

In Alberta, bull trout were listed as a *Species of Special Concern* in 2002 under the Provincial Wildlife Act based upon recommendation from its Endangered Species Conservation Committee (Alberta SRD 2012). In November 2012, COSEWIC (Committee on the Status of Endangered Wildlife In Canada) assessed the status of bull trout in the Saskatchewan River basin of Alberta as 'Threatened' (http://www.cosewic.gc.ca/eng/sct1/SearchResult_e.cfm?commonName=bull+trout&scienceName=&Submit=Submit).

In Montana, bull trout are federally listed as 'Threatened' under the Endangered Species Act and critical habitat has been designated (US Fish and Wildlife Service 2010). Declines there have been attributed to many of the same causes as in Alberta.

Niche Flexibility: Bull trout are one of the most thermally sensitive cold-water species in western North America. Laboratory studies suggest that peak growth in bull trout occurs between 10°-15° C, whereas the upper lethal temperature is about 21° C (Selong et al. 2001). In the Flathead River system in Montana, a new spatial model estimated August stream temperatures of spawning and rearing habitat for bull trout at <13° C and foraging, migrating, and overwintering habitat at <14° C (Jones et al. 2013). Bull trout select stream reaches for spawning where upwelling of ground water provides cooler and well-oxygenated conditions (Baxter and Hauer 2000, USFWS 2010). In winter, warm groundwater and beaver ponds inhibit formation of anchor ice, which otherwise would cause high mortality as young trout emerge (Jakober et al. 1998).

Resistance to Hybridization: Because fish have external fertilization, hybridization is more common in fishes than in any other vertebrate taxa (Leary et al. 1995). In undisturbed ecosystems, reproductive isolation is maintained by spatial and temporal isolation during the spawning period. Barriers to inter-breeding may be lost, however, due to introduction of non-native species and exacerbated by habitat alterations. Non-native fish can also displace native fish through predation and competition.

Competition with non-native lake trout (*Salvelinus namaycush*) in lakes is considered the most significant threat to recovery and conservation of bull trout in several areas (Martinez et al. 2009, USFWS 2010). Lake trout prey on young bull trout and can completely displace bull trout in mountain lakes due to substantial overlap in their niches (Donald and Alger 1993, Fredenberg 2000).

Brook trout can reproduce with bull trout, thereby producing mostly sterile hybrids which reduce reproductive potential in populations (Kitano et al. 1994). In addition, they can depress foraging by bull trout (Nakano et al. 1998) or outcompete them for scarce resources (Gunckel et al. 2002, Warnock 2012). Brook trout can displace or push bull trout from lower-elevation streams (Rieman et al. 2006). Conversely, they may invade from higher elevation if introduced to a headwater lake (Adams et al. 2001). Brook trout are moving into higher gradient/higher elevation streams that once were considered refugia for bull trout (McMahon et al. 2007).

Dispersal and Connectivity: Bull trout are a highly migratory fish that require habitat connectivity – unobstructed passage throughout watersheds to link key spawning, rearing and overwintering habitats for all life stages (Alberta SRD 2012). Most bull trout populations are small in size (even smaller in terms of genetically effective size: Rieman and Allendorf 2001); consequently, habitat connectivity is also important in linking populations (metapopulation), which facilitates gene flow and supports re-establishment of depleted populations (Dunham and Rieman 1999, Warnock et al. 2010). Bull trout have migrated as far as 250 km upriver from Flathead Lake to spawn in their natal tributaries in British Columbia (Fraley and Shepard 1989); juvenile dispersal distances up to 158 km have been recorded in the Oldman River drainage in Alberta (Warnock et al. 2010). Bull trout exhibit high fidelity to selected spawning sites, which can be located at specific patches. Much of the genetic variation in bull trout occurs at very fine geographic scales (Kanda and Allendorf 2001, Spruell et al. 2003, Warnock et al. 2010) – bull trout in adjacent drainages can exhibit genetic differentiation (Meeuwig et al. 2010). Hence, it's vital both to maintain local populations to safeguard genetic diversity and connectivity to promote long-term persistence (Spruell et al. 2003). Fragmentation of streams can be caused by barriers such as dams, hanging culverts, water diversion canals, or water depletion for agricultural use.

Sensitivity to Human Disturbance: Bull trout are vulnerable to a wide range of human disturbances (Alberta SRD 2012).

- ➢ Dams can pose the biggest threat by blocking fish movements, resulting in genetic isolation and loss of migratory populations and altering natural flow regimes and river habitats (Hagen 2008, Muhlfeld et al. 2011).
- ➢ The combination of slow growth, late age at maturity, low fecundity, longevity, and high catchability render bull trout particularly susceptible to overfishing, even with per-capita angler restrictions (Post et al. 2003). Prior to the implementation of the province-wide zero harvest regulation in 1995, bull trout were overexploited in accessible waters throughout the Eastern Slopes of Alberta (Alberta SRD 2012). Some over-exploited populations have recovered in 10 years after zero-harvest regulations were implemented (Johnston et al. 2007). Roads increase ready access for angler mortality and poachers (particularly in small lakes and tributary streams where bull trout are especially vulnerable (Parker et al. 2007).
- ➢ Improper timber harvesting practices and associated roads/culverts can increase sedimentation into spawning streams, block access for trout, remove riparian cover and increase stream temperatures (Baxter et al. 1999, Ripley et al. 2005).
- ➢ Mining and oil and gas activities can cause massive chemical pollution of streams and major mortality of fish (Moore et al. 1991), while associated roads can increase sedimentation and provide access (Ripley et al. 2005). Major highways and railroads can increase the potential for catastrophic spill of toxic substances, too.
- ➢ Agricultural practices can de-water streams, increase water temperature, degrade stream banks and increase sedimentation, and disrupt migrations.

When these activities overlap in space and time, significant cumulative effects can arise. A common denominator in these various impacts is roads, which can affect hydrology of streams and increase access to vulnerable fish populations. Over the past decades, a network of roads has proliferated across the Eastern Slopes of Alberta. In the Kakwa River basin of Alberta, the likelihood of bull trout occurrence decreased with an increase in the percentage of sub-basin harvested for timber and road density (Ripley et al. 2005).

Response to Climate Change: Bull trout will likely be vulnerable to several manifestations of climate change. In Alberta, climate models project that there will be decreased snowpack and more rain-on-snow events and flooding in winter, accelerated melting of snow and earlier runoff in spring, reduced recharge of groundwater and lower base flows, warmer stream temperatures and longer periods of drought in summer, and increased sedimentation due to more wildfires. The net result will be warmer water and lower base flows at low-mid elevations, particularly in late summer and fall when bull trout are migrating and spawning (Figure 7) (Schindler and Donahue 2006).

Warmer temperatures and drought could render the lower elevation sections thermally unsuitable as FMO and SR habitat for these cold-adapted fish, leading to contraction of habitats and/or disconnecting these seasonal habitats (Rieman et al. 2007, Jones et al. 2013). Some of the most dramatic increases in stream temperatures could occur in areas that are burned severely by wildfire and lose the shading cover of streamside trees and shrubs (Issak et al. 2010). In addition, warmer stream temperatures could enable nonnative brook trout to invade higher reaches of streams, conceivably raising the prospects of competition and hybridization (McMahon et al. 2007, McCleary and Hassan 2008). The net outcome would be continued shrinkage of the cold-water niche for bull trout, thereby reducing both the size and connectivity of remaining suitable patches and eventually resulting in fewer bull trout (Haak et al. 2010, Wenger et al. 2011).

Conclusion: Bull trout exhibit **high vulnerability** due to low resistance to a variety of factors. They have a demanding cold-water niche – especially for spawning and rearing – and low resistance to warming water. Bull trout have low resistance to invasion by non-native trout, too. Although adult bull trout can move long distances, human fragmentation of hydroscapes can have acute effects on dispersal and connectivity. Bull trout are vulnerable to several detrimental effects of human activities associated with roads. Finally, climate change may impact the stringent cold-water niche of bull trout and lead to smaller, more isolated populations that could be less viable and thus more vulnerable. Protection of clean, cold, structurally-complex and well-connected habitat from invasion by nonnative fish remains a central element in the conservation of bull trout.

Figure 7. Warmer temperatures and increasing drought projected by climate change scientists will result in diminished stream flows for native trout and human users of water sources.

Montana Department of Fish, Wildlife, and Parks

Methods for Scoring Conservation Importance

Fishery biologists with Alberta ESRD (M. Coombs, J. Earle, T. Clayton, J. Stelfox, *personal communication*) kindly provided spatial data on streams with known (1) spawning and rearing (SR) habitat, and (2) foraging, migrating, and overwintering (FMO) habitat for bull trout. In addition, we gleaned information from the Provincial management plan for bull trout (Alberta SRD 2012) and various studies (Rodtka 2009, Eisler and Popowich 2010, Hurkett et al. 2011). We also extracted data on the occurrence of bull trout but SR and FMO had not been ascertained on these streams.

The primary challenge in conservation of bull trout is to maintain viable populations with genetic integrity in suitable aquatic habitats that are cold, complex, and connected (Alberta SRD 2012). Crucial habitats included lakes, main stems of rivers, and tributaries to capture all the various life history stages and full range of migration/resident strategies. As climate change unfolds, however, waters at lower elevations may become too warm for bull trout, especially for spawning and rearing. Tributaries may provide important future options (refugia) due to higher elevation and the input of cooler groundwater.

Accordingly, I assigned the following importance scores for bull trout:

Very High	(3)	=	spawning and rearing habitat in upper rivers and tributaries (SR)
High	(2)	=	rivers/streams for foraging, migration, overwintering (FMO)
High	(2)	=	occupied streams and rivers but status not fully ascertained; nonetheless, all occupied waters have high value

Key Conservation Areas

'Core areas' for bull trout have been identified in Alberta (Rodtka 2009), using similar protocols developed in United States (Fredenberg et al. 2005). These core areas represent meta-populations (and their important habitats) with demographic and genetic connections that function rather independently of other core populations. In the Southern Canadian Rockies of southwest Alberta, 10 core areas have been delineated (Table 1). Bull trout have been extirpated in upper Crowsnest River; they have *high risk* in 6 core areas: St. Mary River, Drywood Creek, Waterton River, lower Oldman River, upper Livingstone River, and Highwood River. Population size is critically low (<250) and declining in 4 of these core areas: Waterton River, Drywood Creek, lower Oldman River, and Highwood River (Alberta SRD 2012).

Based upon genetic clustering methods, bull trout in the Castle, Oldman, and Livingstone Rivers comprised 3 distinct genetic clusters or 'archipelagos' which merit recognition as conservation units (Warnock et al. (2010). Finer genetic structuring may reflect adaptation to local conditions, and further detail is provided in discussion under each watershed. Even small populations should not be 'written off' as lower priority as they make important contributions toward overall genetic diversity and resiliency (Rieman and Allendorf 2001). In areas such as southwest Alberta where native fish populations have been compromised, management should focus on maintaining overall genetic diversity and conserving all populations and habitats (Warnock et al. 2010).

Approximately 151.7 km of streams with *very high* conservation value (spawning and rearing 'SR') and 264.6 km of *high* conservation value (foraging-migration-overwintering 'FMO') occur in the Southern Canadian Rockies of Alberta (Table 2, Figure 8). Provincial data bases indicate another 642.2 km of streams occupied by bull trout, but their current status has not been determined. Nonetheless, these still have high conservation value due to the depressed status of bull trout. Interestingly, only 11.7 % of the SR habitat and 4.6 % of the FMO habitat lie within Alberta's Wildland Provincial Parks. For each watershed, I describe the key areas and the current conservation ranking according to the Bull Trout Conservation Management Plan 2012-2017 (Alberta SRD 2012). The ranking model integrates current population abundance and trends, species distribution, and the severity, scope and immediacy of threats for each bull trout core area.

Belly-Waterton River watershed: About 12.6 % (19.1 km) of SR habitat and 7.8% (20.7 km) of FMO habitat occur in the Waterton River drainage. Key spawning and rearing areas include North Belly River, Blakiston Creek, and Bauerman Creek in Waterton Lakes National Park. The 2 resident subpopulations of bull trout in the Waterton River drainage are considered *high risk* due to very low numbers (1-50), declining trend, and substantial local threats. Current status of bull trout in Drywood and Yarrow Creek drainages is being determined (J. Blackburn, Alberta Conservation Association, *personal communication*) but is considered *high risk* due to similar reasons. The single subpopulation in the Belly River is considered at risk due to moderate numbers, stable trend, and low severity of threats.

Castle River watershed: About 36.5% (55.4 km) of SR habitat and 39.9% (105.6 km) of FMO habitat occur in the Castle River drainage. Key spawning and rearing areas include upper Pincher Creek, Mill Creek and Whitney Creek, South Castle River, West Castle River, and Gardiner, Lynx, and North and South Lost Creek in the Carbondale River drainage. Other sections of Mill Creek, Castle River, and Carbondale River are FMO habitat. Bull trout in West Castle River and Mill Creek separate at a finer genetic level to comprise 2 subpopulations. And at a finer level yet, there was detectable differentiation between the West Castle and Carbondale Rivers (Warnock et al. 2010). Bull trout in the upper Castle River drainage are considered *at risk* due to moderate numbers (250-1000), stable trend, and moderate imminent threats. Bull trout in the Castle River may act as a source of individuals to the population in the Oldman River (Warnock et al. 2010), which may be vital toward recovering depressed subpopulations.

***Crowsnest River* watershed**: Bull trout have been extirpated in the upper Crowsnest River above Lundbreck Falls. Below these falls, bull trout have been primarily assigned genetically to the Castle River population. So, the river below the falls is considered FMO habitat.

Oldman River watershed: About 23.9% (36.2 km) of SR habitat and 43.0% (113.8 km) of FMO habitat occur in the upper Oldman River drainage. Key spawning and rearing areas include South Racehorse Creek and Daisy

Creek, upper Dutch Creek, Hidden Creek and upper Oldman River. Lower sections of these waters are FMO habitat. Some bull trout may occur in lower reaches of Vicary, Camp, and Bob Creeks. Bull trout in Racehorse Creek and Hidden Creek can be distinguished at a finer genetic level and considered as subpopulations (Warnock et al. 2010). Based upon on-going analysis of data, population size of bull trout in the year 2012 was estimated to be 207 mature fish (95% CI: 85-344), with a declining trend of -10% per year (M. Coombs, ESRD, unpublished data). Thus, the status of bull trout in the upper Oldman River may warrant downgrading to *high risk*.

Bull trout in the Livingstone River above and below Livingstone Falls can be considered 2 subpopulations (upper and lower Livingstone). The resident population in the upper Livingstone is considered *high risk*.

Highwood River watershed: About 27.0% (41.0 km) of SR habitat and 9.3% (24.5 km) of FMO habitat occur in the upper Highwood River drainage. The Highwood River above Etherington Creek is a key spawning and rearing area, while the section below is FMO habitat (Eisler and Popowich 2010). Bull trout also spawn in lower Loomis Creek for about 2 km up to an impassable waterfall; there appears to be suitable spawning habitat for another 4-5 km above that point (Earle 2009). The resident and fluvial populations of bull trout in the Highwood River drainage are considered *high risk* due to low numbers (50-250), declining trend, and substantial imminent threats.

To sum up: the current conservation status of bull trout in the Southern Canadian Rockies of Alberta is poor and declining overall. Many populations rated as 'stable' are likely far below historical population levels. No core areas remain healthy (i.e., low risk) and most are at considerable risk of loss. According to the Province's Bull Trout Conservation Management Plan (Alberta SRD 2012), the dismal status of bull trout

> "has largely been a consequence of the increasing cumulative impacts of industrial and recreational activities within the species historic range as well as competition from introduced fish species. Conserving healthy aquatic ecosystems requires the adoption of disturbance thresholds that will not be exceeded, and a commitment to restoration and protection of degraded habitats."

Table 1. Conservation characteristics of bull trout core areas, Southern Canadian Rockies of Alberta (from Rodtka 2009, Alberta SRD 2012).

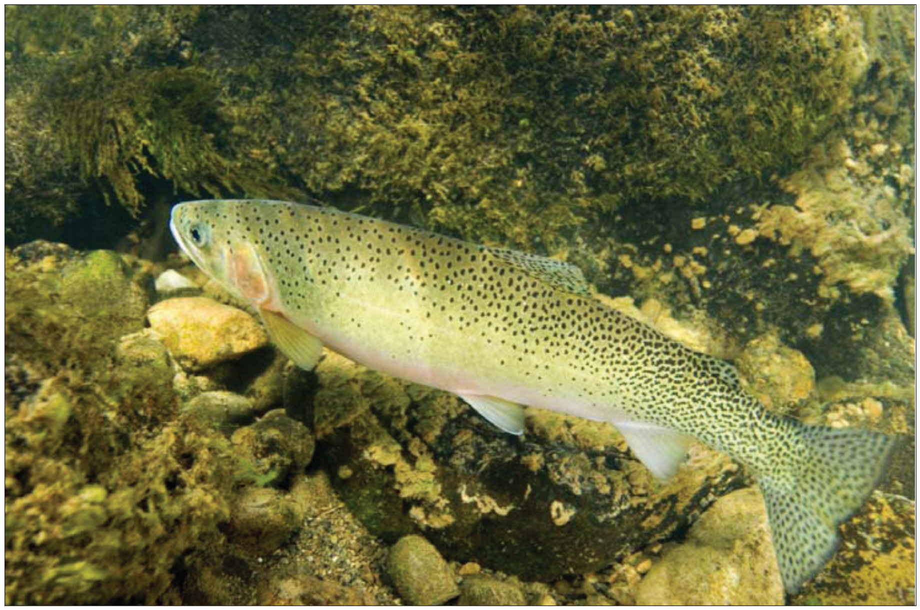
Core Area	Risk	Pop Size	Stream (km)	Trend	Threats
Upper Crowsnest River	E	-	-	-	-
Drywood Creek	High	1-50	4 – 40	Declining	Substantial, imminent
Waterton River	High	1-50	4 – 40	Declining	Substantial, localized
Highwood River	High	50-250	40 - 200	Declining	Widespread, low
Lower Oldman River	High	50-250	40 - 200	Declining	Substantial, imminent
St. Mary River	High	250-1000	40 - 200	Stable	Substantial, imminent
Upper Livingstone River	High	250-1000	4 – 40	Stable	Moderate, imminent
Upper Oldman River	At Risk	250-1000	40 - 200	Stable	Moderate, imminent
Castle River	At Risk	250-1000	200 - 1000	Stable	Moderate, imminent
Belly River	At Risk	250-1000	4 - 40	Stable	Widespread, low

Table 2. Length (km) of streams and percentage of bull trout conservation values (CV) in watersheds across the Southern Canadian Rockies, Alberta.

	Very High CV (3) – SR		High CV (2) – FMO		High CV (1) – occupied	
Watershed	Length	% CV	Length	% CV	Length	% CV
Highwood	41.0	27.0	24.5	9.3	0.0	0.0
Oldman	36.2	23.9	113.8	43.0	258.8	40.3
Crowsnest	0.0	0.0	0.0	0.0	0.0	0.0
Castle	55.4	36.5	105.6	39.9	262.2	40.8
Waterton	19.1	12.6	20.7	7.8	121.2	18.9
TOTAL	151.7	100.0	264.6	100.0	642.2	100.0

Figure 8. Location of key conservation values for bull trout in the Waterton-Belly, Castle, Oldman, and Highwood River watersheds, Southern Canadian Rockies, Alberta. Streams occupied by bull trout are also considered high conservation value. These latter streams have not been edited for waterfalls, which may exclude bull trout.

Westslope Cutthroat Trout



Michael Ready

Vulnerability Profile

Status: The westslope cutthroat trout (WCT) is one of 15 recognized subspecies of native cutthroat trout in western North America and the only one native to Alberta (Behnke 2002). Historically, WCT were abundant in the major rivers and accessible streams in the Oldman River drainage (Waterton, Castle, Crowsnest, and Oldman River) and Bow River drainage (Highwood River) of the Southern Canadian Rockies in southwest Alberta. Numerous historical records indicate that this native fish was abundant throughout its historic range in the (Mayhood et al. 1997). At present, westslope cutthroat trout occupy approximately 5% of the historic range in Alberta due to introductions of non-native fish (especially rainbow trout), habitat degradation, and over-exploitation (cf. Figures 3 and 4 *in* Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017). Currently, genetically-pure westslope cutthroat trout (<1% introgression) are restricted to about 51 fragmented populations located mostly in headwater streams, with total numbers estimated to be <5100 adult individuals (Alberta Westslope Cutthroat Trout Recovery Team 2013). Some 29 of these populations are considered at risk of extirpation due to hybridization with non-native trout and effects of small population size. Hatchery-raised WCT have been transplanted widely in Alberta, including some previously fishless headwater lakes above impassable waterfalls (Alberta SRD 2006). In 2013, the Alberta population of westslope cutthroat trout was listed as '***Threatened***' under the Federal *Species at Risk Act*. (http://www.cosewic.gc.ca/eng/sct1/SearchResult_e.cfm?commonName=cutthroat+trout&scienceName=&Submit=Submit).

Niche Flexibility: Like bull trout, westslope cutthroat trout also have stringent requirements for cold water. Laboratory studies suggest that optimum temperature for growth and long-term persistence in westslope cutthroat trout is about 13-15° C, whereas the upper lethal temperature is about 20° C (Bear et al. 2007). Rainbow trout (RBT), a nonnative competitor and source of genetic introgression, have a greater capacity for growth at warmer temperatures and a higher upper limit of lethal temperature at 24° C in the laboratory. In the North Fork Flathead River in Montana, pure westslope cutthroats were found in stream reaches where average summer temperatures ranged from 6.6°-11° C (Muhlfeld et al. 2009b). Brook trout, another non-native competitor, have similar optimum temperatures as westslope cutthroat trout but can tolerate a wider range of temperatures and may readily replace WCT (Shepard 2010). Thus, westslope cutthroat trout may find refugia in higher elevation streams with colder temperatures (Paul and Post 2001, Rasmussen et al. 2010). Suitable habitat for spawning and rearing occurs in low-gradient streams with cold, well-oxygenated water and clean gravels, with cover provided by large woody debris or boulders and riparian vegetation that stabilizes banks and provides shade.

Resistance to Hybridization: Westslope cutthroat trout have low resistance to hybridization and genetic introgression by non-native trout. Indeed, interbreeding between westslope cutthroat trout and rainbow trout and the resulting loss of genomic integrity is widely considered the greatest threat to the persistence of pure westslope cutthroat trout throughout their range (Shepard et al. 2005, Robinson 2007, Boyer et al. 2008, Alberta WCT Recovery Team 2013). Rainbow trout produce fertile offspring when crossed with cutthroat trout, resulting in genetic introgression. In early stages, populations may be comprised of admixtures of both hybrids and non-hybridized westslope cutthroats. But, in the absence of barriers, introgression often spreads until a hybrid swarm develops, and the native cutthroat genomes become extinct (Leary et al. 1995).

The stocking of rainbow trout within the range of native cutthroat trout has been almost an industry unto itself for much of the 20th century. For example, rainbow trout were released into several drainages in the Southern Canadian Rockies of Alberta over many decades (*in* Alberta SRD 2006).

Castle River	- 6 years between 1934 and 1966
Crowsnest River	- 9 years between 1937 and 1949
Highwood River	- 48 years between 1927 and 2004
Livingstone River	- 6 years between 1940 and 1950
Oldman River	- 57 years between 1926 and 2004

Although no stocking of rainbow trout currently occurs in areas where it would threaten remnant populations of pure westslope cutthroat trout, the policy needs to be reviewed and strengthened to facilitate expansion toward recovery.

Westslope cutthroat trout often spawn in headwater streams, whereas rainbow trout and hybrids usually spawn lower in the drainage. Hybridization was more likely to occur and spread in streams with warmer temperatures at lower elevations, increased number of roads crossing streams, and closer proximity to the main source of hybridization (Rubidge and Taylor 2005, Muhlfeld et al. 2009b). Although the amount of introgression decreases with greater distance from the source (isolation by distance), the spread of hybridization has been facilitated both by stepping-stone invasion and by long-distance dispersal and straying of hybrids and rainbow trout. Importantly, researchers have documented that as little as 20% hybridization can result in a 50% decline in reproductive success (Muhlfeld et al. 2009c). The conservation implication is that even low levels of genetic introgression may facilitate continued expansion of hybridization and place native cutthroat trout at risk, unless source populations of non-native trout are suppressed or eliminated.

Nonetheless, an interesting case of recovery-by-dilution has been documented near Crowsnest Pass (Bennett and Kershner 2009). Summit Lake was stocked with 3,000-50,000 rainbow trout per year in 20 years between 1939 and 1995. During a year of high runoff, rainbow trout were swept downstream into a tributary of the Elk River, which resulted in some introgression (6% hybrids) of westslope cutthroat trout. Recent monitoring, however, has indicated that this effect has been diluted over a 9-year period. Nonetheless, this case illustrates that RBT stocking of high-elevation lakes is a misguided practice that can facilitate the spread of hybridization downstream through much of the stream network (Adams et al. 2001). Bennett (2007) recommended a ban on stocking of any fertile rainbow trout, which could be particularly critical to conserving remaining genetic integrity of westslope cutthroat trout in areas such as the Southern Canadian Rockies of Alberta.

In addition to rainbow trout, brook trout are another widespread non-native species in the western states and provinces which can threaten remnant populations of native cutthroats (Peterson et al. 2004). They have a similar niche with cutthroat trout and can displace the natives in warmer waters at most elevations (Shepard 2010). Growth and reproductive success of the native cutthroats may decline, however, if confined to small, very cold headwater reaches and jeopardize their long-term viability (Coleman and Fausch 2007). Hence, barriers to prevent invasion by brook trout has become an important conservation strategy for preserving viable populations of westslope cutthroat trout (Fausch et al. 2009), along with removal of non-native fish (Quist et al. 2004).

Dispersal and Connectivity: Like other salmonids, westslope cutthroat trout exhibit a high propensity to return to their natal stream ('natal philopatry'). Various genetic studies have detected substantial genetic differentiation in westslope cutthroat trout among drainages; thus, it may be necessary to manage them separately to maintain genetic diversity across a region (beta-diversity) and its evolutionary legacy (Taylor et al. 2003, Drinan et al. 2011). Hence, translocation of WCT from 1 drainage to augment a population in another drainage could be detrimental to maintaining genetic diversity across the region.

The vulnerability of westslope cutthroat trout to genetic hybridization accentuates the trade-off dilemma between connectivity and isolation (Fausch et al. 2009). Theoretically, small and isolated populations have a greater likelihood of extirpation than those that are large and well connected – due to both systematic and random pressures (Gilpin and Hanski 1991). Consequently, a common conservation strategy is to promote connectivity between populations to facilitate both demographic and genetic exchange. In the case of stream fish, however, such connectivity also enables competition and genetic introgression by nonnative species, and artificial barriers may be needed in some places to stop the introgression by nonnative fish … hence, the dilemma. Fausch et al.

(2009) proposed a framework to explicitly examine the trade-offs in specific situations. Where non-native trout do not occur, fish biologists recommend maintaining large areas of interconnected habitats within drainages to furnish options for movements by juvenile fish, provide diverse habitats, and support migratory and resident life histories (Muhlfeld et al. 2012).

Sensitivity to Human Disturbance: The biggest human threat to native westslope cutthroat trout has been purposeful stocking of rainbow trout in the past (and continued illegal releases), resulting in loss of genetic integrity (Shepard et al. 2005). Nonetheless, degradation of habitat quality by various land uses has also been a major contributing factor – especially in southwest Alberta (Alberta WCT Recovery Team 2013). Roads built for timber harvesting, oil & gas exploration and development, mining, and motorized recreation (ATVs) can increase sedimentation into spawning streams, block access for trout from hanging culverts, alter stream channels and flow patterns, remove riparian cover and increase stream temperatures. Problems often arise at crossings of small streams, especially in the headwaters where impacts can propagate downstream. Moreover, roads increase ready access for fish exploitation and mortality by anglers (westslope cutthroat trout are susceptible to over-fishing). Agricultural practices can de-water streams, increase water temperature, degrade stream banks and increase sedimentation, and disrupt migrations. Mining and oil and gas activities can cause massive chemical pollution of streams and major mortality of fish. (*See* the Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017 for a thorough discussion and documentation of these myriad impacts.) The strong implication is that protected areas without any roads or low road density safeguard habitat for vulnerable and threatened populations of westslope cutthroat trout.

Response to Climate Change: Like bull trout, westslope cutthroat trout appear quite vulnerable to myriad effects of climate change (Williams et al. 2009, Haak et al. 2010). Climate change is projected to have major effects on the hydrologic regime, including: decreased snowpack and more rain-on-snow events, accelerated melting of snow and earlier runoff in spring, increased flooding, and reduced recharge of groundwater and lower base flows. Increased warming and evapotranspiration will result in warmer stream temperatures in summer, longer periods of drought, as well as loss of shading cover along streams and increased sedimentation due to more wildfires. The net result of such changes will be warmer water and lower stream levels at low to mid-elevations, particularly in late summer (Sauchyn and Kulshreshta 2008). Warmer stream temperatures could directly stress the physiological limits of cold-water adapted species like cutthroat trout. Haak et al. (2010) examined risk of 4 factors: increasing summer temperature, drought, wildfire, and flooding. Based upon their assessment, populations of westslope cutthroat trout at low to mid-elevations could become more vulnerable – especially if warmer and drier scenarios develop.

In addition, warmer stream temperatures likely will enable rainbow trout to invade even further upstream, where they will compete and hybridize with westslope cutthroat trout (Rahel and Olden 2008). These warmer temperatures may also elevate the lower limits of suitable stream habitat for coldwater trout, thereby squeezing them between lower reaches that are too hot and upper reaches that are too small. The net result would be continued shrinkage in habitat and population numbers, rendering them less resilient (Hilderbrand and Kershner 2000). Intense and widespread wildfires could have greater proportional impacts on these residual habitats and populations (Brown et al. 2001, Dunham et al. 2003). Cascading effects may occur, for example, when warmer winters enable outbreaks of mountain pine beetle in lodgepole pine forests … increasing likelihood for forest fires … leading to pre-emptive or salvage logging on vulnerable sites … resulting in significant soil erosion to streams and fish already stressed by other factors.

Conclusion: Westslope cutthroat trout exhibit **high vulnerability** due to low resistance and resiliency to human impacts. They have a cold-water niche – especially for spawning and rearing – and low resistance to warming water. Moreover, westslope cutthroat have especially low resistance to invasion by non-native trout. Due to the widespread introduction of rainbow trout, many of the genetically-pure populations are now confined to headwater streams – where they have lower growth and productivity. Westslope cutthroat trout are vulnerable to several detrimental effects of human activities associated with roads. Finally, climate change may counteract the thermal advantage niche of westslope cutthroat trout and lead to further isolation of smaller populations in headwaters. Two strategies appear useful: (1) safeguarding habitat integrity of streams that retain genetically-pure populations of westslope cutthroat trout, and (2) stocking streams that have natural barriers with genetically-pure specimens and/or installing barriers to protect selected cutthroat populations.

Methods for Scoring Conservation Importance

Location of streams occupied by pure (>99% genetic integrity) and slightly introgressed (95-99%) was kindly provided by regional fisheries biologists (M. Coombs, J. Earle, T. Clayton; Fish and Wildlife, Alberta ESRD). It should be noted that, in some cases, westslope cutthroat trout may occur higher up the tributary than mapped.

Maintaining genetic integrity of westslope cutthroat trout in suitable cold-water habitat is widely considered to be a primary challenge in their conservation. Although including hybridized populations is subject to debate, some fish managers argue that elimination of any genetically-contaminated population might result in loss of unique phenotypic, genotypic, and behavioral variations (Dowling and Childs 1992). Others have recommended that only genetically pure populations of westslope cutthroat trout should be protected because this would best safeguard their evolutionary legacy, protect local adaptations presumed important for long-term persistence, and minimize opportunity for spread of introgression (Allendorf et al. 2004). Both the Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017 and other contemporary conservation plans (e.g. Montana and Idaho: Shepard et al. 2005) have chosen to emphasize pure populations, while maintaining a portfolio of slightly-introgressed populations.

Accordingly, I assigned the following importance scores for westslope cutthroat trout:

Very High	(3)	=	populations of ≥99 % genetic purity
High	(2)	=	populations of ≥95 % but <99% genetic purity
Moderate	(1)	=	n.a.

Key Conservation Areas

An estimated 236.2 km of streams with *Very High* conservation value (>99% pure) and 195.4 km with *High* conservation value (95-99%) for westslope cutthroat trout occur in the Southern Canadian Rockies of Alberta (Table 3, Figure 9). The most important drainages for westslope cutthroat trout are the upper Oldman River (56% of *Very High* and 28% of *High* values) and upper Castle River (25% of *Very High* and 62% of *High* values) watersheds. Some of these headwater populations are separated from non-native trout (primarily rainbow trout) by barriers, while others are not secure from genetic invasion. The former comprise strongholds for this species in the region, whereas the latter may represent opportunities to recover the species by various actions.

Waterton River watershed: There are no waters with original westslope cutthroat trout >90% genetic integrity in Waterton Lakes National Park. The only pure population of WCT was *introduced* into previously fishless Goat Lake (B. Johnston, WLNP, *personal communication)*. DNA samples of westslope cutthroat trout from Sofa Creek and Dungarvan Creek are awaiting final genetic analysis.

Castle River watershed: Genetically-pure westslope cutthroat trout occur in 59.1 km of streams in the Castle River drainage, while slightly introgressed WCT occur in another 120.8 km. Streams with genetically-pure westslope cutthroat trout include: upper South Castle River, West Castle River, upper reaches of Carbondale River, North Lost Creek, most of Lynx Creek, and Gladstone Creek.

***Crowsnest River* watershed**: Genetically-pure westslope cutthroat trout (>99%) have been eliminated from the main stem of the Crowsnest River but do occur in 25.2 km of streams. Small, remnant populations of pure westslope cutthroat trout occur in Gold Creek, Rock Creek, Allison Creek, 'Sentinel' Creek and Star Creek. Slightly introgressed WCT (>95%) occur in another 14.6 km in upper Blairmore Creek and Island Creek.

Oldman River watershed: Genetically-pure westslope cutthroat trout (>99%) still persist in 157.5 km of streams in the Oldman and Livingstone River drainage, while slightly introgressed WCT (>95%) occur in another 69.8 km (Taylor and Gow 2007). Streams with genetically-pure westslope cutthroat trout include: South and North Racehorse Creeks, Hidden Creek, Cache Creek, and headwaters of the Oldman River (including Pasque, Straight, and Oyster Creeks). Slightly-introgressed, remnant populations occur in upper Dutch, Camp, and Daisy Creeks. On the east side of the Livingstone Range, remnant populations of genetically-pure WCT occur in headwater tributaries (Johnson and Corral Creeks) of Willow Creek, and also in Ernst and Upper Tod Creeks.

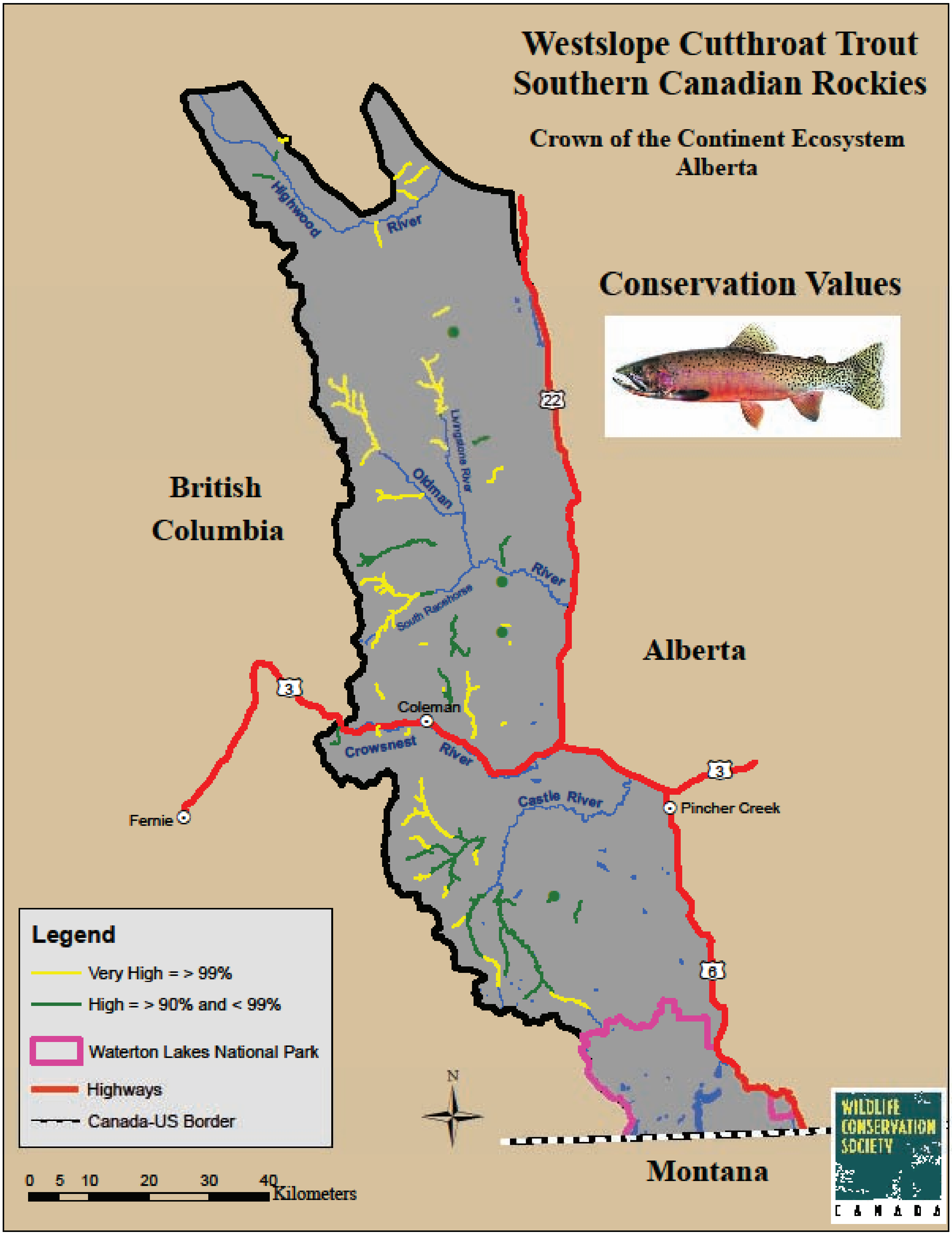
All of these appear to be small, remnant populations that are stream-resident (i.e., migratory life-history forms have been lost). An isolated population of genetically-pure westslope cutthroat trout occurs in the headwaters of the upper Livingstone River above Livingstone Falls (including sections of Beaver, Isolation, Mean, and Savanna Creeks). Below the falls, small, remnant populations occur in Spears Creek and upper White Creek.

Highwood River watershed: Genetically-pure westslope cutthroat trout occur in 19.6 km of streams in the Highwood River drainage, while slightly introgressed populations occur in another 4.8 km. Waters that still retain pure WCT include Picklejar Lakes, and Zephyr, Deep, Cutthroat, and upper Flat Creeks.

Table 3. Length (km) of streams and percentage of westslope cutthroat trout conservation values in watersheds across the Southern Canadian Rockies, Alberta.

	Very High CV (3)		High CV (2)		COMBINED	
Watershed	**Length**	**% CV**	**Length**	**% CV**	**Length**	**% CV**
Highwood	19.6	8.3	4.8	2.5	24.4	5.6
Oldman	132.3	56.0	55.2	28.2	187.5	43.4
Crowsnest	25.2	10.7	14.6	7.5	39.8	9.2
Castle	59.1	25.0	120.8	61.8	179.9	41.7
Waterton	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	236.2	100.0	195.4	100.0	431.6	100.0

Figure 9. Location of conservation values for westslope cutthroat trout in the Castle, Crowsnest, Oldman, and Highwood River watersheds of the Southern Canadian Rockies, Alberta.



Grizzly Bear

Milo Burcham

Vulnerability Profile

Status: In Canada, the western population of the grizzly bear (including Alberta) was assessed as species of Special Concern by COSEWIC in both 2002 and 2012 but has not been listed under SARA (http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=1195). The Provincial government of Alberta listed the grizzly bear as a 'Threatened' species in June, 2010. Stated reasons for listing included: (1) small size of breeding population, (2) restricted dispersal from adjacent jurisdictions, and (3) expectation that current and future land use and human activity will lead to declines. Primary issues were noted: (1) human-caused mortality, and (2) un-restricted road access and use in grizzly habitats that can lead to habitat fragmentation and conflicts with humans, which contributes to increased mortality. The estimated size of the population is approximately 691 grizzly bears.

Niche Flexibility: Grizzly bears exhibit considerable flexibility in their foraging and habitat use over space and time (Schwartz et al. 2003a). Although grizzly bears in the Southern Canadian Rockies use a wide variety of foods, four main groups compose most of their diet: grasses and sedges, forbs and forb roots, berries, and mammals (including ungulates and rodents) (Craighead et al. 1982, Mace and Jonkel 1983, Hammer and Herrero 1987b, Aune and Kasworm 1989, McLellan and Hovey 1995, Nielsen et al. 2010). Here, grizzly bears fed on: (1) ungulates (usually carrion of winter-killed elk and moose or new-born calves), grasses and sedges, and glacier lily (*Erythronium grandiflorum*) bulbs and hedysarum (*Hedysarum* spp.) roots in spring; (2) grasses, horsetails (*Equisetum arvense*), forbs like cow parsnip (*Heracleum lanatum*) and angelica (*Angelica arguta*), and insects (ants, cutworm moth larvae) in summer; (3) huckleberries (*Vaccinium* spp.) and russet buffaloberries or soapberries (*Shepherdia canadensis*) in late summer; and (4) berries, ungulates (gut-piles, weakened animals), and roots in fall.

There are several key habitats that provide 1 or more of these seasonally important foods. Avalanche chutes on steep mountain slopes produce a diversity of foods, including grasses, horsetail, glacier lily and cow-parsnip, and berry-producing shrubs such as serviceberry (*Amelanchier alnifolia*) in the lower and middle sections of the chute and huckleberry in the adjacent stringers of open conifer trees (McLellan and Hovey 2001, Waller and Mace 1997). Avalanche chutes may be especially important to females with cubs-of-the-year who choose to reside in high, secluded basins in rugged terrain (Theberge 2002).

Riparian areas adjacent to streams, lakes, and wetlands represent another critical habitat for grizzly bears, particularly during spring and again in fall. Key foods include grasses and sedges, horsetails, hedysarum, cow parsnip, buffaloberry, and occasional moose (McLellan and Hovey 2001).

Although bears consume a diverse array of foods during spring and early summer, they focus upon berries in late summer and fall for weight gain and fat deposition necessary for successful hibernation and reproduction. Huckleberries are important west of the Continental Divide (McLellan and Hovey 2001), whereas buffaloberry is important along the Eastern Slopes of Alberta (Hamer and Herrero 1987b). Buffaloberry grows in a wide variety of mesic-dry sites including riparian zones/alluvial floodplains and valley bottoms, gentle slopes with various aspects, and relatively open stands of conifer and aspen that have burned in past 10-80 years ago (Hamer and Herrero 1987a, Hamer 1996, Walkup 1991). However, berry production in both species varies greatly among years, which appears influenced by variable weather patterns.

In the face of a shortfall in nutritious food, bears move widely in search of food – which may increase encounters with humans (Mattson et al. 1992). This substantially increases the risk of immediate human-caused mortality, management capture and translocation with problematic success, and food-conditioning or habituation which may lead to future problems.

Reproductive Capacity and Mortality Risk: Grizzly bears exhibit very low reproductive potential and cannot readily compensate for high mortality rates (Schwartz et al. 2003a). Females produce their first litters at approximately 4-8 years of age and are most productive between 8-25 years of age (Schwartz et al. 2003b). They average 2 cubs per litter, with an average interval between litters of 3 years, for an annual production of only 0.5 – 0.8 cubs per year. It's estimated that the average female grizzly bear may produce only 3-4 surviving daughters during a full lifetime. There is no conclusive evidence of a sharp reproductive response or increased survival of young that would compensate for increased mortality (McLellan 1994, Craighead et al. 1995).

Consequently, grizzly bear populations cannot absorb high mortality levels. Survival – particularly of adult females – is the most important factor influencing population growth and long-term viability of grizzly bear populations (Boyce et al. 2001). Specifically, annual survivorship of female grizzly bears should be ≥92% to maintain stable populations (Eberhardt 1990, Garshelis et al. 2005), but this is a difficult and expensive metric to measure. Known mortality rates from human causes should not exceed 4%, with deaths of females not to exceed 30% of that level (US Fish & Wildlife Service 1993).

Most mortality of grizzly bears is human-caused, either from direct shooting or removal by agency personnel if bears become habituated (loss of wariness) or conditioned to human food and garbage (Mattson et al. 1996, McLellan et al. 1999, Gibeau et al. 2002, Benn et al. 2005). Across 13 study areas in the interior mountains of western North America, people killed 75% of 77 grizzly bears that died while radio-collared between 1975 and 1997 (McLellan et al. 1999). It was estimated that approximately half of the deaths would not have been detected without the aid of radio-collars.

This human-caused mortality of grizzly bears often occurs around human settlements and/or within 1 km of roads – especially where open roads are proximal to streams or avalanche chutes in spring and berry patches at lower elevations during late summer-fall (McLellan and Shackleton1988, Mace et al. 1996, Nielsen et al. 2004, Herrero et al. 2005). In the Alberta Central Rockies Ecosystem, 89% of human-caused mortalities (n=172) were within 500 m of a road on provincial lands (Benn 1998). As resource extraction (e.g., oil and gas exploration and development, logging, mining) and motorized recreation expands into hitherto remote areas, road construction provides entry for hunters, poachers, and new sources of food and garbage which elevates mortality risk. Of special concern is human access into areas of naturally rich habitat that attract bears into situations having high risk of mortality ('attractive sinks': Delibes et al. 2001, Nielsen et al. 2006, Ciarniello et al. 2007). The Alberta Grizzly bear Recovery Plan emphasizes that "human use of access (specifically, motorized vehicle routes) is one of the primary threats to grizzly bear persistence" (Alberta SRD 2008:9). Provision of 'security areas', where bears can meet their energetic requirements while minimizing contact with people, has emerged as a critical component of contemporary management for grizzly bears (Weaver et al. 1996, Gibeau et al. 2001, Herrero et al. 2005, Nielsen et al. 2006, Ciarniello et al. 2007, Nielsen et al. 2010).

Dispersal and Connectivity: Relatively little is known about dispersal in grizzly bears. Dispersal by young bears appears to be a gradual process over months or even years (McLellan and Hovey 2001b). Compared to many other carnivores, young grizzlies do not seem to disperse very far from their natal range. In the trans-boundary Flathead area, the average dispersal distance was 10 km for females (longest = 20 km) and 30 km for males (longest = 67 km) (McLellan and Hovey 2001b). Sub-adult females often establish home ranges that overlap their mother's. The implication is that female grizzly bears are unlikely to colonize disjunct areas even at modest distances.

In the Canada-US border region, Proctor et al. (2012) reported extensive genetic and demographic fragmentation that corresponded to settled mountain valleys and major east↔west highways. Both female and male bears reduced their movement rates with increasing settlement and traffic volume but at different thresholds. When human settlement increased to >20% along a fracture zone (e.g., river valley), female grizzlies reduced their movement rates sharply.

Males continued to cross these zones but at lower rates than less settled areas. In areas with >50% settlement, both females and males exhibited much reduced movements in response to traffic, settlement, and mortality. Only 1 female grizzly bear has been detected as a migrant across Highway 3 in the Southern Canadian Rockies of B.C. (Apps et al. 2007).

In contrast, wildlife researchers have documented both female and male grizzlies crossing the Continental Divide between Alberta and British Columbia. At least 8 female grizzlies and 8 adult males had home ranges that spanned the Continental Divide between the upper Highwood and upper Oldman River basins in Alberta and the upper Elk River watershed in British Columbia (Carr 1989, Eastern Slopes Grizzly Bear Project: Herrero 2005). At least 5 male grizzlies were detected in 2007 moving from hair-snaring stations in the B.C. Flathead over the Divide into the Castle area of Alberta (Boulanger et al. 2008).

Enough movements by male bears may mediate gene flow for now, but the low rate of female grizzly bear movements appears insufficient to augment a declining population or colonize one that has been extirpated. Hence, fragmentation of southqnorth connectivity is a real conservation concern. Proctor et al. (2012) recommended (1) securing key linkage habitats across fracture zones that would enable connectivity for female bears, and (2) maintaining large core populations as sources of dispersers.

Sensitivity to Human Disturbance: Grizzly bears are vulnerable to human disturbance at different spatial and temporal scales. Earlier studies indicated that grizzly bears avoid roads 100-900 m away and human settlements even further (Mattson 1987, McLellan and Shackleton 1988, Kasworm and Manley 1990, Apps et al. 2004). The *type* of human activity on a road may affect grizzly bear use. In the trans-border Selkirk Mountains, most of the radio-collared females and males selected against roads open to the general public (Wielgus et al. 2002). Most female bears also selected against roads closed to the public, perhaps because they were in the general vicinity of open roads. But neither female nor male bears selected against restricted roads open to forestry-use only where people were working at a focal site.

In terms of displacement, the *volume of vehicle* traffic may be as important as the road itself. In western Montana, Mace et al. (1996) reported that all collared bears avoided areas within 500 m of roads having >60 vehicles per day. For roads having 11-60 vehicles per day, the majority of sample bears avoided areas within 500 m during spring (7/11), summer (6/10), and fall (8/9). For roads with 10 or fewer vehicles per day, some bears avoided while others did not. In southwest Alberta, Northrup et al. (2012) reported similar findings for bear use within 500 m of roads: (1) for roads with *low* traffic volume (<20 vehicles per 24 hr), bears used areas at night (even crossing roads); but (2) bears avoided or strongly avoided roads with moderate (20-100 vehicles per 24 hr) and high (>100 vehicles per day), respectively. Gated roads had the lowest traffic volumes of any roads. Female bears have used steeper slopes and/or nighttime activity in response to human activities (Waller 2005, Martin et al. 2010).

At a larger spatial scale of composite home ranges (CHR), road density was lower (0.6 km/km^2) within the CHR of adult female bears than outside (1.1 km/km^2) in the Swan Mountains of western Montana (Mace et al. 1996). Approximately 50% of their CHR was un-roaded and >80% of their telemetry locations occurred in blocks of undisturbed habitat > 9 km^2. Many land and resource agencies have embraced the conservation target: core habitat should have road densities below 0.6 km/km^2. Northrup et al. (2012) suggested that this should be amended as follows: to mandate that the majority of these roads should have low volume (<20 vehicles per 24 hr period).

Grizzly bear populations can live in large areas that contain some roads and certain kinds of human activities (e.g., McLellan and Shackleton 1988, Mace et al. 1996). Yet, some bears will displaced from some key habitats and incur direct mortality and/or non-lethal conflicts with humans that result in their eventual removal from the population (Mattson et al. 1996, Gibeau et al. 2002, Herrero et al. 2005). Overall, both the history of grizzly bears in the lower 48 states where grizzly bears have lost 99% of their historical range (Mattson and Merrill 2002) and contemporary studies (Mace et al. 1996, Theberge 2002, Apps et al. 2004) indicate that grizzly bear populations persist longer in areas secure from human settlement and *motorized* access and associated mortality (Gibeau et al. 2001, Nielsen et al. 2006).

Response to Climate Change: With their general resourcefulness and wide-ranging ability, grizzly bears would seem capable of adapting to direct effects of climate change (Servheen and Cross 2010). The most likely ecological effects of warming climate in the Southern Canadian Rockies may be greater plant productivity in currently cold sites and greater extent of berry-producing shrubs due to greater frequency of forest fires (depending upon intensity). On the other hand, less snow could mean decreased avalanche activity. Perhaps the largest implication of climate change for grizzly bears, though, is the extent to which humans will (1) migrate into the Southern Canadian Rockies as a response to more intense climate change (heat, drought, sea rise) elsewhere, and (2) expand development in a scramble for dwindling fossil-fuel and water resources. Ever-increasing numbers of people across the landscape would only exacerbate current challenges of habitat fragmentation and mortality risk.

Conclusion: Despite their resourcefulness, grizzly bears exhibit **high vulnerability** due to low population resiliency. They require secure access to quality forage in spring and late summer – fall, but roads with moderate traffic volume can displace bears from key habitats. Young females do not disperse very far and adult females do not readily cross major highways, which makes bear populations susceptible to landscape fragmentation. Most importantly, bears have very low reproduction and cannot quickly compensate for excessive mortality. Numerous studies have demonstrated that road access into high-quality habitats can increase encounter rates with people and lead to displacement, habituation, or mortality. Altogether, this does not provide much resiliency in human-dominated landscapes.

Methods for Scoring Conservation Importance

The key to successful grizzly bear conservation is to manage both from the bottom-up for secure access to important food resources and from the top-down for lower risk of human-caused mortality (Weaver et al. 1986, Nielsen et al. 2010). I used the peer-reviewed analysis (Nielsen et al. 2009) and GIS layers kindly provided by Scott Nielsen, Gordon Stenhouse and colleagues, which combined data and maps of (1) high-quality habitat components as well as (2) zones of mortality risk around roads.

To map habitat for grizzly bears, I used Resource Selection Function (RSF) values derived from their model that incorporates key habitat components where grizzly bears direct their foraging at various seasons. The model included 7 variables of land cover, 3 variables of forest canopy, 1 variable of soil wetness, and 6 variables related to distance to streamside and forest edge. To determine resource use by bears, the researchers analyzed 121,683 GPS telemetry locations acquired during 1999-2006 from 81 radio-collared grizzly bears (53 females: 28 males). Separate models were derived for each of the 6 grizzly bear units in Alberta – including a combined Waterton-Livingstone unit that encompasses this assessment area in the Southern Canadian Rockies of Alberta. Occupancy of grizzly bears was based upon detections at 2,295 hair-snag survey sites and DNA genotyping across 27,733 km^2 in 4 of the population units. Final habitat predictions for each of the six population units were estimated as the product of regional female grizzly bear occupancy and population-level RSFs. Map predictions were then categorized into 10 ordinal bins representing the relative probability of habitat selection.

To map habitat components for grizzly bears, I used the *maximum* habitat value assigned to a cell for *any* of the 3 defined seasons (spring, summer, late summer-fall). I ranked grizzly bear habitat quality by sorting the bins as follows: (1) high = bins 8-10, (2) moderate = bins 5-7, and low = bins 2-4. To map conservation values for each 1-km^2 grid cell across the study area, I used the data from Nielsen et al. (2009) as follows:

Very High	(3)	=	primary habitats or 'safe harbours' (high-quality habitat and high security)
High	(2)	=	secondary habitats (moderate-quality habitat and high security)
Moderate	(1)	=	'attractive sinks' (high-quality habitat but low security)

Such an approach facilitates identification of conservation areas for grizzly bears (and non-critical areas); it also enables managers to target *strategic* sites to improve security by restraining motorized access.

Key Conservation Areas

Areas of high and moderate habitat value with high security from human-caused displacement and mortality are the landscape foundations of grizzly bear viability. Areas having high habitat *and* high security value (very high score of 3) occurred on 35.1 % of the area (226,418 ha) (Table 4) (Figures 10-11).

Moderate habitat values within secure zones (high score of 2) occurred on another 26.4 % (170,151 ha) – and often adjoined grid cells of higher value. Together, these vital areas covered 61.5 % (396,569 ha). Very-high quality habitat occurs in the foothills region (much of it spring range on private ranchlands) and also in the headwater basins of the upper Castle and Carbondale Rivers, upper Racehorse Creek, upper Livingstone River and upper Highwood River. Adjacent to the Castle River, the Flathead River in B.C. sustains the highest density of grizzly bears recorded thus far for non-coastal populations in North America.

Attractive sinks (sensu Nielsen et al. 2006) are sites that have high habitat value but occur near roads, where the risk of human-caused mortality is considerably greater. Due to the wide-spread occurrence of roads in the Southern Canadian Rockies of Alberta, 19.7 % of the area (127, 063 ha) was mapped as attractive sinks. Traffic volume increases during summer and hunting season on many of these roads, which adds risk of mortality. Numerous studies – as well as the Alberta Grizzly bear Recovery Plan – have called for greater precautionary management of human access into grizzly country (Weaver et al. 1996, Mace et al. 1996, Mattson et al. 1996, Gibeau et al. 2001, Herrero et al. 2005, Nielsen et al. 2010, Northrup et al. 2011). Hence, these *attractive sinks* represent opportunities for the astute land manager to raise the conservation score (from 1 to 3) by strategically closing selected roads and reducing risk. Along with other conservation measures, strategic management of access in the following basins could be especially important for grizzly bear recovery: upper Carbondale and Castle River, upper Racehorse and Dutch Creek, upper Oldman River, and west of Hwy 40/940 in the upper Highwood River (Figure 11).

It should be noted that, in 2008, the Alberta government prepared a draft map of broad 'core and secondary conservation areas' for grizzly bears (Alberta SRD 2008b). The core areas closely followed the analysis by Nielsen et al. (published in 2009). Because the amount of Crown land south of Highway 3 was insufficient to meet the minimum area of 2400 km^2 recommended in the Alberta Grizzly Bear Recovery Plan (2008), all of the Crown land (1,314 km^2) in this 'Waterton' bear population unit was mapped as 'Core'. This includes all of the Castle Special Place and the headwater basin of upper Crowsnest River south of Crowsnest Pass. North of Highway 3 in the 'Livingstone' bear population unit, 3,412 km^2 was mapped as 'Core' due to the interspersion of other lands. This core area includes the upper Crowsnest River on the north side of Crowsnest Pass, much of the upper Oldman River watershed, Livingstone Range, and the headwater basin of the Highwood River.

Table 4. Area (ha) and percentages of grizzly bear conservation values (CV) in the Southern Canadian Rockies, Alberta. CV3 = very high-high habitat values and high security, CV2 = moderate habitat values and high security, and CV1 = very high-high habitat values but low security.

		Very High CV (3)		High CV (2)		Mod CV (1)		All CV
Watershed	**Area (ha)**	**Area**	**% Area**	**Area**	**% Area**	**Area**	**% Area**	**% CV**
S Hwy 3	258,896	75,449	29.1	59,426	23.0	54,670	21.1	36.2
N Hwy 3	386,322	150,969	39.1	110,725	28.7	72,393	18.7	63.8
TOTAL	**645,218**	**226,418**	**35.1**	**170,151**	**26.4**	**127,063**	**19.7**	**523,632**

Figure 10. Location of key habitat components for grizzly bears, Southern Canadian Rockies, Alberta. RSF classes adapted from Nielsen et al. (2006) and Nielsen et al. (2009).

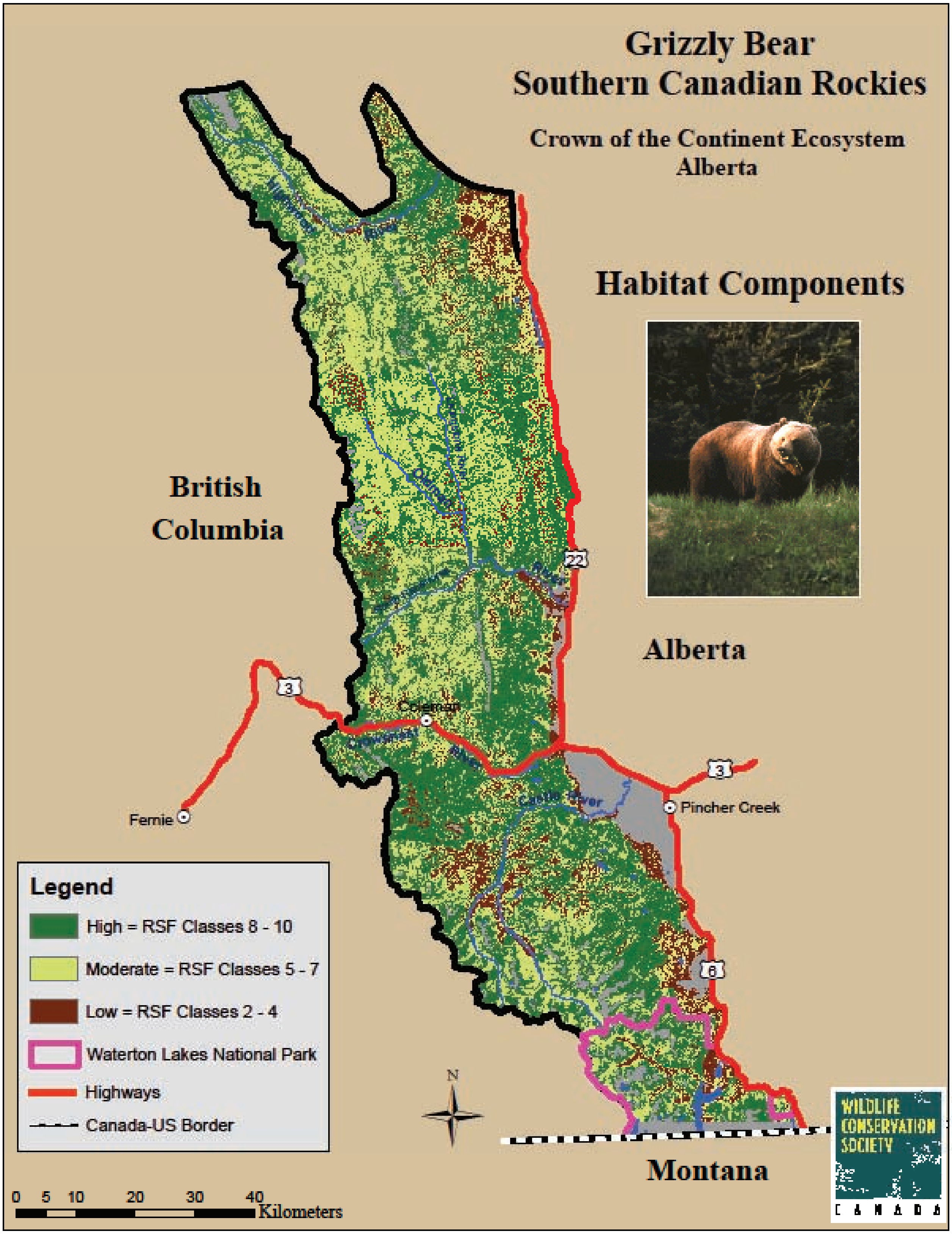
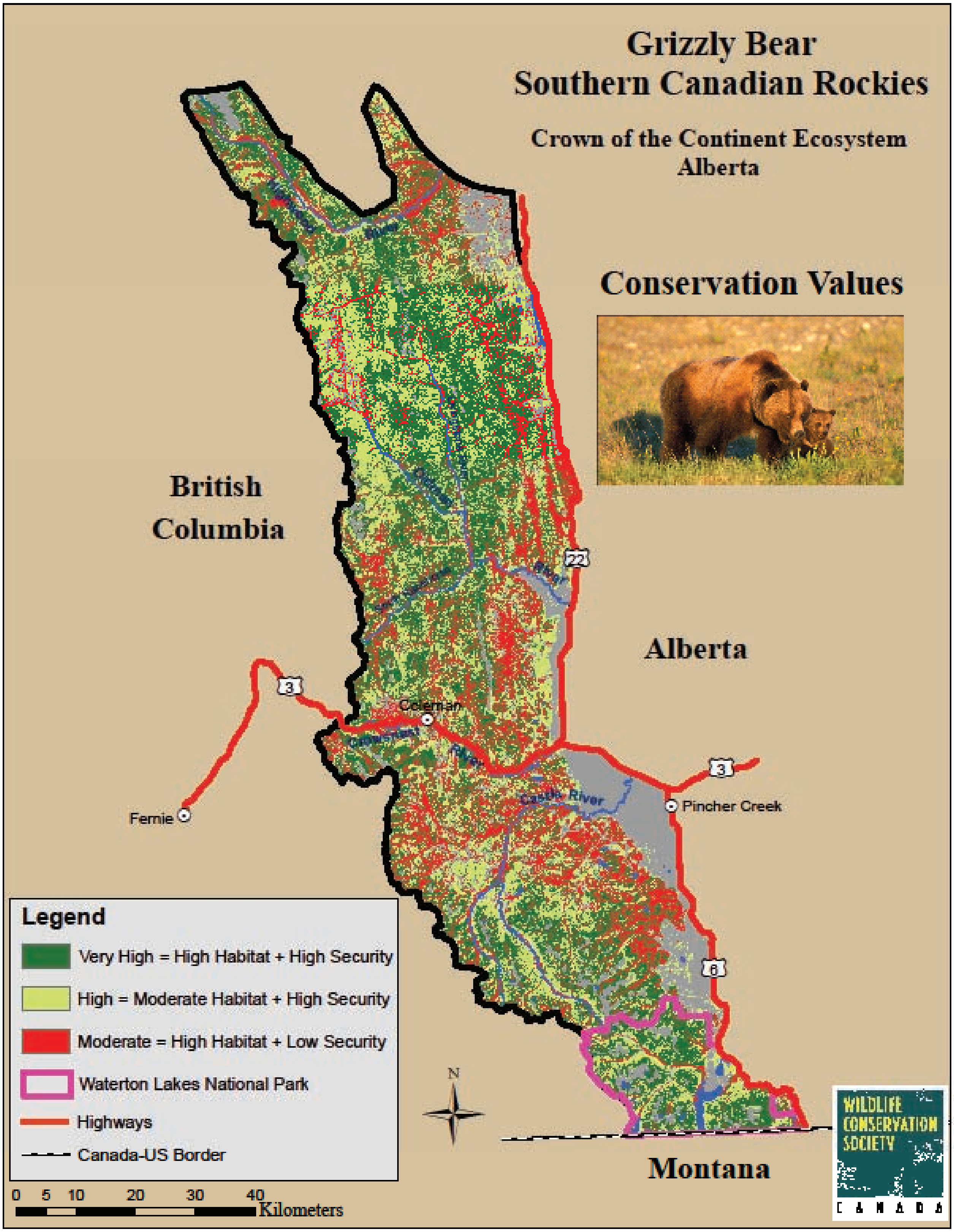


Figure 11. Location of key conservation values for grizzly bears, Southern Canadian Rockies, Alberta. Values adapted from Nielsen et al. (2009).



Wolverine

Larry Master

Vulnerability Profile

Status: The western population of wolverine (including those in Alberta), was assessed by COSEWIC as 'species of special concern' in 2003 (COSEWIC 2003) but has not been listed under the Species At Risk Act (SARA). In the United States, the wolverine was proposed for federal listing as a 'threatened' species under the Endangered Species Act on February 4, 2013 (USFWS 2013).

Niche Flexibility: Wolverines are opportunistic, generalist feeders that exhibit broad regional and seasonal flexibility in their diet (Copeland and Whitman 2003). Comparatively little is known about their summer diet, but they likely use a variety of foods including ground squirrels and marmots, ungulate carrion, microtines, birds, and berries (Magoun 1987, Lofroth et al. 2007, Dalerum et al. 2009). With their traditional burrow sites and early emergence of young, marmots may comprise an important prey in late spring and summer for female wolverines raising young kits (Copeland and Yates 2006, Lofroth et al. 2007, Inman et al. 2012a). For the remainder of the year, wolverines subsist largely on carrion and occasional kills of ungulates (moose, caribou, mountain goats, elk, and deer) (Hornocker and Hash 1981, Magoun 1987, Banci 1987, Lofroth et al. 2007). Other carnivores such as wolves may be important provisioners of carrion (Banci 1987, Van Dijk et al. 2008), but there may be a tradeoff for wolverines between scavenging the food resource and avoiding competition and predation with larger predators (Inman et al. 2012b).

In the western U.S. and Canada, wolverines occur primarily at higher elevations in the subalpine and alpine life zones (Aubry et al. 2007, Copeland et al. 2007, Krebs et al. 2007, Inman 2013). Several researchers have pointed out the strong concordance of wolverine occurrence and persistence of snow cover during spring (mid-April thru mid-May), which covers the end of wolverine denning period (Aubry et al. 2007, Copeland et al. 2010). Female wolverines dig long tunnels in the snow (and under fallen trees/large boulders in the snowpack) for birthing ('natal' dens) and early rearing of kits ('maternal' dens) and may re-use the same sites in subsequent years (Magoun and Copeland 1998, Copeland and Yates 2006). It has been postulated that these snow dens provide thermal insulation and refuge from predators, which aids survival of the young. Later in summer, females 'park' their young at 'rendezvous sites' in talus fields composed of large boulders, often in subalpine cirque basins (Copeland and Yates 2006). Based upon 3917 radio locations of wolverines recorded from 5 study areas in Montana, Idaho, and Wyoming, about 88% of summer locations and 84% of winter locations fell within areas covered by snow during the spring period (calculated from data in Copeland et al. 2010). Nonetheless, certain areas with persistent snow cover may not be occupied by wolverines. Additional factors such as latitude-adjusted elevation and terrain ruggedness also help explain habitat selection by wolverines (Inman 2013). Researchers have offered a 'refrigeration-zone' hypothesis which suggests that caching foods in cold micro-sites allows them to reduce competition from insects/bacteria/other scavengers and extend availability of scarce food resources (Inman et al. 2012a).

With their large plantigrade feet, compact body, and dense fur, wolverines are well adapted to travel and live in snowy environments, which may offer them a competitive advantage over other carnivores (Copeland and Whitman 2003, Inman et al. 2012a). In such low-productivity environments, though, wolverines must range widely in constant search for food. Thus, their home ranges are large relative to their body size, with average annual home ranges (MCP and adaptive kernel methods) of 280 - 400 km^2 for adult females and 772 - 1,525 km^2 for adult males (Hornocker and Hash 1981, Copeland et al. 2007, Krebs et al. 2007, Inman et al. 2012b).

Reproductive Capacity and Mortality Risk: Wolverines have a very low reproductive rate, which may reflect the tenuous nutritional regime for this scavenger. Based upon post-mortem analyses of trapped wolverines, an average of 63% of females (range of averages 50-85%) had fetuses at 2+ years of age (nearly 3-yr-old) (Rausch and Pearson 1972, Liskop et al. 1981, Magoun 1985, Banci and Harestad 1988, Anderson and Aune 2008). Based upon field monitoring of 56 adult female wolverines in Scandinavia, Persson et al. (2006) reported an average age at first reproduction of 3.4 years. Percent of adult females (≥3 years) pregnant in any year in the lab studies varied from 73% to 92%, and average litter size *in utero* varied from 2.2 to 3.5 kits. In the Scandinavian study, an average of 53 % of adult females reproduced (yearly average was 58%), with average litter size of 1.88. Availability of food in the current winter (a variable commodity) influences reproduction by females and a poor winter can affect reproduction in the subsequent year, too (Persson 2005). The net result is low annual production, usually <1.0 offspring per adult female (Copeland and Whitman 2003, Persson et al. 2006). Few female wolverines in the wild are likely to reproduce past the age of 8 years (Rausch and Pearson 1972). Given average parameters and assuming annual survivorship of 0.50 for COYs/Sub-adults and 0.80 for adult females (Krebs et al. 2004, Squires et al. 2007), the average female wolverine may only produce one-two female offspring during her lifetime that survive to reproduce. This is very low, even compared to other large carnivores (Weaver et al. 1996).

With such low reproductive capacity, wolverines cannot sustain or compensate for high mortality. They are susceptible to trapping at bait sites during winter, particularly in years when carrion availability is low. Trapping and hunting accounted for 35% of 62 mortalities recorded during 1972-2001 in 12 telemetry studies of wolverines across western North America (starvation accounted for 29%) (Krebs et al. 2004). These researchers stated that trapping appeared to be an *additive* cause of mortality (not compensatory) and cautioned that high annual survival (≥0.85) of adult female wolverines is requisite to sustaining populations. More recently, researchers working in western Montana reported that licensed trapping accounted for 9 (64%) of 14 recorded mortalities of instrumented wolverines during 2002-2005 (Squires et al. 2007). They estimated that this additive mortality from trapping reduced annual survivorship from 0.80 down to 0.57 and determined that population stability was most sensitive to adult survival. Numerous wolverine researchers have cautioned that trapped populations will likely decline in the absence of immigration from un-trapped populations (Krebs et al. 2004, Squires et al. 2007). Small populations in isolated mountain ranges are especially vulnerable to over-harvest and local extirpation (Squires et al. 2007). In the Southern Canadian Rockies of British Columbia, a total of 114 wolverines were trapped during 1985-2004 (Lofroth and Ott 2007). In an assessment of the sustainability of the wolverine harvest in B.C., researchers estimated that the Flathead and Southern Rockies population units were over-harvested during this period by 167% and 162%, respectively; they urged particular attention and precautionary approach be focused on these units – both are adjacent to the Southern Canadian Rockies of Alberta (Lofroth and Ott 2007).

Numerous wolverine researchers have recommended refugia – such as those created by restricting/eliminating trapping quotas or sanctuaries like Waterton Lakes National Park – as a crucial element in the overall conservation of wolverine (Weaver et al. 1996, Krebs et al. 2004, Squires et al. 2007). Due to the large home ranges of wolverines and their low density, these safe havens need to be managed at a regional and/or metapopulation scale (Inman 2013).

Dispersal and Connectivity: Wolverines are capable of dispersing long distances. Juvenile dispersals of 168 km to 378 km have been reported (Magoun 1985, Gardner et al. 1986, Copeland 1996, Vangen et al. 2001, Inman et al. 2012b). Genetic sampling of wolverines in southern Norway suggests the potential for wolverines there to disperse up to 500 km (Flagstad et al. 2004). Most interesting, a young male wolverine left Grand Teton National Park in northwest Wyoming, crossed expanses of atypical habitat the Red Desert and Interstate Highway 80 in southern Wyoming, and pulled up in Rocky Mountain National Park in northern Colorado – an astounding distance of 900 km (Inman et al. 2009). Young wolverines also make extensive exploratory movements >100 miles, which usually precede actual dispersal (Vangen et al. 2001, Inman et al. 2004). Both males and females make long-distance movements, typically during their second year prior to reaching sexual maturity (Vangen et al. 2001, Dalerum et al. 2007, Inman et al. 2012b). If the territory of a resident adult female becomes vacant, often her daughter will take over that space (Vangen et al. 2001). Using both mitochondrial DNA (maternal-only) and nuclear microsatellite DNA, researchers reported that male gene flow predominated and female gene flow was restricted at the southern portion of their range (Cegelski et al. 2006).

The genetically-effective population size (the number of individuals actually involved in breeding, in contrast to the total number of animals) for wolverines in the northern U.S. Rocky Mountains has been estimated at only 35 individuals (range 28-52) (Schwartz et al. 2009). Due to such low effective population size and the patchy, 'island-like' distribution of suitable wolverine habitat in the Rocky Mountains, maintaining landscape connectivity that facilitates demographic and genetic interchange among sub-populations will be crucial to ensuring the viability of the larger meta-population (Schwartz et al. 2009, Inman 2013). Researchers have found that areas with persistent snow cover during late spring and sparse human footprint (housing density) characterize the least-cost pathways for successful gene flow among sub-populations of wolverines across the northern U.S. Rocky Mountains (Balkenhol et al. 2009, Schwartz et al. 2009, Rainey 2012, Inman 2013).

Sensitivity to Human Disturbance: Wolverines are vulnerable to human disturbance in several ways. Maternal female wolverines appear sensitive to human activity near maternal dens and rendezvous sites, which are used February through June (Magoun and Copeland 1998). With the advent of more powerful snow machines as well as heli-skiing, one concern is that such motorized access could disturb maternal females and young during the critical late winter and spring period.

Major highways can have a significant impact on wolverine movements, too. In winter, wolverines avoided areas within 100 m of the Trans Canada Highway between Yoho and Banff National Parks and preferred areas >1100 m away from the highway (Austin 1998). Wolverines made repeated approaches and retreats and only crossed 3 of 6 times. In the Greater Yellowstone Ecosystem, Packila et al. (2007) documented 43 crossings of U.S. or State highways by 12 wolverines. Subadults making dispersal or exploratory movements comprised the majority (76%) of road crossings, most of which were made during January–March. On a Wyoming highway where, traffic volume commonly exceeded 4,000 vehicles per day, four different wolverines (2F, 2 M) crossed the highway 16 times. At least 3 crossings occurred within a 4-km section where forest cover bordered close to the highway, about 4 km from the nearest human settlement.

Response to Climate Change: Wolverines may be especially sensitive to climate change. As noted, the broad distribution of wolverines, their foraging and reproductive ecology, and travel routes associated with successful dispersal seem strongly linked to areas characterized by persistent snow cover during spring (Aubry et al. 2007, Schwartz et al. 2009, Copeland et al. 2010, McKelvey et al. 2011, Inman et al. 2012a). Moreover, 90% of 1474 wolverine locations during summer in the northern U.S. Rocky Mountains occurred in areas with average maximum temperatures during August <22.8° C (calculated from data in Copeland et al. 2010). This is consistent with the hypothesis that wolverines select cooler habitats at higher elevations during hot summer months in the southern sector of their range. Warming climate could impact the ecology and populations of wolverines' alpine prey such as hoary marmots (Lofroth et al. 2007) and reduce the abundance of ungulate carrion due to milder winter conditions (Wilmers and Post 2006). Some of the biggest changes wrought by global warming may be alterations to mountain snowpack. Recent warming has already led to substantial reductions in spring snow cover in the mountains of western North America (Mote et al. 2005, Pederson et al. 2010). Future projections under various scenarios through the year 2040 suggest this trend will continue, notably at low to mid-elevations (Pederson et al. 2011). The extent of persistent snow cover in spring could decrease by 27% by 2045 in Montana (data not available for Alberta) (McKelvey et al. 2011). Wolverines will be quite vulnerable to such changes, with likely reductions in the size of suitable habitat patches, loss of connectivity, and reduced effectiveness of its caching strategy to extend food availability.

Conclusion: Wolverines exhibit **high vulnerability** due to low resiliency. Although they have a broad foraging niche, their selection for reproductive habitat, summer habitat, and dispersal routes is closely linked to areas characterized by persistence of snow cover during spring. Wolverines have extremely low reproductive rates. Consequently, they cannot sustain high mortality rates, which can be exacerbated by trapping pressure – especially in areas of disjunct habitat patches. Trapping also may obviate the likelihood of successful dispersal by juvenile wolverines, which could be important to the viability of regional populations. Wolverines appear sensitive to human disturbance near natal den sites, and major highways may impede movements leading to fragmentation. Due to their multi-faceted adaptation to snow environments, wolverines appear particularly vulnerable to reductions in suitable habitat as a result of projected climate change.

Methods for Scoring Conservation Importance

I identified key conservation areas for wolverines by using a model developed by several veteran wolverine researchers (Copeland et al. 2010). The 'Copeland' model uses snow cover to predict geographic occurrence of wolverines across its circumboreal range. These investigators developed a composite of MODIS satellite images (7 years from 2000-2006) that represented persistent snow cover throughout April 24 – May 15, which encompasses the end of the wolverine's reproductive denning period. Approximately 89% of summer and 81% of winter telemetry locations from 8 study areas in western North America concurred with spring snow coverage. Moreover, about 90% of 62 known wolverine den sites in North America occurred within spring snow cover for 5-7 years (J. Copeland, *unpublished data*). Pathways of dispersal by wolverines also appear limited largely to areas of spring snow cover (Schwartz et al. 2009). Thus, many central features of wolverine ecology – historical occurrence, habitat use across gender/age/seasons, den sites and dispersals – correspond to this bioclimatic envelope of spring snow cover.

Wolverine habitat identified by the Copeland model corresponds closely with an alternative model developed by Robert Inman from long-term studies in the Greater Yellowstone Ecosystem (Inman 2013). The 'Inman' model included 2 snow variables (April 1 snow depth, distance to snow on April 1), 3 topographic variables (latitude-adjusted elevation, terrain ruggedness index, distance to high-elevation talus), 1 vegetation variable (distance to treecover), and 2 human variables (human population density, road density). In a companion study in the Southern Canadian Rockies of British Columbia, I found that 89 % and 86 % of 36 wolverine observations fell within the areas predicted by the Copeland and Inman models (Weaver 2013). Another study in Yellowstone National Park reported that both models accounted for >90% of telemetry locations of 4 wolverines (Murphy et al. 2011). Hence, there was strong agreement between the models, which provided additional confidence in using the Copeland model.

Because wolverine appear to be an obligate to areas covered by snow during spring (Copeland et al. 2010, Inman 2013), less snowpack as projected by climate change models will negatively affect wolverine habitat (Peacock 2011). Using an ensemble of climate-change models, McKelvey et al. (2011) estimated about a 27% loss of wolverine habitat in Montana by year 2045. Because snow cover may be lost disproportionately at lower elevations of wolverine habitat, I approximated this loss by subtracting snow class 2 from the Copeland model, which yielded a 20% loss of habitat across the Southern Canadian Rockies of Alberta.

Accordingly, I assigned the following importance scores for wolverine:

Very High	(3)	=	Maternal Habitat
High	(2)	=	Future Primary Habitat
Moderate	(1)	=	Primary Habitat

Key Conservation Areas

Due to the effects of warmer air coming down the eastern slopes of the Continental Divide, the snowy landscapes favored by wolverines are naturally more limited on the Alberta side compared to British Columbia. Nonetheless, the Copeland model mapped 49.4% (318,841 ha) of the Southern Canadian Rockies of Alberta as primary habitat and 7.9% (51,040 ha) as maternal habitat (Table 5, Figure 12). Primary and maternal habitat occurs all along the Continental Divide border with British Columbia.

South of Highway 3: Suitable primary habitat for wolverine occurs throughout the higher country in the southwest corner of Alberta. The largest expanse occurs in the Castle River watershed, where suitable habitat extends from the Continental Divide eastward for 15-20 km out toward the foothills. From West Castle Creek north to Highway 3, the extent of primary habitat is limited to a strip about 5-10 km wide adjacent to the Continental Divide. This strip comes to a narrow point south of Highway 3 at Crowsnest Lake. Suitable *maternal* habitat for wolverines is even more limited to narrow bands adjacent to the Continental Divide. In the Castle River drainage, the band is 1-4 km wide in most places. There are patches of maternal habitat on the ridges between upper Castle Creek and upper Pincher Creek. This suggests that linkage across the valley of upper Castle River could be important for connectivity at the local scale. From West Castle Creek north to Highway 3, maternal habitat becomes tightly confined to a strip 0.1-2.0 km wide along the Continental Divide and ceases about 6 km south of Highway 3.

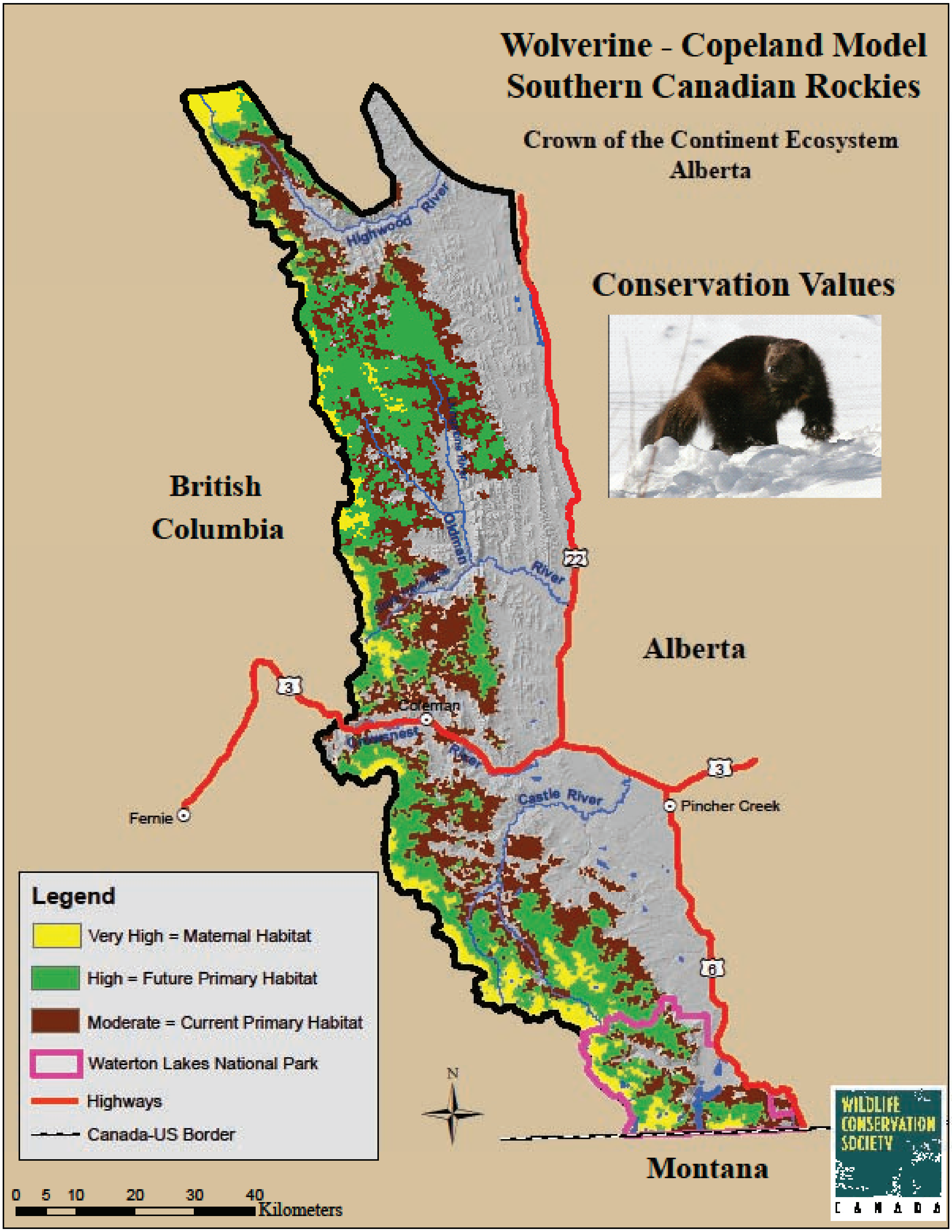
North of Highway 3: Suitable primary habitat for wolverines north of the Crowsnest Highway extends from the Continental Divide eastward for 10-28 km out to the foothills. All suitable wolverine habitat is 8-22 km west of Highway 22, and most is west of Forestry Trunk Road 940. The closest proximity of wolverine habitats along each side of Highway 3 is near Crowsnest Pass where the distance is about 2 km. The largest expanse occurs in a block comprising the upper Oldman River basin, Livingstone River basin, and Plateau Mountain. Suitable *maternal* habitat for wolverines is extremely limited to a 1-2 km wide band adjacent to the Continental Divide. This strip broadens to about 8 km wide in the headwaters of the Highwood River drainage. This suggests that linkage across Highway 40 south of Highwood Pass could be important for connectivity at the local scale.

Projected warming in the regional climate may diminish primary habitat by approximately 40% – from 50% down to 30% – especially at lower to mid elevations along the eastern flank of wolverine range. Primary habitats in the West Castle and Carbondale River basins could shrink substantially. Shrinkage of habitat now contiguous could render the connection more tenuous between the Blairmore mountain range and areas west of Blairmore Creek.

Table 5. Amount (ha) and percentages of wolverine habitat (Copeland model) in the Southern Canadian Rockies, Alberta.

Watershed	Maternal Habitat (3)		Future Primary Habitat (2)		Primary Habitat (1)	
	Area	% Area	Area	% Area	Area	% Area
S Hwy 3	28,738	11.1	87,178	33.7	137,518	53.1
N Hwy 3	22,302	5.7	106,215	27.5	181,323	46.9
TOTAL	**51,040**	**7.9**	**193,393**	**30.0**	**318,841**	**49.4**

Figure 12. Location of key conservation values for wolverines using Copeland model, Southern Canadian Rockies, Alberta.



Mountain Goat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Vulnerability Profile

Status: Mountain goats are managed as trophy big game species in Alberta. Due to its typical habitat requirements for steep cliffs, distribution of mountain goats in southwest Alberta is constrained to a narrow strip along the Continental Divide. By the late 1960s, mountain goats had almost been eliminated from this region by over-hunting, which had been facilitated by rapidly increasing development of road/trail access to mountain goat habitat for extraction of minerals/oil & gas and timber. The mountain goat hunting season in Alberta was closed in 1988 but resumed in the southwest region in 2001. Small numbers of mountain goats were transplanted to various areas along the Eastern Slopes of southern Alberta during the late 1980s and 1990s, with variable but low success. Current population of mountain goats in the Southern Canadian Rockies of Alberta is 250-300 animals, and a limited hunt under special license drawing is permitted. Despite a management emphasis on hunting male goats, killing of nannies continues to be of concern (Alberta SRD 2003, Smith and Hobson 2008).

Niche Flexibility: Mountain goats have broad flexibility in their diet (Côté and Festa-Bianchet 2003). They will feed on grasses, sedges, lichens, herbs, mountain shrubs, and conifer needles – sometimes, all on the same cliff. Indeed, they are masters of the opportunistic foraging microniche (Chadwick 1983). In contrast, mountain goats have very stringent habitat preferences based upon topography. Simply put, they select cliff faces usually ≥40° – the steeper, the better because steep cliffs shed snow that buries the rest of the high country (Chadwick 1983, Gross et al. 2002, Poole et al. 2009). Most of the time, mountain goats are found on or within 250-400 m of cliffs that serve as escape terrain (Gross et al. 2002, Poole and Heard 2003), and females with kids often stay closer to cliffs to minimize risk of predation (Hamel and Côté 2007). Winter is a critical season for mountain goats due to the energetic costs of moving through deep snow (Côté and Festa-Bianchet 2003). Mountain goats adopt two winter-coping strategies: (1) remain on high-elevation windswept slopes with nearby escape terrain, or (2) in areas with deeper snow, move to bands of cliffs at lower elevations (Chadwick 1983, Rice 2008, Poole et al. 2009). In areas with dry, shallow snow conditions, mountain goats may winter on the same mountain top where they spent the summer, too. In areas where summer temperatures and solar radiation becomes intense, goats may select for cooler aspects or sites. Thus, the broad foraging niche of mountain goats may have evolved to compensate for their narrow habitat preference for safety among the cliffs (Geist 1971). Because their alpine plant foods contain low sodium and high potassium levels, mountain goats may travel considerable distance (up to 24 km) even through forests to obtain supplemental minerals (sodium, magnesium, and carbonates) (Hebert and Cowan 1971, Ayotte et al. 2008, Poole et al. 2010). Mountain goats in southern Alberta rely heavily on mineral licks, especially during July and August (Jokinen et al. 2013).

Reproductive Capacity and Mortality Risk: Compared to other ungulates, native populations of mountain goats have very low reproductive potential (Côté and Festa-Bianchet 2003). Young goats grow more slowly than juvenile bighorn sheep, and female goats may delay age of first reproduction until 4 or 5 years, or even older (Festa-Bianchet and Côté 2008). Prime reproductive age for female mountain goats is from 6 to 12 years of age. A nanny typically carries only a single kid, but up to a 1/3 of adult females (>3 years old) may not produce offspring in a given year (Côté and Festa-Bianchet 2003). These parameters may improve *initially* for females in introduced populations (Swenson 1985), but others have urged caution in assuming compensatory reproduction in harvested populations (Cote et al. 2001). The longer a female goat lives, the more offspring she is likely to produce. Hence, longevity of female mountain goats is paramount to their lifetime reproductive success (Festa-Bianchet and Côté 2008). Native populations of mountain goats have extremely limited capacity to compensate for excessive mortality – especially of adult females.

The history of mountain goat populations harvested by hunters is strewn with case studies of excessive kill rates – particularly of adult females who can be difficult to distinguish (Côté et al. 2001, Hamel et al. 2006 and references therein). Excessive harvest is often facilitated by new road access (Chadwick 1983). Fortunately, many contemporary wildlife managers have embraced this realization and reduced harvest quotas for mountain goats. Some mountain goats, of course, also die from a variety of natural factors such as falls, avalanches, starvation, and predation (Côté and Festa-Bianchet 2003).

Dispersal and Connectivity: Young mountain goats appear to disperse more commonly and further distance than do bighorn sheep (Festa-Bianchet and Côté 2008). In the population of goats introduced to the Olympic National Park, young individuals of both genders (but mostly 2-3 year-old males) dispersed an average of 40 km (maximum >90 km) (Stevens 1983). Thus, goats appear to have moderate capacity for re-colonization through dispersal.

Sensitivity to Human Disturbance: Mountain goats appear particularly sensitive to disturbance from certain human activities (Joslin 1986, Côté and Festa-Bianchet 2003). Several studies have documented behavioral responses of goats to helicopters ranging from short movements (<100 m) and short bouts of nervous activity to panicked goats running at full speed over precipitous terrain resulting in at least 1 case of a broken leg (Côté 1996, Goldstein et al. 2005). The closer the helicopter, the stronger the behavioral reaction by goats. It does not appear that mountain goats habituate over time to helicopter activity. Goats likely would be vulnerable to disturbance to a variety of helicopter-supported activities: including backcountry skiing, fishing, biking and hiking, sightseeing, exploration for minerals/oil and gas, and wildlife research. Consequences of helicopter harassment could include abandonment of critical habitat, which could result in a decline in local goat populations (Festa-Bianchet and Côté 2008). Researchers have recommended no-fly buffer zones ranging in size from 1.0 km (Goldstein et al. 2005) to 2.0 km (Foster and Rahs 1983, Côté 1996). From the long-term study of mountains goats at Caw Ridge, Alberta, researchers reported that goats were moderately to strongly disturbed by All-Terrain-Vehicles (ATVs) on 44% of occasions, particularly during direct and rapid approaches (St-Louis et al. 2013). They recommended regulating use of ATVs in areas with mountain goats. Of course, mountain goats likely are susceptible to mechanized industrial activities (oil & gas, mining, logging) in alpine areas, at mineral licks, or on winter range.

Response to Climate Change: Vulnerability of mountain goats to climate change is not well understood at present (Festa-Bianchet and Côté 2008). Projected warming of +2° C over the next 40-50 years in the region could be even warmer at higher elevations in the alpine. With such warming, subalpine forests could shift 300 m or higher in elevation resulting in considerable shrinkage of the alpine areas. Conceivably, warmer daytime temperatures and more intense solar radiation in the alpine during summer could force a reduction in foraging time for mountain goats, whose tolerance for heat does not seem high. Adequate foraging in summer is important for female ungulates that must bear and nurse young and acquire good body condition to survive the following winter. In wintering sites where deep moist snow is more common, rain-on-snow events could create crusted snow conditions. This would be especially tough on young goats that have not reached full body size and cannot paw as well as adults (Chadwick 1983). For these mountain-top denizens, perhaps the best conservation strategy for now is to provide security from mechanized disturbance on a variety of cliff aspects and keep other pressures such as hunting quotas at very low levels, if any (Hamel et al. 2006).

Conclusion: Mountain goats exhibit **high vulnerability**. They are constrained to live on or very near cliffs that provide escape terrain from predators and more accessible forage in winter. Female goats have very low reproduction and cannot quickly compensate for excessive mortality (notably hunting). Goats, particularly males, do disperse modest distances which may provide connectivity among some populations. Mountain goats are especially sensitive to motorized disturbance. In terms of climate-smart conservation strategies, maintaining secure access to a variety of aspects among cliffs and reducing other pressures could provide options.

Methods for Scoring Conservation Importance

For mapping summer habitat of mountain goats, we develop a step-wise model. First, we calculated terrain ruggedness following a method developed by Poole et al. (2009) to define escape terrain for mountain goats. We used the curvature function in ArcGIS to generate a curvature grid (at 30m resolution) and then did a moving window analysis for standard deviation within a 90m radius of each grid cell. This provided a measure of the variability of the rate of change in slope for each grid cell. Thus, a high ruggedness value would indicate a high degree of change in slope and cliff complexity. Escape terrain was defined as pixels from the ruggedness grid with a value ≥1.854 (the top 3 of 5 classes when displaying the grid using natural breaks). Next, we constrained the model to escape terrain between elevation contours of 1900 m and 2500 m. Finally, we buffered those areas by 300 m as a conservative estimate of foraging distance away from escape terrain (Chadwick 1983, Hamel and Côté 2007). About 95.1% of 508 summer locations collected 2003-2011 fell within predicted summer habitat, and another 2.6% occurred within 90 m (location data courtesy of M. Jokinen, Alberta Conservation Association). For distribution of mountain goat winter ranges (November-March), we used the same step-wise model but made two adjustments. We limited winter range to south-southwest aspects (157°-247°) and lowered elevation by 200m to the 1700 m contour (Chadwick 1983, Poole et al. 2009).

Accordingly, I assigned the following importance scores for mountain goats:

Very High	(3)	=	suitable winter habitat
High	(2)	=	suitable summer habitat
Moderate	(1)	=	n.a.

Key Conservation Areas

Mountainous habitats on the Alberta side of the Southern Canadian Rockies appear more suitable for bighorn sheep; nonetheless, there are a few key areas with habitat suitable for mountain goats. Based upon the habitat model, winter habitat occurs on 2.3% (14,620 ha) of the area, and summer habitat on 9.1% (58,845 ha) (Table 6). During various surveys of goats in the Southern Canadian Rockies over the past decade, biologists have counted 350-400 mountain goats on Provincial lands and another 80-120 in Waterton Lakes National Park (Bergman 2006, Jokinen and Hale 2013). Much of goat range in southwest Alberta continues to be affected by the development of more access trails and roads and both industrial and motorized recreation. In particular, access into high alpine areas is a real threat to mountain goat populations (M. Jokinen, ACA, *personal communication*). Commercial helicopter touring is becoming popular and poses a significant threat to the seclusion of goat habitat. Wildlife managers from both Alberta and British Columbia must work together because many of the goats in this Goat Management Area inhabit areas on both sides of the provincial border.

South of Highway 3: The broadest expanse of habitat suitable for mountain goats lies south of Highway 3. About 2.8% of suitable winter and 11.6% of summer habitat for mountain goats is located south of Highway 3 in the Carbondale and Castle Creek basins close to the Continental Divide. Suitable summer habitat consists of rugged terrain along much of the Continental Divide from Waterton Lakes National Park north to Mount McLaren just south of Crowsnest Pass (Figure 13). In the Castle Creek basin, goats occupy suitable habitat up to 15 km east of the Divide (Mount Dungarvan). From the headwaters of West Castle Creek north, suitably rugged habitat is confined to within 1-5 km of the Divide (few goats have been observed on Barnaby Ridge). These areas in Alberta are connected to more extensive habitat for mountain goats on the British Columbia side of the Divide, especially across from the headwaters of West Castle Creek and Carbondale River (Lost Creek and Lynx Creek). About 70% of the goat population on Provincial land lives south of Highway 3.

North of Highway 3: North of the Crowsnest Highway, habitat suitable for mountain goats is distributed in a narrow strip 2-3 km wide (up to 10 km) along the Continental Divide. Linear patches of rugged habitat also occur in disjunct mountain ranges further east, including south and north ends of Livingstone Range and Cabin Ridge. About 1.9% of winter and 7.5% of summer habitat occurs north of Highway 3 (Table 6, Figure 13). These areas in Alberta are connected to more extensive habitat for mountain goats on the British Columbia side of the Divide – especially across from the headwaters of South and North Racehorse Creek, Dutch Creek, and north to Beehive Mountain at the head of the Oldman River. A narrow strip of suitable habitat (1-3 km wide) is essentially continuous along the Continental Divide from the head of Cataract Creek north to head of Storm Creek near Highwood Pass. In recent years, wildlife biologists have counted upwards of 186 goats – mostly along the Continental Divide but also on Crowsnest Mountain and in the Livingstone Range (Jokinen and Hale 2010).

Connectivity for mountain goats across Highway 3 appears tenuous. The closest habitats on each side of the highway are about 3 km apart, and the closest known sightings of goats are 6 km apart. Importantly, there is the major highway, railroad, and Crowsnest Lake impeding movement through the most likely route. Prospects for connectivity on the B.C. side of Crowsnest Pass are no better.

Table 6. Area (ha) and percentages of mountain goat habitat south and north of Highway 3 in the Southern Canadian Rockies, Alberta.

Watershed	Total Area	Winter Habitat (3)			Summer Habitat (2)		
		Area	% Area	% WH	Area	% Area	% SH
S Hwy 3	258,896	7,344	2.8	50.2	30,033	11.6	51.0
N Hwy 3	386,322	7,276	1.9	49.8	28,812	7.5	49.0
TOTAL	**645,218**	**14,620**	**2.3**	**100.0**	**58,845**	**9.1**	**100.0**

Figure 13. Location of key winter and summer habitats for mountain goats, Southern Canadian Rockies, Alberta.

Bighorn Sheep

John Weaver

Vulnerability Profile

Status: Rocky Mountain bighorn sheep – the Provincial mammal – are managed as trophy big game species in Alberta. On Provincial lands, population numbers have increased from ~1500 animals in 1915 to ~6500 animals in 2011. An additional ~4,500 bighorn sheep inhabit National Parks in Alberta, bringing the total population size to ~11,000. Excessive hunter harvest of trophy bighorn sheep rams, however, has emerged as a management concern – notably in the Southern Canadian Rockies portion of Alberta (Alberta SRD 2012).

Niche Flexibility: Rocky Mountain bighorn sheep have relatively low flexibility in their foraging and habitat niche (Geist 1971). Bighorn sheep feed primarily on grasses (especially bunchgrasses and fescues), though they occasionally consume palatable forbs and shrubs (Shackleton et al. 1999, Demarchi et al. 2000, Montana FWP 2009). During the short summer season, bighorn sheep often range in the alpine. Due to their strong affinity and perhaps physiological dependence on mineral licks during late spring-summer, sheep may travel several miles (even through forests) to visit such sites (Shackleton et al. 1999). Deep snow can hinder movements of bighorn sheep (especially ewes and lambs) and their access to grass forage, particularly if snowfall lasts for several days and/or becomes hard crusted. Thus, in winter, sheep usually select sites where deep snow does not accumulate due to low elevation, south exposure, and/or wind. Fire suppression can result in encroachment of open slopes by dense stands of conifers, which compromises the size and quality of these habitat patches (Schirokauer 1996). Moreover, bighorn sheep (particularly ewes with lambs) usually stay within 400-500 feet of rocky terrain and cliffs that provide escape habitat (defined as slopes > 27°) from terrestrial predators (Erickson 1972, Sweanor et al. 1996). Cliffs also provide available forage when snow events preclude use of other sites. This close interspersion of rocky terrain/cliffs with south-facing or wind-swept grassy slopes delimits suitable habitat during winter for Rocky Mountain bighorn sheep (Demarchi et al. 2000, Dicus 2002). Consequently, sheep also have low flexibility in their selection of habitat.

Reproductive Capacity and Mortality Risk: Rocky Mountain bighorn sheep have moderate reproductive potential (Demarchi et al. 2000). A ewe usually does not reproduce until 3 years of age and typically carries only a single lamb each year thereafter, but pregnancy rates can exceed 90% (Geist 1971, Jorgensen et al. 1993). Under high population density, though, age of first reproduction may be postponed and mature ewes may forego lamb production (Festa-Bianchet and Jorgensen 1998).

Adult survivorship is usually high between ages 2 and 8 years, but survival of lambs to 1 year can be low (10-60%) and varies substantially – depending upon maternal nutrition, spring weather, and the quality or vigor of the population (Shackleton et al. 1999, Demarchi et al. 2000). Adult bighorn sheep generally have an annual mortality rates of about 10% from natural causes. Bighorn sheep are notoriously susceptible to virulent outbreaks of pneumonia usually caused by *Pasturella* spp. bacteria transmitted by domestic sheep, which can decimate up to 95% of a herd rather quickly (Onderka et al. 1988, Bunch et al. 1999, Demarchi et al. 2000, see Miller et al. 2012 for recent review). Bighorn sheep populations recover slowly from such reductions, depending upon the quality of the range. Hence, bighorn sheep exhibit low resistance to disease and possess low capacity to compensate rapidly for excessive mortality. Most contemporary management plans for bighorn sheep (e.g. Montana FWP 2009) have endorsed the conclusion that domestic sheep should be kept away from bighorn sheep range (Martin et al. 1996).

Dispersal and Connectivity: Bighorn sheep find their niche in patches of montane and alpine grassland that remain stable through time, and they exhibit high fidelity to these ranges. In undisturbed situations, most suitable patches are already occupied by sheep. Although sheep migrate between traditional seasonal ranges, dispersing into unknown areas where there is a low likelihood of finding suitable habitat would not be a good strategy. Instead, juveniles inherit home ranges from adults and pass them on as a living tradition to their offspring (Geist 1971). Male bighorns occasionally move upwards of 30-50 km between herds, which could maintain some genetic connectivity (DeCesare and Pletscher 2006). Nonetheless, bighorn sheep have been perceived as poor dispersers with low potential for natural re-colonization of distant, vacant habitat (Shackleton et al. 1999). Actually, this could serve to compartmentalize herds and retard transmission of disease.

Sensitivity to Human Disturbance: Bighorn sheep exhibit a variety of behavioral responses to human activities ranging from habituation to cardiac alarm and displacement (Geist 1971, Andryk 1983, Shackleton et al. 1999). For example, sheep tolerate industrial activities and readily use open-pit coal mines that have been re-claimed (MacCallum and Geist 1992). Sheep also seem to habituate to predictable, repeated activities including highway traffic and even helicopter overflights beyond 0.25 miles (MacArthur et al. 1982, Stockwell et al. 1991). On the other hand, vehicle traffic and human activity impacted use of a nearby mineral lick by bighorn sheep (Keller and Bender 2007). Additionally, bighorn sheep do react negatively to approaching humans on foot, especially when accompanied by a dog (MacArthur et al. 1982). Chronic disturbances at critical sites (i.e., mineral licks) and/or of sensitive groups (ewes and lambs) could compromise the health and productivity of bighorn sheep populations. Roads, ATV use, and helicopter-based activities have proliferated throughout the Eastern Slopes in Alberta since the 1950s, impinging upon alpine summer and key winter ranges and altering hunting experiences. In B.C., Demarchi et al. (2000) did not believe implementation of recommendations for coordination of access management had been adequate for bighorn sheep conservation. Motorized access by ATVs, snowmobiles, and helicopters continues to be a management issue.

Response to Climate Change: Potential effects of climate change on Rocky Mountain bighorn sheep appear variable with contrasting implications. The winter season is widely considered to be the most challenging for bighorn sheep survival (Shackleton et al. 1999). Warmer winters with less snow could result in milder conditions and more expansive range for bighorn sheep, particularly if frequency of fires increases and removes encroaching conifers from potential winter ranges. This scenario, however, could also enable elk populations to increase and range more widely during winter (Wang et al. 2002), which could result in direct competition with bighorn sheep for forage. Rain-on-snow events following periods of deep snowfall, however, could create a hard-crusted snow that would reduce sheep access to ground forage. Perhaps the best conservation strategy for now is to provide stress-free security along an elevation gradient of south-facing or wind-swept slopes interspersed with cliffs. This would allow bighorn sheep options for moving up or down in response to changing conditions.

Conclusion: Bighorn sheep exhibit **moderate to high vulnerability**. They have a narrow feeding niche on grasses and are constrained to live on or near cliffs for escape terrain. Female sheep have moderate reproduction, but bighorn sheep are highly susceptible to outbreaks of disease (some carried by domestic sheep) that can decimate a herd quickly. Because Rocky Mountain bighorn sheep have strong fidelity to chosen sites, they do not disperse very readily and have a low capacity for re-colonizing vacant habitats. Bighorn sheep appear less sensitive to disturbance than goats. In terms of climate-change conservation strategies, maintaining secure access to cliffs and rocky terrain along an elevation gradient could provide options for bighorn sheep on montane winter ranges. Possible increase in elk-bighorn sheep competition should be monitored.

Methods for Scoring Conservation Importance

For location of winter ranges, I used the most recent map of winter ranges delineated by local ungulate biologists with many years of experience along the Eastern Slopes of Alberta (kindly by J. Jorgenson, Fish and Wildlife, Alberta ESRD).

For distribution of bighorn sheep summer ranges, I developed a step-wise model similar to the one described for mountain goats. First, we calculated terrain ruggedness using the curvature function in ArcGIS to generate a curvature grid (at 30m resolution) and then performed a moving window analysis for standard deviation within a 90m radius of each grid cell (Poole et al. 2009). Escape terrain was defined as pixels from the ruggedness grid with a value ≥1.854 (the top 3 of 5 classes when displaying the grid using natural breaks). Next, we constrained the model to escape terrain between elevation 1700 m and 2500 m. We buffered those areas by 210 m as a conservative estimate of foraging distance away from escape terrain (Sweanor et al. 1996). Approximately 99.4% of winter locations and 80.3% of summer locations from the Castle-Yarrow herd fell within predicted summer habitat (location data courtesy of M. Jokinen, Alberta Conservation Association).

Accordingly, I assigned the following importance scores for bighorn sheep:

Very High	(3)	=	known winter ranges
High	(2)	=	suitable summer habitat
Moderate	(1)	=	n.a.

Key Conservation Areas

Based upon DNA analysis of hunter-killed rams, three genetically-distinct groups of bighorn sheep have been recognized for Sheep Management Areas (SMA) in the Southern Canadian Rockies of Alberta:

(1) West Castle-Yarrow SMA: estimated population of ~260 sheep on provincial lands south of Highway 3 in the Waterton and Castle watersheds;

(2) Livingstone SMA: estimated population >355 sheep north of Highway 3 in the Oldman and Livingstone River watersheds; and

(3) Kananaskis SMA: includes some sheep range in Highwood River watershed and extends further north through Kananaskis Country with total population estimate of ~900 sheep (Alberta SRD 2012).

Altogether, there are 11-13 critical winter ranges used by bighorn sheep in the Southern Canadian Rockies of Alberta between Waterton Lakes National Park and Kananaskis Country (Table 7, Figure 14).

South of Highway 3: In the West Castle-Yarrow SMA, there are 4 winter ranges south of Highway 3, encompassing approximately 46,555 ha (7.2% of the study area). The largest one called Prairie Bluff-Yarrow Creek extends from the north border of Waterton Lakes National Park north to Prairie Bluff. Two winter ranges are located in the Castle River basin, one on the west side called Barnaby Ridge and the other on the east side called Table-Castle Mountain (Windsor Ridge). From there, it is ~29 km north to the next winter range called Crowsnest Pass, which is situated along the Mount McLaren massif just south of the pass. This winter range is proximal to one just across the Divide in B.C. along the lower slopes of Mount Ptolemy.

According to the habitat model, there is suitable summer habitat for bighorn sheep all along the Continental Divide from Waterton Lakes National Park north to nearly Crowsnest Pass. Although some sheep spend the summer on their winter ranges, others may migrate westward to the high country along the Continental Divide. Some also move into Waterton Lakes National Park.

North of Highway 3: There are 9 mapped winter ranges north of Highway 3, encompassing ~ 40,100 ha (6.2% of the study area). The closest one to Highway 3 extends along the narrow crest of the Livingstone Range from near Blairmore, AB, about 39 km north through the Livingstone Gap to White Creek. There are 2 winter ranges in the headwaters of the Oldman River (Cabin Ridge and Pasque Mountain) and another in the north end of the Livingstone Range (Mount Livingstone Provincial Natural Area). Further north, the next 3 winter ranges – Plateau Mountain, Cataract Creek, and Mount Head – are nearly contiguous. Importantly, there may be a linkage across Highway 541near Eyrie Gap for sheep to move between Cataract Creek and Mount Head winter ranges.

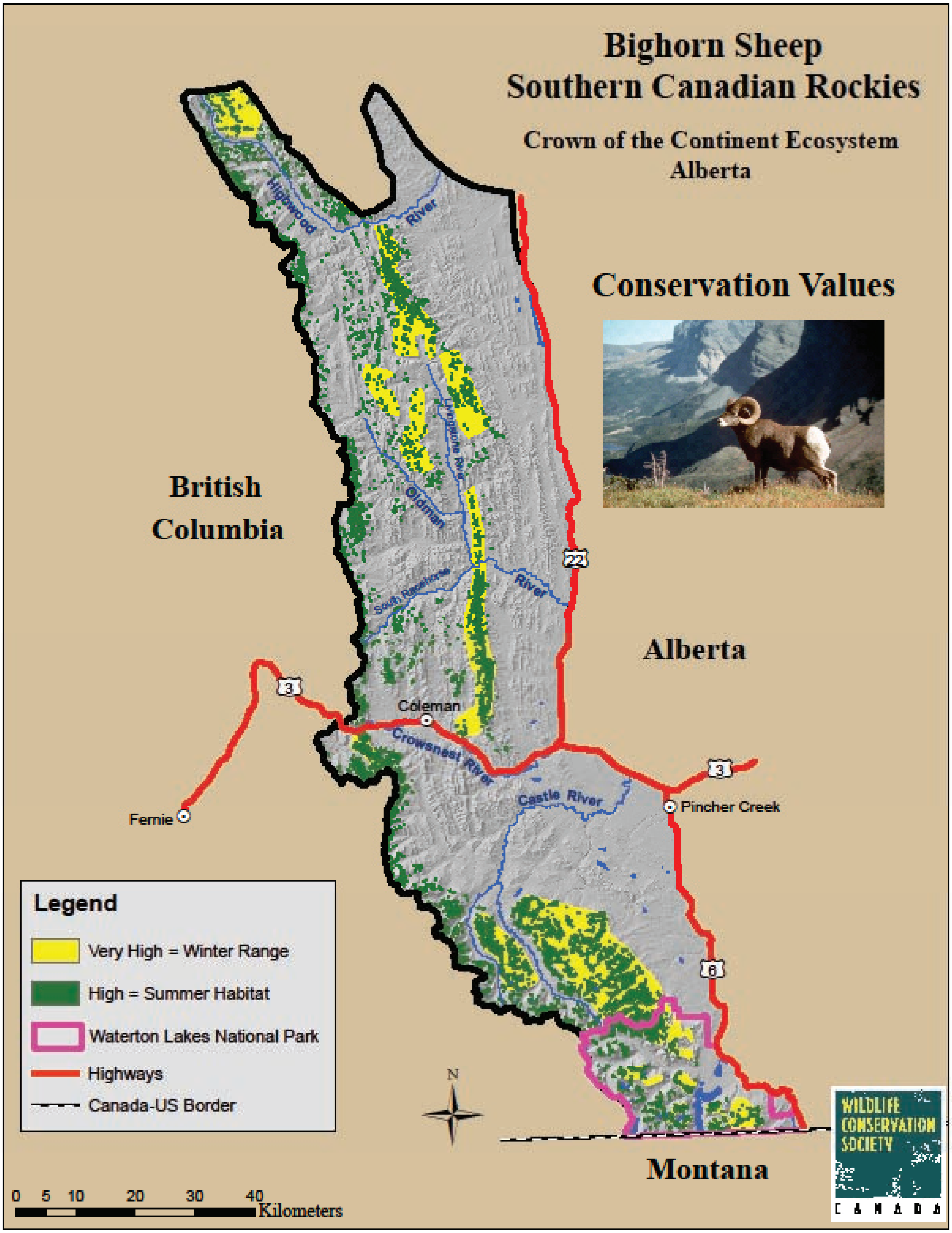
The habitat model indicates suitable summer habitat for bighorn sheep all along the Continental Divide from Crowsnest Pass north to the head of the Highwood River. Summer habitat for bighorn sheep extends all along the B.C. side of the Continental Divide, too. The Mist Mountain winter range on the east of Highway 40 at the head of the Highwood River basin merges with the Gibraltar winter range which lies at the head of the Sheep River.

The proportion of trophy rams in the Livingstone SMA is 1% (well below the 5% guideline) and 4% for the entire Kananaskis SMA. Again, this indicates the need for a precautionary approach to harvest.

Table 7. Area (ha) and percentages of bighorn sheep habitat in the Southern Canadian Rockies, Alberta.

Watershed	Total Area	Winter Habitat (3)			Summer Habitat (2)		
		Area	% Area	% WH	Area	% Area	% SH
S Hwy 3	258,896	46,555	18.0	50.2	49,468	19.1	51.0
N Hwy 3	386,322	40,100	10.4	49.8	51,395	13.3	49.0
TOTAL	**645,218**	**86,655**	**13.4**	**100.0**	**100,863**	**15.6**	**100.0**

Figure 14. Location of key winter ranges and summer habitats for bighorn sheep, Southern Canadian Rockies, Alberta.



3. CORE AREAS AND CONNECTIVITY ACROSS SOUTHERN CANADIAN ROCKIES OF ALBERTA

Core Areas: Synthesis of Conservation Values

To derive a *composite value* (CV), conservation values for each species were projected onto a grid of 1-km^2 cells across the study area (n = 6,452 cells). Then, I simply summed up the values across all 6 species for each cell. Although the maximum tally for a cell could have been 18 (6 species x highest score of 3), the maximum realized score was 14. I present the top 50% (values 8-14) and top 75% (values 4-14) of the composite values. In some places, the composite score might be low, but the site may be important for at least one of the vulnerable species. So, I mapped *species importance values* (SIV) whereby a grid cell with a score of 3 (*very high*) or 2 (*high*) for any species was highlighted. It should be noted that the SIV of 2 may represent a less critical but still essential component of the species' annual range (e.g., foraging/migrating/over-wintering habitat for bull trout). Here, I synthesize these two measures of conservation values across the Southern Canadian Rockies of Alberta and characterize the density and distribution of these values for each of the major watersheds.

Overall, the top 50% of composite values were located on 25.4 % (163,585 ha) of the study area, whereas the top 75% values were found on 62% (346,962 ha) (Table 8). This represents a significant concentration of these composite values; hence, certain key areas comprise a 'best buy' of top values for this suite of species. From a regional perspective, the Castle Special Place area on Crown land stands out for its remarkable clustering of top 50% composite values. The Castle and Oldman River basins (27% each) account for the majority of the top 50% CV. The Highwood and Waterton watersheds contribute about 18% each. The top 50% CV are clustered in the headwater basins of the following

(Figure 15): • Waterton River in Waterton Lakes National Park; • Drywood and Yarrow Creeks in the Front Canyons; • Castle River and Barnaby Ridge, West Castle River, and Carbondale River; • Crowsnest River south of Highway 3 and Crowsnest Mountain; • Oldman River including upper reaches of South and North Racehorse Creek, Dutch Creek, Hidden Creek, and Cabin Ridge; • Livingstone River and Livingstone Range; and • Highwood River from the head of Cataract Creek north to Highwood Pass.

In terms of Species Importance Values, the very high scores (3) occurred on 45.1% (291,132 ha) of the area and high scores (2) on 25.8% (166,627 ha) (Table 9). **Thus, most (71%) of the Southern Canadian Rockies of Alberta has high-very high value for 1 or more vulnerable species.** Very high Species Importance Values are concentrated in the following areas (Figure 16): • again, there is a remarkable concentration of SIV throughout much of the Castle Special Place and adjacent Waterton Lakes National Park; • headwater basins of Carbondale and Crowsnest River; • Livingstone Range; • headwater basins of the Oldman River, including Racehorse and Dutch Creeks; • throughout the upper Livingstone River basin; and • headwater basin of the Highwood River.

Table 8. Area (ha) and percentage of composite values in watersheds across the Southern Canadian Rockies, Alberta.

Watershed	Area (ha)	50% Conservation Values			75% Conservation Values		
		Area	% Area	% CV	Area	% Area	% CV
S Hwy 3	258,896	78,894	30.5	48.2	135,653	52.4	39.1
N Hwy 3	386,322	84,691	21.9	51.8	211,309	54.7	60.9
TOTAL	**645,218**	**163,585**	**25.4**	**100.0**	**346,962**	**53.8**	**100.0**
Highwood	129,068	29,986	23.2	18.3	73,557	57.0	21.2
Oldman	196,839	44,120	22.4	27.0	114,426	58.1	33.0
Crowsnest	94,176	15,928	16.9	9.7	33,809	35.9	9.7
Castle	144,062	44,272	30.7	27.1	74,703	51.9	21.5
Waterton	81,073	29,279	36.1	17.9	50,467	62.2	14.6

Table 9. Area (ha) and percentage of Species Importance Values (SIV) in watersheds across the Southern Canadian Rockies, Alberta.

Watershed	SIV = 3			SIV = 2			Combined		
	Area	% Area	% SIV	Area	% Area	% SIV	Area	% Area	% SIV
S Hwy 3	111,509	43.1	38.3	53,695	20.7	32.2	165,204	63.8	36.1
N Hwy 3	179,623	46.5	61.7	112,932	29.2	67.8	292,555	75.7	63.9
TOTAL	**291,132**	**45.1**	**100.0**	**166,627**	**25.8**	**100.0**	**457,759**	**70.9**	**100.0**
Highwood	61,249	9.5	21.4	37,423	5.8	22.5	98,672	15.3	21.6
Oldman	97,618	15.1	33.5	60,393	9.4	36.2	158,011	24.5	34.5
Crowsnest	32,590	5.1	11.2	23,022	3.6	13.8	55,612	8.6	12.1
Castle	56,269	8.7	19.3	32,289	5.0	19.4	88,558	13.7	19.3
Waterton	43,406	6.7	14.9	13,500	2.1	8.1	56,906	8.8	12.4

Figure 15. Distribution of composite scores for six vulnerable fish and wildlife species, Southern Canadian Rockies, Alberta.

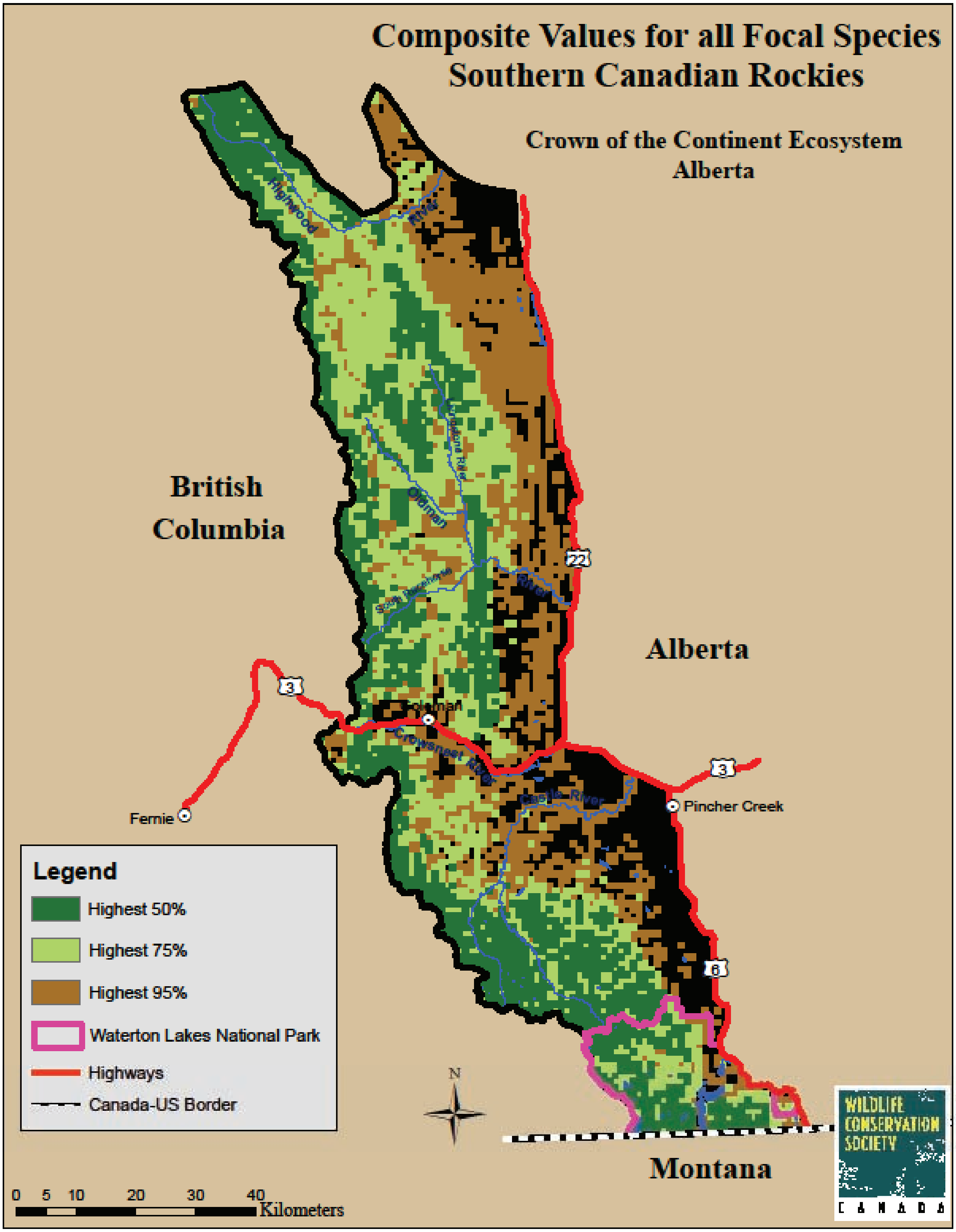
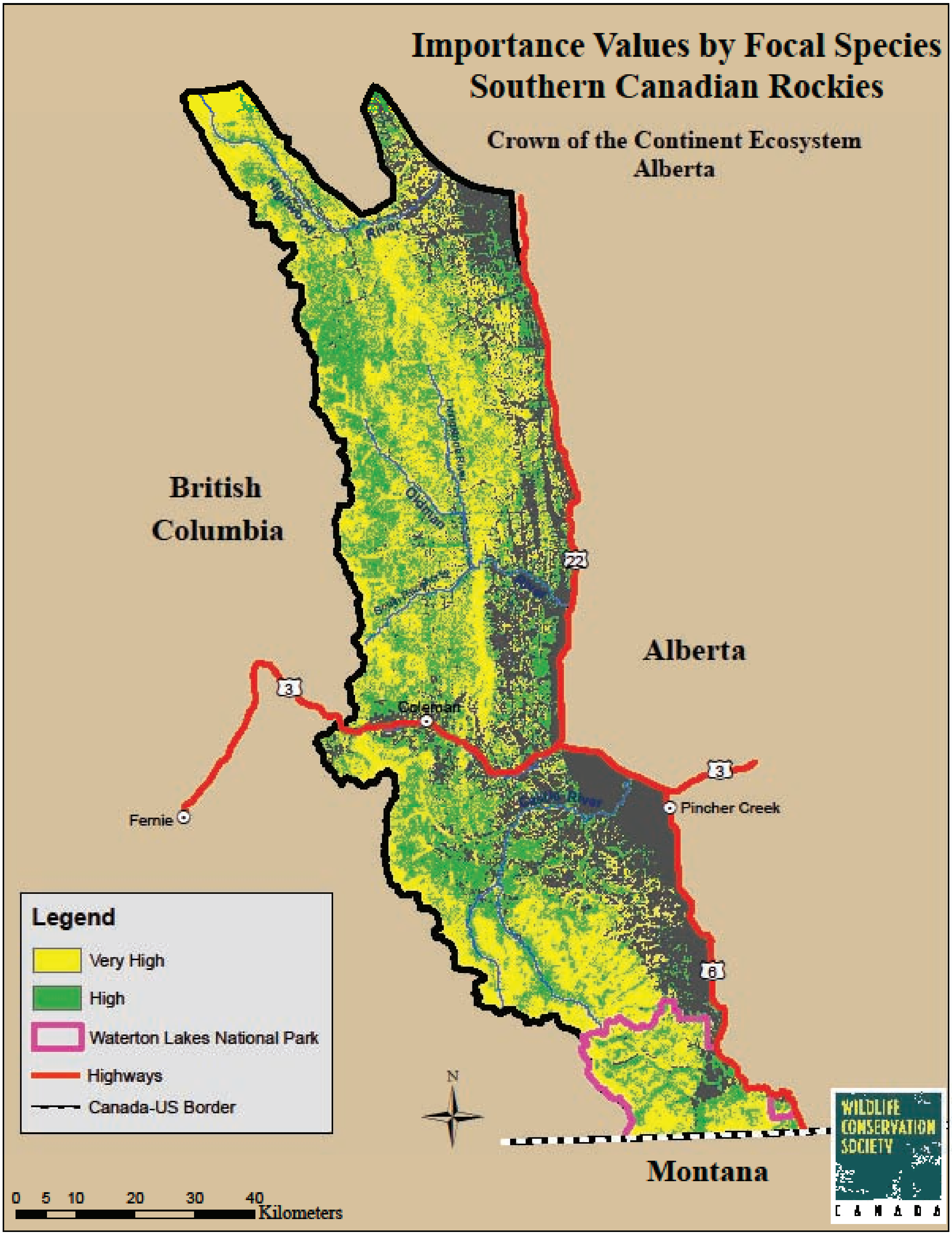


Figure 16. Distribution of species importance scores for any one of 6 vulnerable fish and wildlife species, Southern Canadian Rockies, Alberta.



Landscape Connectivity

It appears that the most important mechanism by which species coped with previous large-scale climate changes in the earth's history has been to move and colonize newly suitable habitat (Huntley 2005). Such shifts have already been documented in numerous species in response to contemporary changes in climate (Parmesan 2006). However, habitat fragmentation can interfere with the ability of species to track shifting climatic conditions. Consequently, many conservation scientists call for conservation corridors and linkages between existing and future habitats as a means to support necessary movements (Chetkiewicz et al. 2006, Rudnick et al. 2012). A complementary strategy is to increase the size and number of ecologically-diverse areas that are protected by various designations (Hodgson et al. 2009). The recent book Safe Passages: Highways, Wildlife, and Habitat Connectivity (Beckman et al. 2010) provides an outstanding overview of current projects, practices, and partnerships across the country – including several from the Crown of the Continent Ecosystem.

Highway 3 (and associated railroad) is a major east↔west transportation route across the Southern Canadian Rockies of Alberta (Figure 17). Several investigations have examined potential linkages across Highway 3 between Elko, B.C. and Lundbreck, Alberta for various wildlife species (Apps et al. 2007, Clevenger et al. 2010, Proctor et al. 2012, Weaver 2013). Here, I identify the few plausible linkages across Highway 3 in Alberta for these vulnerable wildlife species. Lastly, we identify several key mountain passes which provide corollary connectivity east↔west across the Continental Divide between British Columbia and Alberta.

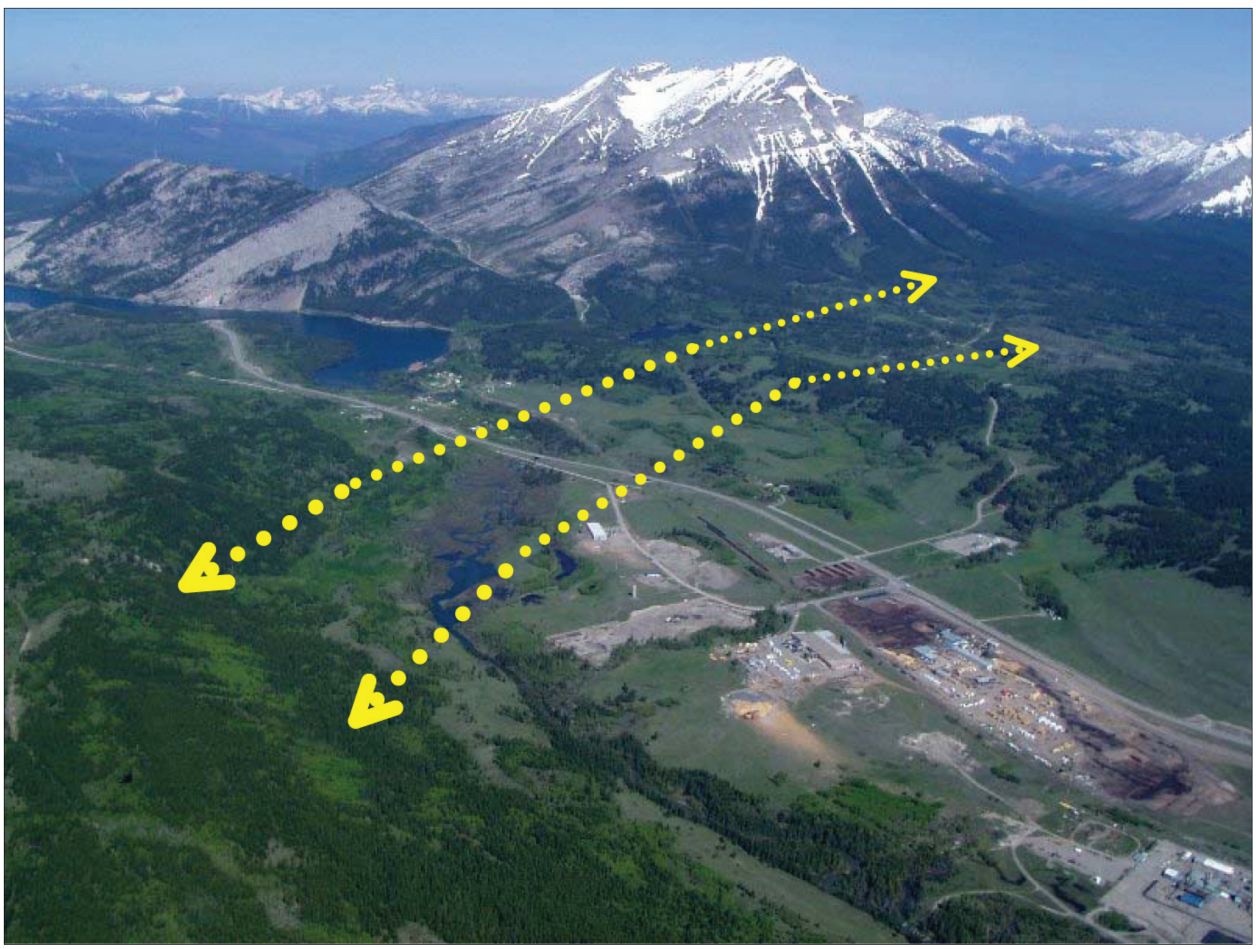
Multi-species Linkages across Highway 3

In this section, I coalesce our findings with previous studies for grizzly bears (Apps 1997), several carnivore species (Apps et al. 2007), and ungulates/vehicle collisions (Clevenger et al. 2010). In a very thorough and detailed assessment, Clevenger et al. (2010) identified several high-priority locations within various linkage zones along Highway 3 (their Figure 10). They assigned a subjective score from 1 (low) to 5 (high) based on the following criteria: (1) local conservation value, (2) regional conservation significance, (3) land-use security, (4) highway mortality, and (5) opportunities for highway mitigation. Here, I use their location names for linkage zones and sites as a handy reference (see Figure 18). I also bring forward their recommendations to reduce mortality and facilitate movements, should re-construction or twinning of Highway 3 occur in the future. The narrative starts near Crowsnest Pass at the Alberta-B.C. border and proceeds eastward along Highway 3 to the town of Blairmore.

Crowsnest Lakes (Score 3.4/4.0) – For the suite of vulnerable mammals in this report, the site between Island Lake and Crowsnest Lake (just east of Crowsnest Pass) has the highest potential regional significance of any linkage sites along Highway 3 in Alberta. There is high-very high habitat proximal to the highway on both sides of the highway here for grizzly bear (0.1 km between habitats), wolverine (2.5 km), bighorn sheep (3.2 km), mountain goat (3.5 km). Consequently, the composite value for these species also is the highest of any section along Highway 3. There is very high mortality of bighorn sheep here from collisions with vehicles, which may be adversely affecting the local population. Mountain goats cross here occasionally. In a recent study of wolverines based in the upper Flathead River basin in B.C., a GPS-collared female wolverine had numerous locations on the south side of Highway 3 at this site but was never recorded crossing the highway (McLellan and Servheen 2013).

Unfortunately, successful passage at this site is rather problematic due to several obstacles. The distance between the two lakes is 1.2 km. A rock quarry on the north side of the highway at the base of the mountain essentially spans that entire distance, whereas another rock quarry on the south side is nearly 0.6 km wide. The railroad runs all along the north side of each lake and the potential crossing. There are access roads to each quarry and to the railroad at Hazell. Where suitable habitat for several species converge close to the highway (at the southwest corner of Crowsnest Lake), there is a major parking area for big rigs and nearby houses. The most plausible crossing site (<300 m wide) might be between the south quarry and the aforementioned houses near Crowsnest Lake.

Figure 17. Successful wildlife crossing of Highway 3 near Crowsnest Pass, Alberta may be problematic due to vehicle traffic, trains round-clock, human settlements, and open landscapes. Appropriate crossing structures are needed to enable safe passage at a few critical sites.



Clayton Apps

During winter, road salt on Highway 3 should be replaced with alternative de-icing agents to reduce attraction of bighorn sheep to the highway. Fencing could be installed to funnel bighorn sheep movement away from Highway 3 toward Emerald Lake. If the highway is re-constructed, there should a wildlife underpass and fencing installed at the plausible crossing site.

Crowsnest West (Score 3.6) – This well-defined site is located where the Crowsnest River passes under Highway 3 about 1 km east of Crowsnest Lake. Although the distance between suitable habitat on each side of the highway is still short for grizzly bear (0.1 km), the shortest distance increases for the other species – wolverine (4.0 km), bighorn sheep (5.9 km), and mountain goat (6.2 km). Composite values are lower because the habitat in the immediate vicinity of the crossing is less suitable for bighorn sheep and mountain goat.

There are several obstacles at this site, too, that could reduce permeability to movements. The area north of the highway is privately owned, with expanding residential developments; lands south of the highway are a mix of private, public and municipal ownership. East of the site is a former industrial area, and the railroad has a siding here as well. The railroad runs along the north side of Crowsnest Creek and Crowsnest Lake.

Measures to promote connectivity at this site would include: (1) maintenance of riparian habitat, (2) widening of the bridge to allow level passageway (>3m wide) along each side of the creek under the bridge, and (3) bear-awareness campaign to reduce availability of attractants such as food and garbage. Efforts to secure conservation easements in the surrounding area should be continued.

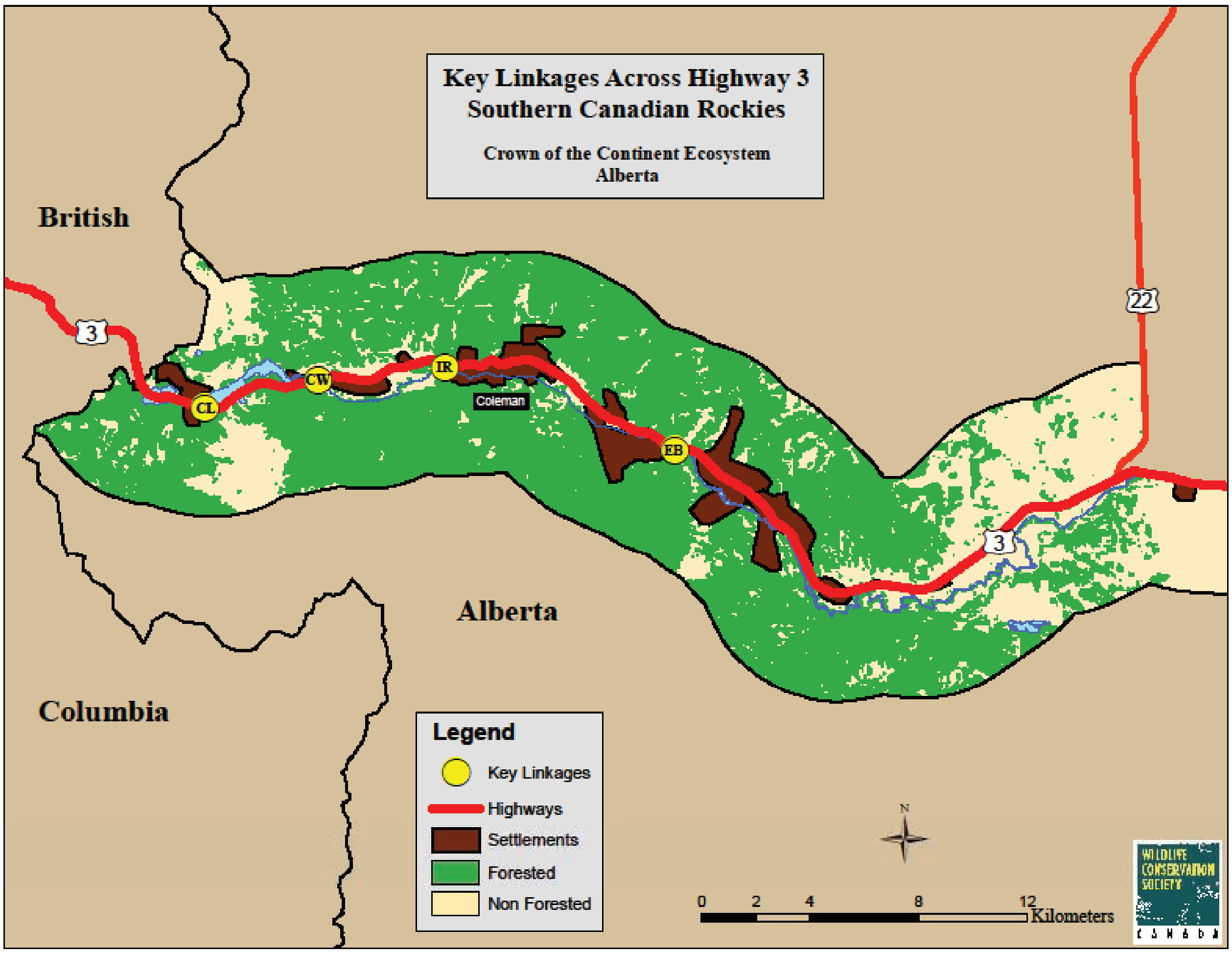
Iron Ridge (Score 3.2) – This site is about 2.5 km west of Coleman, Alberta, where the highway bisects what is locally known as Iron Ridge. Star Creek comes into Crowsnest River from the south. This site stands out as a 'pinch point' where 'safe harbour' habitat for grizzly bears comes closest to the highway on each side (Nielsen et al. 2006). Unfortunately, at least 1 grizzly bear was killed in a collision here a few years ago. Lands to the west represent important ungulate winter range - particularly for elk – and mortality by vehicle collision is rather high.

According to the Highway 3 transportation mitigation report (Clevenger et al. 2010), this area has high potential for conservation. Compatible ownership of some lands to the north and south of the highway site could provide a nucleus for security. To create connectivity between the various ownerships, however, there are a few key private parcels that would need to be secured for conservation purposes.

East Blairmore Bridge (Score 2.6) – According to the Highway 3 report, this site was selected to address bighorn sheep movement across Highway 3 under the existing Crowsnest River bridge. In addition, Alberta conservation officers attempt to keep the sheep off the highway due to their close proximity to town. There is high-very high habitat values for grizzly bears both north and south of Highway 3, and safe-harbour' habitat comes right down to the highway here. Thus, it has some potential for connectivity for grizzly bears.

In closing this chapter, securing connectivity across fracture zones like Highway 3 east of Crowsnest Pass is important for demographic and genetic resiliency of vulnerable wildlife species, as well as for broader movements in response to climate change. Time for addressing this issue is ticking, though, because expanding developments and highways leave permanent infrastructures. As these build up, options for providing wildlife connectivity vanish … and another critical landscape becomes fragmented.

Figure 18. Location of important linkage zones for vulnerable wildlife species across Highway 3, Southern Canadian Rockies, Alberta. Based upon information in reports by Apps et al. (2007), Clevenger et al. 2010, and Weaver (this report). CL = Crowsnest Lakes, CW = Crowsnest West, IR = Iron Ridge, and EB = East Blairmore linkages.



Connectivity across Continental Divide between Alberta and B.C.

The mountain passes along the Continental Divide on an east-west axis between Alberta and British Columbia are very important for landscape connectivity for grizzly bears, wolverines, and other wildlife species in the Southern Canadian Rockies. This is especially critical for female grizzly bears whose movements across Hwy 3 have become quite restricted (Proctor et al. 2012). I compiled information from scientific studies (Carr 1989, Eastern Slopes Grizzly Bear Project - Herrero 2005, Apps et al. 2007, various DNA-based inventories of grizzly bears in both Alberta and B.C. – Boulanger et al. 2007, Boulanger et al. 2008) and interviews with local researchers and guides/outfitters to identify the most important of these passes. In the following narrative, the name of the connecting river/creek on the Alberta side is provided in parentheses, and the numbers correspond to the passes shown on the accompanying map (Figure 19). Passes in **bold** are perhaps more important for regional connectivity.

Elk Pass/Tobermory Pass (Boulton Creek) (#1-2) likely is a major N⇔S movement corridor for many wildlife species (including grizzly bears and wolverine) moving between Kananaskis Lakes area of Peter Lougheed Provincial Park in Alberta and the headwaters of the Elk River in British Columbia.

Further south along the Continental Divide, grizzly bears use **Weary Gap** (McPhail Creek), **Fording Pass** (Baril Creek), and a pass south of Mount Gass (west tributary to headwaters of Oldman River) – thereby connecting the Don Getty Wildland Provincial Park in Alberta to the upper Elk Valley in British Columbia (#3-4). **Tornado Pass** (#5) and North Fork Pass (headwaters of Dutch Creek) appear important for several species. **Racehorse Pass** (west tributary to South Racehorse Creek) and **Deadman Pass** (west tributary to Allison Creek) have tremendous importance for safe passage of both male and female grizzly bears and may be used by wolverine and bighorn sheep as well (#6-7).

South of Hwy 3, terrain along the Continental Divide becomes less rugged which allows animals more options in crossing. Nonetheless, certain passes are regularly used by grizzly bears and other wildlife. Tent Mountain Pass (Crowsnest Creek) and **Ptolemy Pass** (East Crowsnest Creek) are especially important (#8-9) for grizzly bears to navigate around Crowsnest Pass. Wolverines may go through Ptolemy Pass as well. For connectivity between the Castle River Special Management Area in Alberta and the Canadian Flathead River in B.C., grizzly bears, wolverine and other wildlife cross various gaps in the vicinity of **North Kootenay Pass** (head of Carbondale River), pass north of Mount Haig (Syncline Brook), and through **Middle Kootenay Pass** (tributary to West Castle River) to connect with the (#10-12).

For passage between Waterton Lakes National Park in Alberta and the Canadian Flathead in British Columbia, grizzly bears and perhaps wolverines use **Sage Pass** (Bauerman Creek) and **South Kootenay Pass** (Lone Creek tributary to Blakiston Creek) (#13-14).

Figure 19. Location of important mountain passes for connectivity across Continental Divide, Southern Canadian Rockies, Alberta and British Columbia.

4. PROTECTING HEADWATER HAVENS IN THE SOUTHERN CANADIAN ROCKIES OF ALBERTA

Voices and Visions for the Southern Canadian Rockies of Alberta

The Southern Canadian Rockies have been recognized as beautiful landscapes and important as headwaters of great rivers. For many years, the Eastern Slopes of Alberta enjoyed 'de-facto' protection due to the few roads, local economies, and modest resource extraction. People lived a traditional western lifestyle and enjoyed the open spaces, clean air and water, diverse and abundant fish and wildlife. A naturalist and outfitter like Andy Russell could guide visitors for many days horseback through soul-lifting wild country rich in fish and wildlife. The wild beauty of the land, however, began changing in the 1950s as extraction of oil & gas and timber and timber expanded. The network of accompanying roads spread throughout the Southern Canadian Rockies, eventually penetrating all major valleys and into most tributary valleys. More recently, prosperous regional (globalized) economies have lead to burgeoning outdoor recreation, facilitated by advances in 4-WD and ATVs. The once-secluded havens of security for these vulnerable species had been breached. Declines in their distribution and abundance followed the spread of the human footprint.

Now, many people in southern Alberta have renewed their voice for the rich heritage of the Southern Canadian Rockies. Various surveys of residents in southwest Alberta have found that local people value the following: (1) reliable supply of clean water, (2) habitat to sustain diverse wildlife, (3) open space and traditional rural lifestyle, (4) clean air, (5) sustainable production of foods, (6) low-impact recreation, (7) aesthetic landscapes, and (8) ethic of stewardship (Castle Special Place Working Group 2009, Stark et al. 2011). The Southern Foothills Community Report states:

> "Residents call for coordinated land-use and water planning, with proactive, long-term, integrated plans based on sound science and local consultation. They strongly urge watershed protection as the highest priority for land-use planning and management. Similarly, they call on land managers to foster connected, functioning landscapes, which in turn will help maintain healthy ecosystems and the region's traditional economy and culture."

That's a pretty clear statement of the values and aspirations so strongly held by local residents and visitors alike.

Matching Stewardship with Wildlife Riches and Conservation Challenges

This conservation assessment has documented the critical importance of the Southern Canadian Rockies in Alberta for a unique suite of vulnerable fish and wildlife species that have been vanquished in so many other areas of their original range. Some of the highlights include:

- Regional strongholds for remnant populations of the 'Threatened' bull trout are found in the Castle River, upper Oldman River, and upper Highwood River drainages.
- Many of the remaining but 'Threatened' populations of genetically-pure westslope cutthroat trout in Alberta occur in the upper Oldman and Livingstone River drainages, upper Castle and Carbondale River drainages, South Racehorse Creek, and tributaries to the upper Highwood River.
- About 60% of the area provides high-moderate habitat value for 'Threatened' grizzly bears, but another 20% needs better management of access to facilitate recovery.
- About 50% of the area has suitable habitat for the rare wolverine, primarily in the higher terrain of the headwater basins of the Castle, Oldman, and Highwood Rivers.
- The iconic mountain goat finds suitable habitat in the rugged terrain along the Continental Divide.
- The Eastern Slopes of Alberta have long been known for outstanding populations of bighorn sheep. About 11 critical winter ranges are located in the area.
- Most (71%) of the Southern Canadian Rockies of Alberta has very high or high conservation value for 1 or more vulnerable species. About 25% of the area has the top 50% of composite values, whereas 62% of the area has the top 75% of composite values.

How well does the existing system of National Park and Wildland Provincial Parks in the Southern Canadian Rockies of Alberta provide for these vulnerable species?

Waterton Lakes National Park comprises **7.8%** of the total study area and accounts for **13.0%** of the top 50% Composite Values and **10.6%** of the top 75% CV (Table 10). It encompasses the following proportions of the *very high*

Importance Values (score = 3) for each species: bull trout 12.0%, westslope cutthroat trout 0.0%, grizzly bear 8.8%, wolverine 16.5%, mountain goat 21.5%, and bighorn sheep 12.9% (Table 11).

Along the Great Divide north of Waterton Lakes National Park in Alberta, however, there is no adequate protection of the headwaters for ~177 km. On Provincial lands of Alberta, existing Wildland Parks comprise **8.0%** of the total study area and account for **16.5%** of the top 50% CV and **13.5%** of the top 75% CV. They contain the following proportions of the *very high* Importance Values for these vulnerable species: bull trout 7.7%, westslope cutthroat trout 3.0%, grizzly bear 11.5%, wolverine 20.6%, mountain goat 15.5%, and bighorn sheep 10.3%. But these Wildland Provincial Parks are too small and too isolated to provide adequate protection and connectivity.

More than 70% of the top 50% CV and 75% of the top 75% CV for these vulnerable species remain unprotected in the Southern Canadian Rockies of Alberta. Hence, there is a mis-match between current protection of vulnerable fish and wildlife habitat and multiplying threats. The challenge is to provide a higher level of committed stewardship commensurate with these remarkable treasures of native fish and wildlife. Clearly, it is time to protect and connect these headwater havens in the Southern Canadian Rockies of Alberta.

Wildland Provincial Parks: Building Resiliency for Changing Times

During times of uncertainty, a common strategy among managers facing risk to valued resources is to minimize their exposure by placing them in 'safe havens' or refugia (Weaver et al. 1996). Indeed, the powerful role of refugia in persistence of populations has emerged as one of the most robust concepts in modern ecology (Fahrig 1988). Conceptually, refugia can be identified and managed as population *sources* by (1) maximizing birth rates (natality) through enhancement of habitat productivity, or (2) minimizing mortality through reduced access or curtailment of harvest. In the broader sense, then, refugia are 'safe havens' from habitat loss and overexploitation and serve as sources of population spillover and dispersers to the larger region. Both the ecological profiles and the historical record of extirpations attest to the need for some form of refugia or safe havens for vulnerable fish and wildlife species.

More recently, conservation biologists have applied the concept of refugia or safe havens for resiliency in the midst of climate change (Keppel et al. 2012). With scientific consensus on projections of warming of 2°- 4° C and increasing aridity in some places over the next 50-100 years, it's reasonable to expect shifts upward in elevation or northward in latitude where *comparatively* cooler and mesic (not dry) conditions once common may still occur (Parmesan 2006). Moreover, topographic complexity will provide more micro-refugia from mosaic disturbances such as fire, insects, etc. These are robust, strategic responses to both the trend and the variability of climate change. In the Central Interior of British Columbia, ecologists and land planners have been modeling climate refugia for vulnerable species to identify conservation areas (Kittel et al. 2011). This resilience approach does not require a capacity to predict the future with precision, but rather a qualitative capacity to devise systems that can absorb and accommodate future events in whatever surprise form they may take (Walker and Salt 2006).

To function most effectively, safe havens should be scaled in size to meet the needs of wide-ranging, vulnerable species and dynamic ecological processes. One fundamental tenet, for example, might be to encompass the full array of seasonal habitats used by an 'umbrella' species such as grizzly bears. Numerous studies have emphasized that high survivorship of adult female grizzly bears is of paramount importance to persistence of populations (e.g., Garshelis et al. 2005) and have called for provision of 'security areas' (Gibeau et al. 2001) or 'safe harbours' (Nielsen et al. 2006). In the mountains of western Montana, grizzly bear biologists characterized core areas used by adult female grizzlies as predominantly roadless (≥ 60% of area ≥ 0.5 km from a road), with a range of elevations (Mace and Waller 1997). They recommended that such cores areas be high priority for habitat conservation. Multi-annual home ranges of 33 female grizzly bears in the Eastern Slopes of Alberta averaged 521 km^2 (Stevens and Gibeau 2005). Another key tenet might be to facilitate potential adaptation to changing climates by providing a range of elevations, aspects, and topographic complexity from river valley to mountain peak. Depending on the species and landscapes, these can be overlapping and/or complementary features.

What options are available in Alberta for building safe havens of resiliency at adequate landscape scales? Currently, there is a hodge-podge of 7 various designations established under 2 different statutes. (Some have urged reform of this legislated framework to provide a more coherent organization of protected areas.) These designations (from most protective to least protective) include: (1) Wilderness Area, (2) Ecological Reserve, (3) Wildland Provincial Park, (4) Heritage Rangelands, (5) Provincial Park, (6) Natural Area, and (7) Provincial Recreation Area. Each has particular purposes, accompanied by varying restrictions on commercial and recreational activities.

Although the 'Wilderness Area' and 'Ecological Reserve' designations provide the most stringent protection, they also prohibit *any hunting and fishing* in addition to industrial activity. This provision contrasts notably with the Wilderness Act in the United States, which has protected millions of acres with the support of hunting and fishing constituencies. In retrospect, no wilderness areas have been designated in Alberta since the first and only three areas were established in the 1960s with the enabling legislation. 'Ecological Reserves' typically are very small areas to protect discrete features such as wetlands and do not serve large, wide-ranging animals adequately. 'Heritage Rangeland' applies specifically to grasslands and does not restrict mineral leasing (interestingly, it does prohibit off-highway vehicles). 'Provincial Parks' and 'Natural Areas' do not restrict any commercial or other activity by legislation; the responsible Minister may proscribe certain protections in accompanying management plan or regulations. 'Provincial Recreation Areas' provide the least protection because they are not really designed to protect Nature.

I have concluded that the category of '*Wildland* Provincial Parks' offers the best option for protecting large important areas in the Southern Canadian Rockies of Alberta. Wildland Provincial Parks are a type of Provincial Park established in 1996 specifically to protect natural heritage over large areas and provide opportunities for backcountry recreation. Wildland provincial parks are large, undeveloped natural landscapes that retain their primeval character. Notwithstanding, some commercial activities can occur. This is the type of designation used most frequently in recent years to provide some protection to larger areas.

- New surface rights for oil & gas, mining, and other industrial activities cannot be granted after designation. Exception is new rights can be granted for logging and grazing.
- Trails and primitive backcountry campsites are provided in some wildland parks to minimize visitor impacts on natural heritage values.
- Some wildland parks provide significant opportunities for adventure activities such as backpacking, wildlife viewing, mountain climbing and trail riding.
- Designated trails for off-highway vehicle riding and snowmobiling are provided in some wildland parks.

Efficacy of these wildland parks for safeguarding vulnerable fish and wildlife species and their habitats, however, depends upon the extent and intensity of commercial logging, grazing, and motorized access. There are several options for zoning Wildland Parks to provide better protection of wildlife habitat and security beyond the general regulations (or lack thereof). Under the Provincial Parks Act for Alberta, "The Minister may:

- Establish a framework that provides a basis for zoning the whole or any part of a park or recreation area so as to manage, regulate or confine the various uses of land within the park or recreation area [Parks Act s. 13(1)(b)]
- Prohibit or restrict access in any part of a park [Parks Act s.13(1)(a.1)]
- close any part of a park [Parks Act s.13(1)(a)]"
- "The Minister may make regulations respecting the planning and zoning of land [Parks Act s.12(2)(p)]
- Such regulations may apply to all parks or to "particular parts of identified parks or recreation areas" [Parks Act s.12.1]
- Zoning regulations under Parks Act s.12(2)(p) must be in accordance with any regional plan under Alberta Land Stewardship Act (Parks Act s.12.3]"

Clearly, the Minister has the statutory flexibility to designate zones within a Wildland Park toward better land management.

New *Wildland* Provincial Parks: Connecting Values and Places

Recommendation 257,065 ha

To protect and connect the headwater havens for vulnerable fish and wildlife species, I recommend 257, 065 ha be designated as *Wildland* Provincial Parks (Figure 20). Designation of these Wildland Parks along the Continental Divide would provide vital connectivity from Waterton Lakes National Park north to Kananaskis Country and nearby Banff National Park. Moreover, they would protect the 'water towers' that provide precious water to people of the South Saskatchewan River basin. Although site-specific conservation measures are needed in some circumstances (e.g., in-stream barriers to keep non-native trout from hybridizing native trout), designation of these wildland parks would signal a first-order commitment to conservation and recovery.

These new Wildland Provincial Parks would protect 66% of lands containing the top 50% of the composite scores on just 40% of the assessment area (Table 9). Importantly, they would increase the *very-high* conservation scores for vulnerable species substantially compared to existing parks (in parens): bull trout **70.1%** (19.7), westslope cutthroat trout **81.2%** (3.0), grizzly bear **46.5%** (20.3), wolverine **59.2%** (37.1), mountain goat **58.9%** (37.0), and bighorn sheep **69.0%** (23.2) (Table 10). Hence, these new Provincial Wildland Parks would bring a high return-on-investment in terms of conservation gains for land area.

These areas are contiguous and should be protected as a single connected system of 1 or more Wildland Provincial Parks. To provide further detail, I describe the fish and wildlife values in each of the various watersheds that would be protected by the proposed designation of Wildland Provincial Park.

Castle-Waterton River Watershed

Recommendation: 98,097 ha as *Wildland* Provincial Park

This designation would include essentially all of the Castle Special Place recommended for a Wildland Provincial Park by the Citizen's Initiative (2009). It would include the headwaters of the Castle/ Carbondale and Waterton Rivers, which provide much of the water in southwest Alberta. On just 15.2% of the land base in the Southern Canadian Rockies of Alberta, designation of this Wildland Park would encompass 30.9% of the top 50% Composite Values and 23.6% of the top 75% Composite Values. It would help protect 37% of the identified spawning/rearing areas for bull trout and 25% of the remaining genetically-pure populations of the threatened westslope cutthroat trout in the region. A Wildland Provincial Park in the Castle Special Place would provide important habitat and security for grizzly bears; moreover, it would connect areas used by the internationally-recognized dense population of grizzly bears in the trans-border Flathead River basin of British Columbia. The higher snowfall in the Castle-Waterton area results in more maternal habitat for the rare wolverine than elsewhere in southwest Alberta. This proposed Wildland Park would also include vital winter ranges and summer habitat for several herds of bighorn sheep. It would encompass year-round habitat for mountain goats that also wander back and forth across the Continental Divide shared with British Columbia. To summarize: The concentration of high conservation values for vulnerable fish and wildlife species in the Castle-Waterton area – coupled with its strategic geographic position adjacent to the Waterton-Glacier International Peace Park and the Canadian Flathead – makes a compelling case and 'best-buy' for designation of a *Wildland* Provincial Park. Some of these conservation values would be compromised or degraded by the extensive area open to motorized vehicles (ATVs, snowmobiles). To protect habitat and provide security for these vulnerable species, I recommend 76,314 ha of the Wildland Provincial Park be designated a *Wild Zone* with no motorized access (Figure 20).

Crowsnest River Watershed

Recommendation: 21,577 ha as *Wildland* Provincial Park

This proposed *Wildland* Provincial includes areas on both sides of Highway 3 just east of Crowsnest Pass at the headwaters of the Crowsnest River. On just 3.3% of the land base in the Southern Canadian Rockies of Alberta, designation of this Wildland Park would encompass 5.9% of the top 50% CV and 4.67% of the top 75% CV – almost entirely for the mammals in the vulnerable suite. Radio-tracking of grizzly bears and wolverines have revealed their use of high-quality habitat on both sides of the highway, as well as nearby mountain passes into British Columbia. A herd of bighorn sheep that winters here suffers an unsustainable rate of mortality from collisions with vehicles. There may be a few mountain goats inhabiting the area. Perhaps most importantly, a Wildland Provincial Park in the Crowsnest Pass would provide a ramp to the 2 potential but narrow corridors across busy Highway 3 and thereby promote regional connectivity through the Southern Canadian Rockies of Alberta. Because dispersal movements by wildlife can be a gradual process over time, it's important to provide secure habitat to facilitate some residency. To provide security and promote connectivity for these vulnerable species, I recommend 13,640 ha of the Wildland Provincial Park be designated a *Wild Zone* with no motorized access (Figure 20).

Oldman River Watershed

Recommendation: 82,006 ha as *Wildland* Provincial Park

This would include the headwaters of the Oldman and Livingstone Rivers, which provide much of the water in southwest Alberta. On just 12.7% of the land base in the Southern Canadian Rockies of Alberta, designation of this Wildland Park would encompass 18.8% of the top 50% CV and 20.3% of the top 75% CV. Importantly, 56% of the remaining genetically-pure populations of the threatened westslope cutthroat trout in the region would be encompassed by this designation – along with 24% of the identified spawning/rearing areas for bull trout. High-quality habitat for grizzly bears is extensive throughout the Oldman River watershed, especially in the headwater basins of Racehorse and Dutch Creeks, Oldman and Livingstone Rivers. All of these areas also provide primary habitat for wolverines, but suitable maternal habitat appears limited to a narrow strip along the Continental Divide. This same narrow strip along the

Divide encompasses year-round range for mountain goats and summer habitat for bighorn sheep. Two winter ranges for the sheep occur at Cabin Ridge and Pasque Mountain. To summarize: high conservation values for vulnerable fish and wildlife species extend continuously along the Continental Divide in the upper Oldman River area and headwaters of the Livingstone River. Several mountain passes – Deadman, Racehorse, and Tornado – provide important connection to key habitats in adjacent areas of B.C. Designation of a Wildland Provincial Park in the headwaters of the Oldman and Livingstone River would protect key areas for these vulnerable species and enhance regional connectivity both north⇔south and east⇔west. Some of these conservation values would be compromised or degraded by the extensive area open to motorized vehicles (ATVs, snowmobiles). To protect habitat and provide security for these vulnerable species, I recommend 47,284 ha of the Wildland Provincial Park be designated a *Wild Zone* with no motorized access (Figure 20).

Highwood River Watershed

Recommendation: 43,223 ha as *Wildland* Provincial Park

This would include the headwaters of the Highwood River, an important source of water in the foothills of southwest Alberta. On just 6.7% of the land base in the Southern Canadian Rockies of Alberta, designation of this Wildland Park would encompass 6.2% of the top 50% CV and 10.6% of the top 75% CV. Most importantly, it would connect with and augment existing Wildland Provincial Parks that protect additional lands of high value at the very headwaters of the Highwood River basin. The upper reaches of the Highwood River provide some of the most extensive spawning areas for migratory bull trout along the Eastern Slopes (27% of spawning habitat in the region). A few remnant populations of genetically-pure westslope cutthroat trout occur here, too. There are extensive patches of high-quality habitat for grizzly bears, notably from Highway 40 west to the Continental Divide. Radio-tracking by the Eastern Slopes grizzly bear project team documented numerous locations of grizzlies, with the home ranges of female bears in this area extending into Kananaskis Country and over the Divide into the headwater basins of the Elk River in British Columbia. Much of the upper Highwood River basin provides primary habitat for the rare wolverine, and the high snowfall makes the headwater basins suitable as maternal habitat. This proposed Wildland Park would also include vital winter ranges and summer habitat for several herds of bighorn sheep. It would encompass year-round habitat for mountain goats that also wander back and forth across the Continental Divide shared with British Columbia. To summarize: The concentration of high conservation values for vulnerable fish and wildlife species in the headwaters of the Highwood River basin – coupled with its strategic contiguity with existing Wildland Provincial Parks and the very important headwaters of the Elk River in B.C. – makes a compelling case for designation of a Wildland Provincial Park. Some of these conservation values would be compromised or degraded by certain areas open to motorized vehicles (ATVs, snowmobiles). To protect habitat and provide security for these vulnerable species, I recommend 26,470 ha of the Wildland Provincial Park be designated a *Wild Zone* with no motorized access (Figure 20).

Table 10. Area (ha) of Composite Values within Waterton Lakes National Park, existing Provincial Wildland Parks and Reserves and proposed Provincial Wildland Parks, Southern Canadian Rockies, Alberta.

	Waterton Lake National Park		Existing Wildland Parks		Proposed Wildland Parks		TOTAL	
Watershed	**Top 50%**	**Top 75%**	**Top 50%**	**Top 75%**	**Top 50%**	**Top 75%**	**Top 50%**	**Top 75%**
Highwood			19,721	28,135	10,118	36,782		
Oldman			7,249	18,804	33,698	74,206		
Crowsnest			0	0	14,153	22,835		
Castle			0	0	42,766	69,872		
Waterton			0	0	7,813	12,016		
(w/o WLNP)			0	0				
TOTAL	**21,332**	**37,324**	**26,970**	**46,939**	**108,548**	**215,711**	**163,585**	**346,962**
% TOTAL	**13.0**	**10.6**	**16.5**	**13.5**	**66.4**	**62.2**	**95.9**	**86.3**
% Area	**7.8**	**7.8**	**8.0**	**8.0**	**39.8**	**39.8**	**40.5**	**53.8**

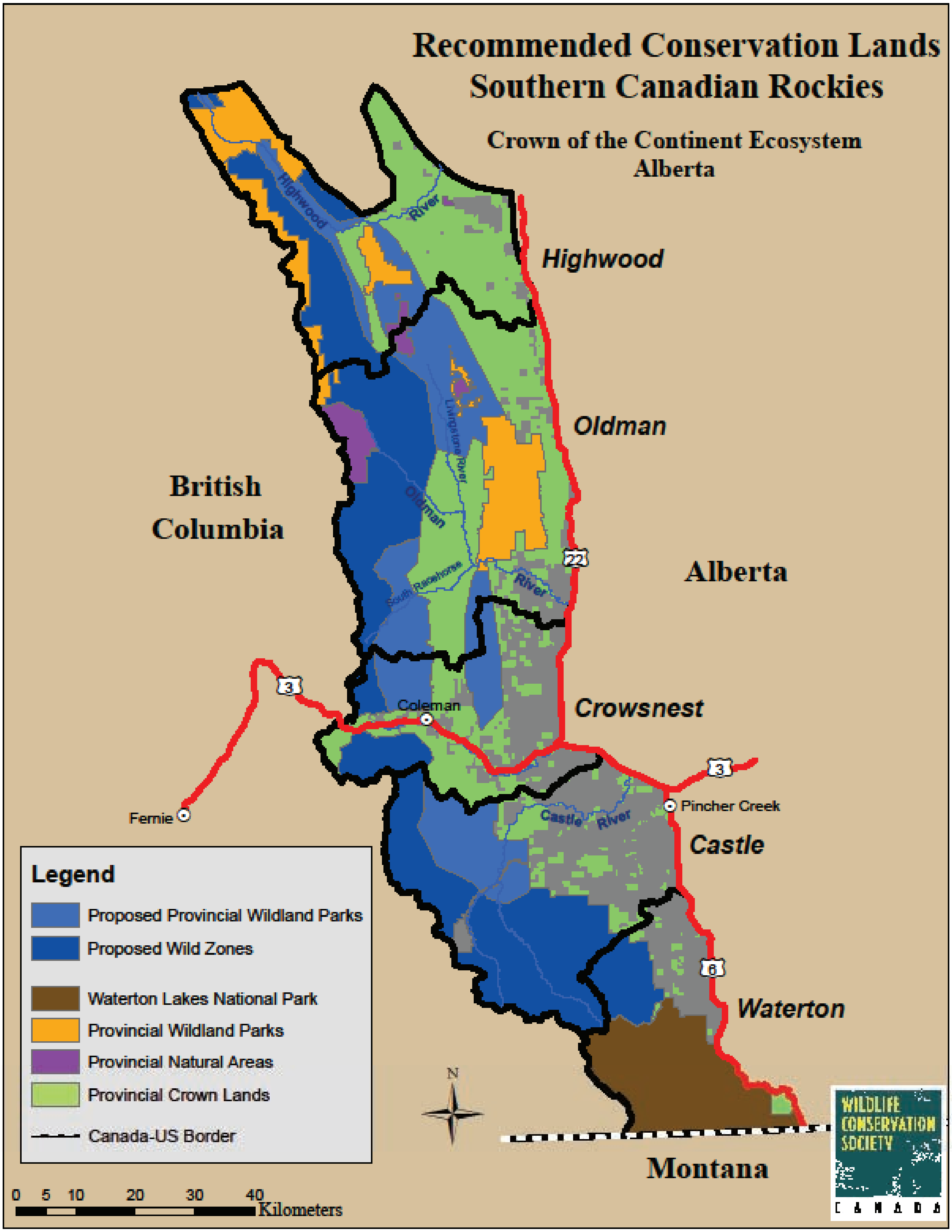
Table 11. Percent of Species Importance values within Waterton Lakes National Park (WLNP), existing Wildland Provincial Parks (WPP), and proposed Wildland Provincial Parks, Alberta.

Species	Very High				High			
	Total	**WLNP**	**Exist WPP**	**Prop WPP**	**Total**	**WLNP**	**Exist WPP**	**Prop WPP**
Bull Trout	89.8	12.0	7.7	**70.1**	34.2	7.7	1.7	**24.8**
WCT	84.2	0.0	3.0	**81.2**	78.0	0.0	3.4	**74.6**
Grizzly Bear	66.8	8.8	11.5	**46.5**	62.4	7.7	6.4	**48.3**
Wolverine	96.3	16.5	20.6	**59.2**	93.1	12.0	13.2	**67.9**
Mtn Goat	95.9	21.5	15.5	**58.9**	93.2	16.4	19.0	**58.2**
BighornSheep	92.2	12.9	10.3	**69.0**	91.2	11.5	13.3	**66.4**

Table 12. Area (ha) of Provincial Wildland Park and Wild Zone proposed for the Southern Canadian Rockies, Alberta.

Watershed	Wildland Provincial Park	Wild Zone	% Wild Zone
Highwood	43,223	26,470	61.2
Oldman	85,810	47,284	55.1
Crowsnest	29,935	13,640	45.6
Castle	85,309	63,526	74.5
Waterton	12,788	12,788	100.0
TOTAL	**257,065**	**163,708**	**63.7**

Figure 20. Location of recommended Wildland Provincial Parks in primary watersheds, Southern Canadian Rockies, Alberta.



Livingstone Range

Recommendation: 12,162 ha as *Wildland* Provincial Park

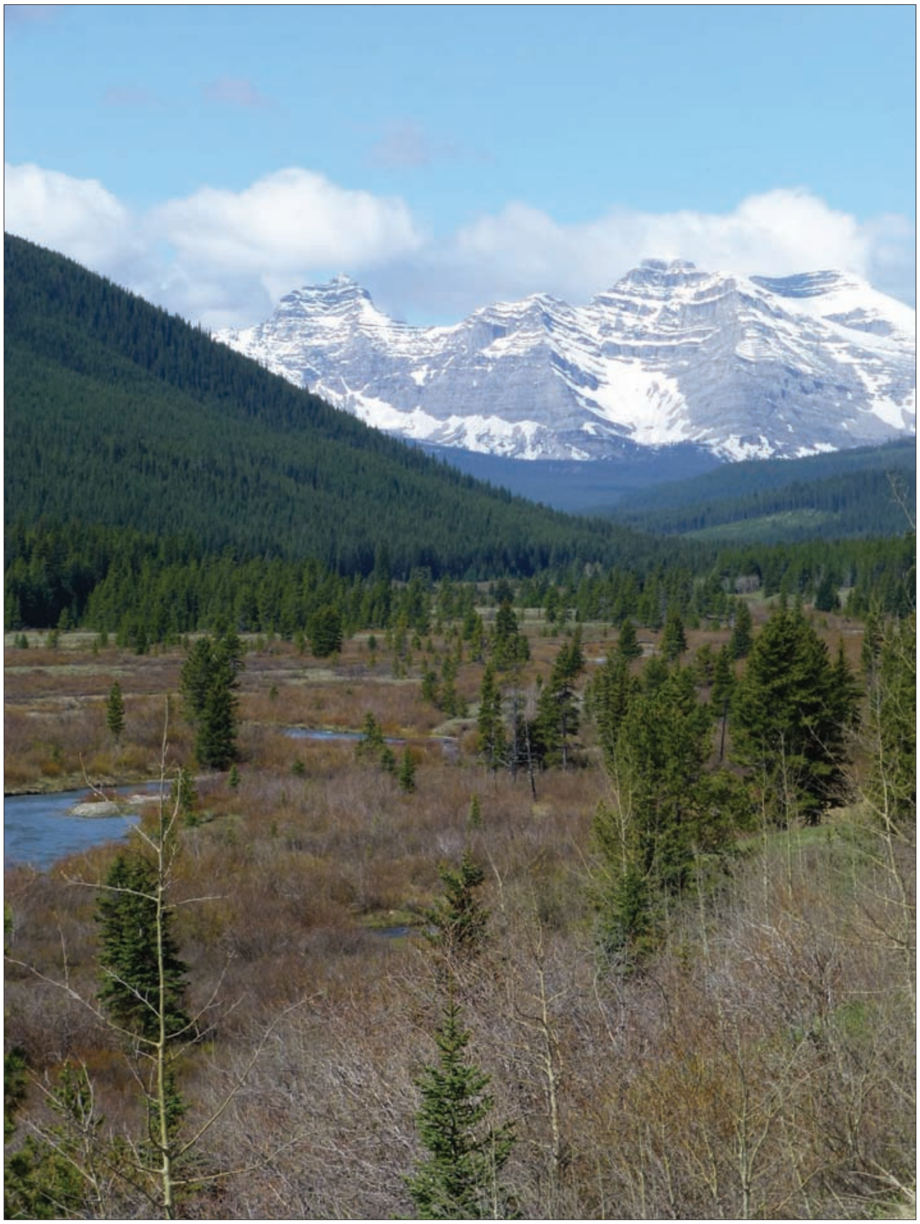
The Livingstone Range is a narrow mountain block west of Highway 22, which extends from the town of Blairmore northward toward the headwaters of the Livingstone River. The proposed Wildland Provincial Park would encompass the south end of the range to the Livingstone Gap and connect to the Bob Creek Wildland Provincial Park. On just 1.9% of the land base in the Southern Canadian Rockies of Alberta, designation of this Wildland Park would encompass 4.6% of the top 50% CV and 3.0% of the top 75% CV. The Livingstone Range is a winter and summer range for a herd of bighorn sheep and for some 20-25 mountain goats, too. Although the rocky crest of the range is not considered good habitat for grizzly bears, a narrow strip of high-quality habitat runs all along its eastern flank and widens toward the south end. The security value of some of this habitat is compromised by roads. The crest and western slopes of the Livingstone Range appears suitable as primary habitat for wolverine but not for maternal habitat. There is no conservation value for bull trout here, but the headwaters of Gold Creek have a small population of pure westslope cutthroat trout. Overall, the Livingstone Range ranks lower in conservation value for these species compared to the other proposed Wildland Provincial Parks closer to the Continental Divide.

Safeguarding the Headwater Havens

Expanding resource extraction and practices over the past 50 years have been rough on the vulnerable native fish and wildlife of the Southern Canadian Rockies of Alberta. Once-abundant populations have been extirpated from some areas and diminished in others ... habitats have been lost, connectivity has been fractured, and genetic integrity compromised. The result is remnant populations, small and isolated versions of once vigorous populations. The prospect of ever-expanding human developments and warming climate casts a shadow over their future as wildlife conservation values lose out in an arena of competitive pressures for development of commodity resources.

... and yet … these vulnerable species persist for the moment and represent starting points for restoring the wild heritage which people both from Alberta and abroad cherish. Protecting the headwater havens of the spectacular Southern Canadian Rockies with new and connected Wildland Provincial Parks will help ensure that these remarkable treasures of native fish and wildlife and precious water will be enjoyed by people today and generations yet to follow. Today is not too late, but tomorrow may be.

Figure 21. Protecting the headwater havens of the spectacular Southern Canadian Rockies of Alberta with new Wildland Provincial Parks will help ensure that these remarkable treasures of native fish and wildlife and precious water will be enjoyed by people today and generations yet to follow.



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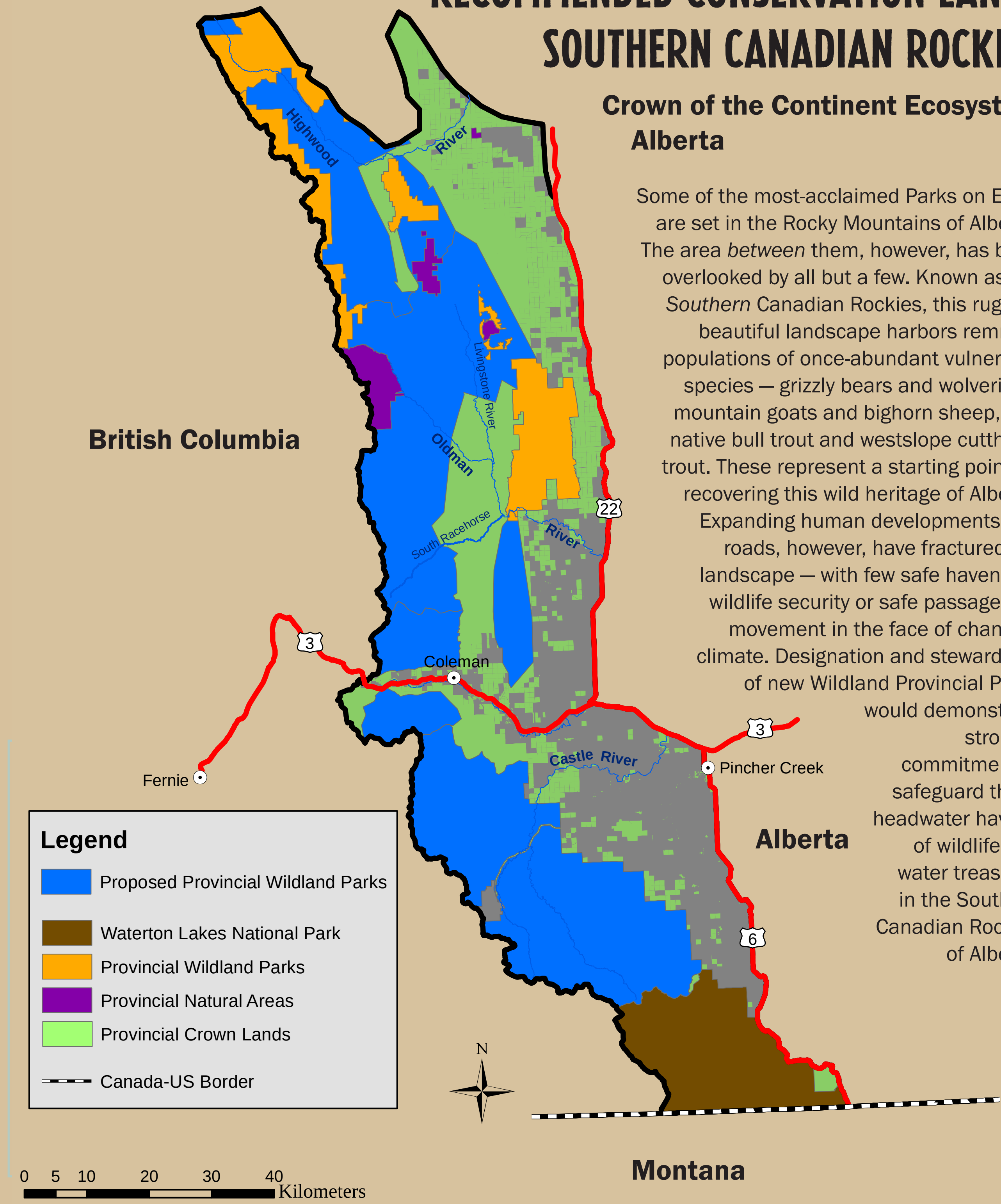
RECOMMENDED CONSERVATION LANDS SOUTHERN CANADIAN ROCKIES

Crown of the Continent Ecosystem Alberta

Some of the most-acclaimed Parks on Earth are set in the Rocky Mountains of Alberta. The area *between* them, however, has been overlooked by all but a few. Known as the *Southern* Canadian Rockies, this rugged, beautiful landscape harbors remnant populations of once-abundant vulnerable species — grizzly bears and wolverines, mountain goats and bighorn sheep, and native bull trout and westslope cutthroat trout. These represent a starting point for recovering this wild heritage of Alberta. Expanding human developments and roads, however, have fractured the landscape — with few safe havens for wildlife security or safe passages for movement in the face of changing climate. Designation and stewardship of new Wildland Provincial Parks would demonstrate stronger commitment to safeguard these headwater havens of wildlife and water treasures in the Southern Canadian Rockies of Alberta.



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