Columbia Valley Environmental Resource Database Analysis

Prepared for the
Columbia Wetland Stewardship Partners

Maggie Romuld, MSc RPBio

Dr. Suzanne Bayley

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Executive Summary

The Columbia Wetlands Stewardship Partnership (CWSP) has identified a number of objectives to guide the work of the organization. The objectives include maintaining the functional processes that drive the Columbia Wetland system; all the present habitat elements in the system; and the entire range of historically present species in the wetlands and the river system. The CWSP has also stated that it is "important for the CWSP and agencies to have a knowledge of the natural range of variation of natural processes so that they can detect changes that may be affecting the ecosystem, especially those changes that can be influenced by management actions."

To fulfil those objectives, the CWSP must have access to the results of projects designed to expand knowledge of Columbia Wetland ecosystems, and must understand where there are knowledge gaps that could derail attempts to maintain or improve those systems. Therefore, in early 2017, CWSP initiated the creation of a resource database containing documents relevant to the headwater region of the Columbia River.

This report forms the second half of the database project. It includes a brief overview of the information currently available in the CWSP database and a summary of the status of various wetland components, including species and habitats of interest, water resources, ecosystem processes and climate change. The discussion then turns to a summary of the current management and action plans related to the previously described components and the identification of knowledge gaps and opportunities. This analysis does not include a recommendation of specific projects; its sole intent is to help guide discussions of potential projects that Partners might undertake.

To identify research and monitoring opportunities, the database was initially searched by broad keywords to break the large number of documents into manageable units and identify more- or less-relevant reports and research. Documents within the resulting sub-list of relevant reports were reviewed to create summaries of individual abiotic and biotic elements and identify knowledge gaps for key elements. While there are many topics of interest addressed within the database, not all topics can be considered key to addressing the stated objectives of the Partners. For example, some issues, such as a lack of consistent water monitoring, potential impacts of climate change, or those dealing with key habitats or species, were considered of more relevance than those of peripheral species, or concerns of limited geographical extent. Issues related to dams and their management were also considered outside the scope of this project.

Numerous management plans, action plans, strategies and guidelines have been developed for components of the Columbia Wetlands ecosystem or include this region within their scope. While the data within some of these plans is not specific to the wetlands, many of them identify knowledge gaps that need to be addressed to improve the understanding, management and stewardship of the Columbia Wetlands. This information has been included within this report where appropriate and was used to highlight monitoring and research opportunities.

Several recurring themes emerged through the evaluation of what is currently in the database, and what authors suggested is needed to better understand and manage the Columbia Wetlands. The following list (coarsely grouped, and not prioritized) briefly summarizes the most frequently mentioned and recognized knowledge gaps:

- Water quality data for the wetlands and Upper Columbia River
- Streamflow of the Upper Columbia River and the wetland water regime, including minimum flow requirements for wetland ecosystem maintenance
- Regional groundwater resources
- Implications of climate change to wetland ecosystem function
- Mapped riparian and wetland habitats
- Critical geomorphic and hydrologic processes that drive the presence of riparian habitat, and the causes of its loss
- Aquatic and terrestrial plants, and plants and plant communities at risk in the wetlands
- Status of cottonwood habitat in the wetlands
- Wetland-specific connectivity or habitat fragmentation
- Beaver and muskrat as agents of change
- Fire in the wetlands and its impact on wetland ecosystems
- Freshwater biodiversity
- Implications of the increase of kokanee in the system
- At-risk bird inventory, sensitive or critical habitat, and population status
- At-risk amphibian inventory, sensitive or critical habitat, and population status
- At-risk fish inventory, sensitive or critical habitat, and population status
- Game fish inventories, spawning data and abundance
- The seasonal use of wetland and riparian habitat by bears and other large mammals
- Identification and impact of both aquatic and terrestrial invasive species

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1.0 Introduction

1.1 Overview

This report includes a brief overview of the information currently available in the Columbia Wetlands Stewardship Partners (CWSP) database and a summary of the status of the various components of the wetland ecosystem, including species and habitats of interest, water resources, ecosystem processes and climate change. The discussion then turns to a summary of the current management and action plans related to the previously described components and the identification of knowledge gaps and opportunities.

1.2 Approach

Columbia Wetlands Stewardship Partners was formed in 2006 and now includes representatives from 35 groups, communities, and agencies. The partnership includes federal and provincial agencies concerned with the wetlands, local NGOs with an interest in the river and wetlands, regional First Nations, the tourism and forestry sectors, and communities along the wetlands.

The CWSP has identified a number of objectives, including: maintaining the functional processes that drive the Columbia Wetland system; all the present habitat elements in the system; and the entire range of historically present species in the wetlands and the river system. This resource analysis was undertaken with those objectives front of mind; it summarizes the information currently available on various wetland components, and identifies opportunities for research and monitoring to better manage the Columbia Wetlands and adjacent low elevation landscape. This report is intended to help guide discussions of potential projects that Partners might undertake.

To identify research and monitoring opportunities, the database was initially searched by broad keywords to break the large number of documents into manageable units and identify more- or less-relevant reports and research. The resulting sub-list of reports was reviewed to create summaries of individual abiotic and biotic elements, and identify knowledge gaps for key elements. While there are many topics of interest addressed within the database, not all topics can be considered key to addressing the stated objectives of the Partners. Some issues, such as a lack of consistent water monitoring, impacts of climate change, and key habitats or species, were considered of more relevance than those of peripheral species, or concerns of limited geographical extent. Issues related to dams and their management were also considered outside the scope of this project.

All summaries are based on literature currently within the database. There are many excellent publications in the database that provide recent data and thorough discussions of wetland elements. However, it was clear from the review of documents that while the database is comprehensive, there are wetland-specific resources yet to be included. Although the database now tops 1400 entries, the bibliographies of publications considered important to this report occasionally contained references that had not yet been included. Those documents were reviewed if possible and subsequently entered into

the database. There are also some important topics, such as waterfowl and shorebird survey results, that are still under-represented in the database. Outside references were occasionally checked to provide additional context and up-to-date status when information was lacking within the database. COSEWIC status reports and the BC Conservation Data Centre were the outside sources most often accessed.

The database will be regularly updated and it should be considered a living resource; this review provides a snapshot of what we know from the resources available in 2017. Note that within the list of cited literature, only the author, date, and title of the document are provided. The CWSP database is the true list of references for this report as all documents were involved in the analysis. All bibliographic information can be found within the database.

Numerous management plans, action plans, strategies, and guidelines have been developed for components of the Columbia Wetlands ecosystem or include this region within their scope. Many of them identify knowledge gaps that need to be addressed to improve the understanding, management, and stewardship of the Columbia Wetlands. This information has been included to highlight monitoring and research opportunities. Many studies and reports also contain recommended actions. These have been included where appropriate for informational purposes only; the CWSP is not recommending them as actions for the Partners to undertake. Indeed, this analysis does not include any recommendations for specific projects; its sole intent is to help guide discussions of potential projects that CWSP might undertake to fulfil their mandate.

It should be noted that documents within the database variously refer to the "Upper Columbia Valley" watershed, or the "Upper Columbia Basin." This geographic label is somewhat ambiguous in the literature. Some authors identify the Upper Columbia Basin as the Canadian portion of the larger, international Columbia River Basin. Other authors, primarily Canadian, refer to the Canadian portion as just the "Columbia Basin," and the name "Upper Columbia Basin" is reserved for the headwater reaches of the Columbia River. Within this report, the Upper Columbia Basin or Upper Columbia Valley refer to the headwater reaches of the Columbia River. More specifically, this report limits its focus to the Columbia Wetlands and associated benchlands within the Columbia River Valley from the south end of Columbia Lake to Donald, BC. It includes the floodplain complex along the Columbia River; riparian cottonwood habitats along the levees of the main river, the alluvial fans that protrude into the wetlands; and marshes, fens, and bogs on low elevation benches along the main river floodplain.

1.3 Area of Interest

The Columbia Wetlands are situated within the Columbia River floodplain in the Rocky Mountain Trench between Canal Flats and Donald in south eastern BC. They extend for approximately 180 kilometres and encompass over 26,000 hectares within a long flat valley between the Rocky Mountains to the east and the Purcell Mountains to the west. In this low grade, upstream reach of the Columbia River, the main channel meanders across its floodplain around alluvial fans which have formed at tributary outflows. According to Jamieson and Hennan (1998), these protruding fans have had a damming effect on the river and have led to the creation of the lakes and shallow floodplain areas that constitute the Columbia Wetlands. Numerous marshes, fens, bogs and ponds have formed within the bends of the river or on low benches along the floodplain, creating an almost continuous wetland. Jamieson and Hennan further suggest that "The combination of low river gradient, the flat valley floor and seasonal flooding keeps the water table near the ground surface throughout the summer."

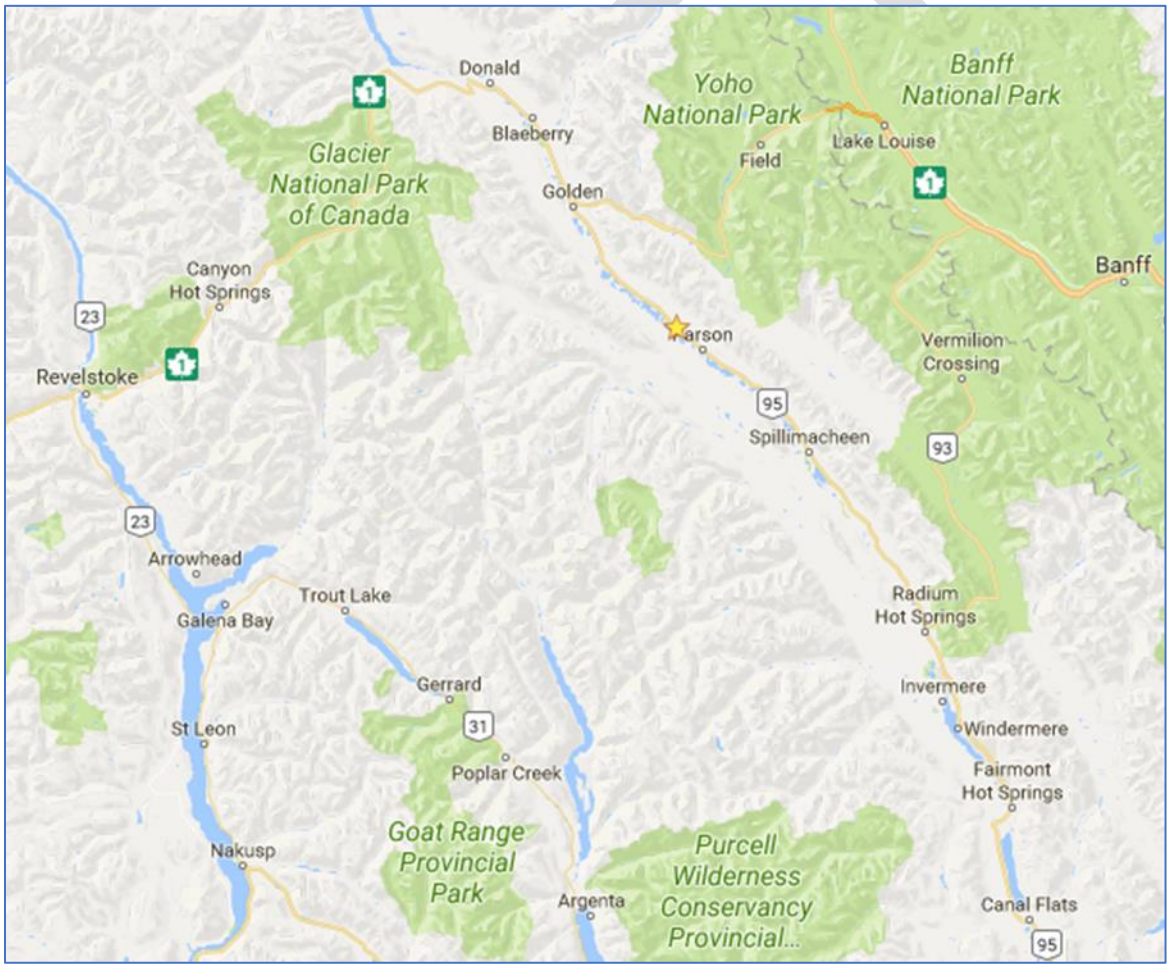

Figure 1. Area of interest. The Columbia Wetlands extend from Canal Flats in the south to Donald, BC in the north.

2.0 Overview of Database

2.1 Summary

It was apparent from the literature review that several topics and species have received significant attention while others have not. Many of the entries in the database are survey or inventory documents related to either fish, forests, or terrestrial/upland priority species. Though these are important to regional ecosystems, many are not directly linked to valley wetlands and were considered less relevant to this specific project. The sheer number of database entries precluded a deep review of those reports. The following list provides a brief analysis of resources in the database:

- Few reports within the database describe the distribution, abundance, or dynamics of different classes of wetlands found within the Columbia Wetlands system. There is a recurring theme throughout the reviewed documents that riparian and wetland habitat types have been inadequately mapped and studied within the Columbia Basin.
- Information regarding aquatic or terrestrial plants and plant communities at risk in the Columbia Wetlands is limited in the database.
- Very few documents within the CWSP database discuss open- or shallow-water vegetation.
- Few documents discuss the status or dynamics of cottonwood habitat in the wetlands, and this was identified as a significant information gap in several reports.
- Research in freshwater biodiversity is generally under-represented.
- Relatively few studies have focused on the geomorphology of the Columbia Wetlands, even though the ongoing geomorphological processes of sediment erosion and deposition are key drivers of the Columbia River system. A few studies examined the role of levees in the wetlands.
- Several documents within the database suggest that we need to develop a better understanding of the critical processes that drive the presence of riparian habitat, and the natural variation of those processes, so that we might understand the causes of its loss.
- The issue of habitat fragmentation is discussed peripherally in reports about habitat and wildlife. There are only a few regionally-relevant or wetland-specific connectivity or habitat fragmentation documents in the database; most of the documents deal with fragmentation in a broader context and within the broader region.
- Several documents within the database refer to fires on forested lands, but very few discuss fire in the Columbia Wetlands and its episodic disturbance to wetland ecosystem functioning. A number of documents include a discussion about the effects of fire suppression on habitats and species.
- Few documents describe the streamflow of the Upper Columbia River or the wetland water regime. Carver (2017) presents the most comprehensive review of water monitoring and water resources within the Columbia Basin, including future projections of river flow. Several reports include expressions of concern regarding the future availability of water under climate change and increased pressure from development.
- Long-term water quantity monitoring has been carried out at only one downstream site within the Columbia Wetlands (Nicholson Bridge), and there is consensus between documents in the CWSP database that there is an inadequate amount of water quantity or quality data for the

wetlands and the headwater reaches of the river. Several documents included discussions of water quality issues relating to either agriculture, industry, or human settlements. By far, most of the documents relating to water quality in the CWSP database refer to Lake Windermere.

- Several authors suggest the need for more research regarding regional groundwater resources.
- A number of reports within the database outline the current understanding of potential climate change impacts within the Columbia Basin. Many more suggest the need to understand how climate change may impact wetland species, habitats, nutrient levels, and channel morphology. The most recent and relevant climate change document is Water Monitoring and Climate Change in the Upper Columbia Basin: Summary of Current Status and Opportunities (Carver 2017). However, that document focuses on the entire Canadian portion of the Columbia River Basin.
- Important and/or at-risk plant and animal species can be found within the Columbia Wetlands and adjacent low elevation lands, but wetland-specific studies are limited in the CWSP database. The potential loss or decline of important wetland species was frequently mentioned in documents about regional biodiversity, but there appeared to be little baseline data upon which to base this prediction.
- There are several dozen regional and bench lake inventories in the database, spanning over 60 years of record keeping; however, they are primarily fish inventory reports. Lake inventories conducted in the past two decades provide more biophysical information and provide valuable baseline data.
- There have been significant changes in the fisheries and nutrient flows in the Upper Columbia River since the construction of a series of dams beginning in the 40s. Sturgeon, burbot and kokanee have been well studied regionally, but several reports suggest a need for more research on the implications of the increase of kokanee in the Columbia River system.
- There is limited data regarding sport and non-sport fish within the wetlands (data is available for bench lakes and tributaries, Columbia Lake and Lake Windermere).
- There are several management plans relating to at-risk bird species in the region, and some birds have been well-studied. There is a stated need for more monitoring and research of habitat and population status.
- Waterfowl and shorebird data is lacking in the database.
- Several amphibians have received attention within the region. Reports in the database suggest an ongoing need for studies regarding the northern leopard frog, western painted turtle and western toad.
- Ungulates appear to have been well studied in the region, especially in the past. There is a long history of elk conservation in the province and a broad range of elk inventory and management documents within the CWSP database. Numerous aerial and ground-based surveys have been conducted for bighorn sheep in the Kootenay Region over the past decades. Very few documents within the CWSP database concern themselves exclusively with deer, especially in the low elevation wetland landscape. A number mention deer peripherally in discussions of aerial surveys of moose, goats, elk or caribou, or in higher elevation winter range. Moose

research is not well represented in the database. Many documents discuss mountain goats and caribou although their typical habitat places them outside the scope of this report.

- No reports within the CWSP database refer solely to cougars, however, cougar are frequently mentioned in documents that discuss wildlife predation. Wolves are also discussed peripherally with regard to their role as predators. There is very little mention of either lynx or bobcat within the CWSP database. Although wolverine have been well studied in the past decade, very little is known about the size of the population of wolverine in BC, and even less is known about wolverine in this region.
- Riparian areas are seasonally important for bears because they provide fresh vegetation, however, most studies of bears within the region focus on sub-alpine and alpine environments, which are outside the scope of this report. Several studies have been conducted on transportation corridors in and around the Columbia River valley bottom, but very few details have emerged regarding their use by bears.
- Badger are well represented in the database. Though numerous and substantial research and recovery actions have been undertaken for badgers in BC, including many in the East Kootenay region, significant knowledge gaps exist.
- Beaver have been implicated as an agent of change in levee breaks on the wetlands, and both beaver and muskrat as agents of vegetation change in riparian areas. Several authors suggest that this is an important topic and there is a need for research in this area.
- Few documents within the CWSP database refer solely to the status or ecology of invertebrates within the region.
- Invasive species have received considerable attention in the past decade. Several year-end reports provide updates on the status of invasive species within the region. The Riparian and Wetlands Action Plan (2014) suggests that while aquatic invasive species have not yet had a major impact on ecological process in the wetlands, terrestrial invasive plants are a concern in adjacent areas. Both aquatic and terrestrial invasive species are an issue in nearby watersheds.

2.2 Summary: Broad Search by Keyword

To identify research and monitoring opportunities, the database was initially searched by broad keywords to categorize more- or less-relevant reports and research. The resulting sub-list of reports was reviewed to create summaries of individual abiotic and biotic elements. The gross number of references paints a very broad picture of available documents. Some are out-dated, and in others the key word is not the primary focus of the study and little detail is available. Secondary searches were conducted under broad categories e.g., "bird," or "fish" to identify species of interest or importance to the wetland ecosystem. Species of interest were selected based on the frequency of occurrence within wetland documents.

Table 1. Summary of Database Resources (as of July 2017)

Broad Category	Initial Key Word Search	Gross Number of References
Ecosystems	Bench	51
	Biodiversity	48
	Cottonwood	11
	Ecology	50
	Ecosystems	74
	Fen	16
	Forest	381
	Grass	73
	Habitat	471
	Marsh	23
	Meadow	6
	Riparian	56
	Shrub	23
	Stream	131
	Wetland	122
Plants	Aquatic vegetation	7
	Emergent vegetation	5
	Endemic	5
	Invasive plants	14
	Open water	15
	Plant communities	21
	Plants	177
	Terrestrial	28
	Trees	113
Species at Risk	Amphibian	25
	Bird	71
	Conservation	217
	Endangered	70
	Fish	71
	Invasive Species	30
	Invertebrates	9
	Mammal	153
	Plant	55
	Predator	7
	Threatened	43
	Ungulate	70

Table 1. Summary of Database Resources cont'

Broad Category	Initial Keyword Search	Gross Number of References
Wildlife	Amphibians	27
	Bears	44
	Birds	141
	Deer	27
	Elk	82
	Fish	344
	Goat	22
	Moose	22
	Vertebrates	43
	Wildlife	280
Data	Data	352
	Data gaps	15
Fragmentation	Dam	116
	Fence	10
	Fragmentation	28
	Railway	12
	Road	157
	Fires	28
Glacier	Glacier	69
	Glacial	10
	Meltwaters	2
Hydrology	Basin	130
	Climate change	52
	Columbia Lake	130
	Hydrology	58
	Instream flows	2
	Lake level	33
	Lake Windermere	62
	Lakes	279
	Peak flows	5
	Watershed	79
Management/Maps	Action plan	82
	Managed	34
	Management	598
	Management Plans	86
	Map	154
	Mapping	55
	Monitoring	184
	Plans	112
	Recovery	118
	Regulatory	6
	Report	531
	Stewardship	58
	Strategy	62
	Survey	305

3.0 Available Information and Status of Component

3.1 Habitats and Processes

3.1.1 Wetlands

Few documents within the database describe the distribution or dynamics of different classes of wetlands found within the Columbia Wetlands system. Regionally specific reports include the Columbia River Wetlands Inventory (Worgan 2004), commissioned by the Columbia Valley Greenways Alliance, which provides an overview of published ecological, jurisdictional, and cultural information relating to the Columbia Wetlands from Invermere to Donald, BC. The Inventory includes base mapping and imagery as well as ecological, cultural, recreational, and jurisdictional inventories. This is a valuable resource although many of the links to sources of information are "stale-dated." Several updated links have been provided in Table 2 within the mapping section of this report.

The Science Committee: Columbia Wetlands Stewardship Partners (2010) provides a short discussion of the most important habitats within the Columbia Wetlands. These habitats include the Columbia River and its channels; major tributary streams; two large lakes (Columbia and Windermere); open water lakes and ponds; fully-flooded or perched marshes, and the range of marshes that fall hydrologically between those two extremes; shrub thickets and sedge meadows; deciduous shrubs and forest communities on levees along main river channels; and mixed forest communities on alluvial fans bordering the river.

The Columbia Basin Riparian and Wetlands Action Plan (FWCP 2014) contains a comprehensive and detailed discussion of wetland and riparian systems in the Upper Columbia Valley, including hydro-related and non-hydro-related impacts and threats, limiting factors (natural and human-caused), trends and knowledge status, implications of climate change, and knowledge gaps. The summary for the Upper Columbia Valley also includes a discussion about types of wetlands in the floodplain complex, bench wetlands, alluvial floodplain cottonwood stands, nutrient inputs to the system, managed wetlands, and the change in floodplain habitats over time. The following is taken in whole from the Riparian and Wetlands Action Plan (2014, including references therein):

Habitat Status: *In general, wetland habitats in this focal area (Upper Columbia Valley) are in good condition, supported by a natural hydrograph.*
Habitat Trends: *The floodplain wetlands along the Columbia River are in close to natural condition. Diking for agriculture is very limited in this system. A photo comparison of historic to recent photographs for the Columbia Wetlands shows little apparent change for the period 1883 to 2011 (Jamieson 2011) in the marsh and river portion of the system. There have been significant natural fluctuations in marsh types and other wetland landforms from the 1940s to present, most showing a loss of emergent marsh and an increase in open water (Carli 2010; Rooney et al. 2013); due to natural processes in this kind of system. Large areas on the alluvial fans that intrude into the wetlands were developed for agriculture and residential development in the early part of the last century. Ecological processes have been*

compromised by settlement, hay field development and by cattle grazing on these sites. There are no data on habitat changes over time in the higher elevation wetlands.
Habitat Connectivity: *Development along the two major lakes in the systems compromise the ability of species such as painted turtles (Chrysemys picta) to move between habitat patches. Habitat mapping and shoreline management processes are being developed for both lakes. There are potential barriers to movement in the communities of Athalmer and Golden, where the aquatic system is restricted to the width of the river by human settlement.*
Species Status: *The area supports almost the entire range of wetland and riparian species that occurred pre-settlement. Only two species are known to have been extirpated: the Columbia River variant of Chinook salmon (Oncorhynchus tshawytscha) and the Northern Leopard frog (Dithionates pipiens). White Sturgeon likely used the system pre-settlement but recent surveys have not located any sturgeon in the Kinbasket River or Upper Columbia River (M. Thomas, pers.comm.). Leopard frogs were re-introduced into the system in 2013 (P. Ohanjanian, pers. comm.).*
Species Trends: *There is some historic Canadian Wildlife Service data for migratory waterfowl, both nesting surveys and fall migration counts; however, data collection methodology has not been consistent (B. Harrison, pers. comm.)…Osprey and Great blue heron numbers have been monitored in the system for several years (Machmer 2007). Amphibians and reptiles were surveyed in a recent basin wide survey (Dulisse and Hausleitner 2010). There are no data on shorebirds and several other guilds and species groups.*

More general, but still relevant, information about wetlands can be found in several reports in the database. Mackenzie and Banner (2001) discuss the challenges of classifying wetlands because of their unique characteristics: wetland and riparian ecosystems are almost always complexes of associated ecosystems (rather than homogenous sites) that act together as single ecological landscape units. They further discuss the value of wetlands and the role of ecologically-based classification in understanding wetland ecosystems and applying ecosystem management principles. Ducks Unlimited also discusses wetlands in a series of factsheets broadly describing the differences – and similarities – between wet meadows, marshes, fens, bogs and swamps (Intermountain Wetland Conservation Program, various N.D.).

Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia (Cox and Cullington 2009) is one of a series of guideline and best management practice documents that provide guidance on the protection and management of ecosystems in BC. The document includes a description of the different types of wetlands found in BC, their status and ecology, and guidelines for economic, recreational, and environmental activities. Wetland Ways was "written primarily for people who are planning some form of activity or development near wetlands, as well as those looking for guidance on ways to best maintain the high ecological values in these areas."

Wetlands in British Columbia: A Primer for Local Governments (Wetland Stewardship Partnership 2010) discusses the types of wetlands found in BC and explains why wetlands are worthy of protection. The

Primer also discusses the ecosystem services provided by wetlands and summarizes their status and trends (at that time).

3.1.2 Wetland Ecological Processes

Jamieson et al. (2009) describe the ecosystem dynamics of the Columbia Wetlands. They suggest that plant and animal species are adapted to a still-natural hydrograph with a spring freshet that plays a critical role in maintaining wetland habitat. They also discuss other factors affecting wetland ecosystem processes. These factors include: fire, beaver (altering levees and water levels), muskrat (altering aquatic vegetation), and variable nutrient cycling because of changes in fisheries over the past half century. Jamieson also suggests that bald eagle populations may be increasing in response to increased food sources in the river due to higher nutrient levels and kokanee carcasses, and that otters, osprey and other fish-eating predators may have also responded to the expansion of kokanee numbers in the Upper Columbia system.

The Columbia Basin Riparian and Wetlands Action Plan (FWCP 2014) also contains an excellent description of basic ecological processes occurring in the Columbia River floodplain complex and driving the productivity of its systems. Productivity is based on "the annual spring freshet, variation in flood intensity, and wetland depth and duration across the flood plain, the turbidity of the water during such events, and the temperature and nutrient status of the sediment and water that flows into the wetlands during such events."

3.1.3 Biodiversity

Appendix B of Taking Nature's Pulse: The Status of Biodiversity in British Columbia (Austin et al. (eds.) 2008) summarizes the state of knowledge (and information gaps) for the major taxa of native terrestrial and freshwater organisms (at that time). An excellent resource, the table lists "major taxa of extant, native, free-living terrestrial and freshwater organisms in BC, with tabular summaries of the availability of up-to-date species checklists, handbooks or systematic monographs, computerized geo-referenced distributional databases, and local (British Columbia) taxonomic/systematic expertise."

The Biodiversity Atlas of British Columbia is designed to serve as a companion document to Taking Nature's Pulse. The Atlas provides a broad overview of the province's range of terrestrial and freshwater biodiversity and brings together data from numerous sources summarized in map form (Austin and Eriksson 2009). Both the Atlas and Taking Nature's Pulse are projects of Biodiversity BC, a partnership of conservation groups and government agencies. The Atlas includes a discussion of the conservation status of major drainage areas in BC, and ranks the Columbia River drainage as "imperilled."

Several technical reports contributed to the final Biodiversity Atlas of BC. Holt (2007) identifies Columbia Wetlands as a "special element" of biodiversity in BC. According to the report, special elements are those elements of biodiversity that "represent a significant aspect of biodiversity in the global or

national context; are not identified elsewhere in the Biodiversity Status Report; and may not be managed adequately using on-going coarse filter strategies."

Gayton (2007) "made an attempt to identify and document the major impacts on biodiversity in British Columbia." Within his report Gayton categorizes and describes thirteen impact categories – most, if not all – of which can be found in the Upper Columbia Valley: urban sprawl; aquatic, terrestrial and atmospheric pollution; fresh water use; waterbody alteration and impoundment; energy use; introduced invasive species; forest harvesting; roads, transmission lines, pipelines, seismic lines; mineral, gravel, oil, coal and gas extraction; agriculture; fire suppression; back country recreation; and fishing and fish farming. An interesting excerpt from Gayton's conclusions:

In researching this Report, the author was struck by the number of existing plans, action plans, accords, frameworks, logic models, agreements and treaties for the preservation of biodiversity. This redundancy in planning (which this Report could be logically accused of as well) speaks to a hesitancy, or an unwillingness, to commit to concrete action to preserve biodiversity. It seems high time to move beyond the planning and background report stage.

Compass Resource Management (2007) continues the conversation regarding impacts to provincial biodiversity by providing an overall summary and assessment of climate change impacts on biodiversity in BC. The report identifies climate stressors and responses in a range of ecosystems and concludes that "climate change – including changes in long-term average conditions, variability or the frequency or severity of extreme events – will affect biodiversity from genes to species to ecosystems."

The Biodiversity Atlas Report Database includes reports from regional agencies including the Fish and Wildlife Compensation Program (from 1983-2011 inclusive), reports from specific projects, and links to peer-reviewed journal abstracts. The website also supports citizen science and it provides several web-based reporting tools, including: Roadkill Reporter, Nest Box Reporter and Wildlife Tree Reporter.

Only one document within the database discussed the *Columbia Basin* Biodiversity Atlas. The Project Phase One Final Report (Osprey Communications 2001) summarized an exercise to assess the need for a regional atlas and provides recommendations for developing it. Further research unearthed more recent documents and the web-based atlas. The Atlas includes data on primarily terrestrial species, with information on some amphibian and aquatic species (especially fish). According to the website, when they choose which species to profile and map, they "most often select species whose survival is in question. The Atlas is an evolving initiative which will change over time, with the addition of more species layers and information."

An Adaptive Science Strategy for the Columbia Wetlands System (Science Committee Columbia Wetlands Stewardship Partners 2010) states that maintaining biodiversity in the wetland system is one of three overarching objectives of the partnership (the others are maintaining system function and maintaining habitat quality). Within that document, the discussion surrounding biodiversity includes a

summary of prior work and objectives for maintaining biodiversity. These include: identifying species at risk and of concern; identifying species that are not listed but may become of concern in the future; identifying long-term monitoring that is required for maintaining species; and maintaining hunted species and species that play an important functional role in the system. A work plan and prioritized list of recommended actions – and the rationale behind those actions – is also included.

3.1.4 Ecosystem Services

The Value of Nature to Canadians Study Taskforce: Federal, Provincial, and Territorial Governments of Canada produced an Ecosystem Services Toolkit (Preston and Raudsepp-Hearne 2017). Within that document they discuss biodiversity as an essential component of ecosystem services, stating that biodiversity underpins ecosystem resilience, integrity and functioning, and that human activity has caused major declines in biodiversity worldwide and significant degradation of ecosystems. The report provides guidance on conducting ecosystem services assessments, assessments that typically "requires biophysical measures and descriptions of the ecosystems and the dynamics involved in the production of ecological services."

Valuing Ecosystem Services in the Columbia River Treaty (Cotter 2016) evaluates Canada's participation in the Columbia River Treaty, suggesting that the parties do not account for the value of ecosystem services in the payments made under the Treaty. Wetlands in British Columbia: A Primer for Local Governments (Wetland Stewardship Partnership 2010) discusses ecosystem services provided by wetlands and summarizes the status and trends of wetland ecosystems in BC. The report lists the following ecosystem services provided by wetlands: ease water shortages and drought; maintain and improve water quality; provide flood control, maintain natural drainage, and prevent soil erosion; provide important habitat for fish and wildlife, including birds; provide recreational, educational, and scientific opportunities; provide agricultural products; and have the potential to mitigate the magnitude and impacts of climate change. The document also includes a summary of the costs associated with damaging wetlands.

3.1.5 Geomorphology

Relatively few studies have focused on the geomorphology of the Columbia Wetlands, even though the ongoing geomorphological processes of sediment erosion and deposition are key drivers of the Columbia River system. Early and ongoing work by Smith (1982) focused on the dynamics of the anastomosing Columbia River between Radium Hot Springs and Golden. Another early study (Sawicki 1991) describes the geomorphology of the Late Pleistocene post-glacial lake, named Glacial Lake Invermere, which filled the Upper Columbia River Valley. Several more recent studies, Makaske (2001), Makaske et al. (2002, 2009); Tabata and Hicken (2003); Abbado et al. (2005); and Lavooi (2010), have also examined the anastomosing nature of the river, studying the river's hydraulic and sedimentary processes.

Within the past decade several scientists have examined the Columbia River and its wetlands in terms of natural levee development (Filguiera-Rivera et al. 2007), and how river connectivity influences water, sediment transport and wetland vegetation (Rooney et al. 2013; Carli and Bayley 2015). Bayley and Galbraith (2007) also discuss levee forming processes and their role in maintaining intact wetland ecosystems.

Jamieson et al. (2009) and Carli and Bayley (2015) discuss the possible role of beaver as modifiers of channel morphology, and agents of change in the loss of marsh and shrub wetlands and an associated increase of open water. Elsewhere, beaver are mentioned only tangentially – primarily as prey species (Lofroth et al. 2007) – although Gebhauer and Huntley (2016) states the need for research regarding the role of beaver in declining cottonwood communities within a broader discussion about potential research in the Columbia National Wildlife Area.

3.1.6 Habitat Fragmentation

The issue of fragmentation is discussed peripherally in numerous reports about habitat and wildlife. Most of the documents deal with fragmentation in a broader context and within the broader region. Several older documents concentrate on species-specific fragmentation or mortality issues, including: the impacts of transportation corridors on bear habitat use patterns (Munro 1999); highway effects on grey wolves (Callaghan 1998); and wildlife mortalities on railways (Wells et al. 1999). More recent studies examined badger roadkill risk (Kinley and Newhouse 2009); carnivore core areas and connectivity (Apps et al. 2007); caribou habitat fragmentation (Apps and McLellan 2005; Serrouya et al. 2006; van Oort et al. 2011), and barriers such as wildlife exclusion fencing (Harper and Morley 2012).

There are a few regionally-relevant or wetland-specific connectivity documents in the database. These include: Fragmentation and Disturbance of the Southern Canadian Yellowstone to Yukon (Y2Y) Wetlands Due to Human Infrastructure (Bayley et al. 2004) and Habitat Linkages for Species at Risk in the Upper Columbia Valley (Adams 2009; 2010). The Bayley study covered a large area within south eastern BC and south-western Alberta, but contained two smaller more-detailed study areas, one of which included the Upper Columbia River Valley from Kinbasket Reservoir in the north to Canal Flats in the south. Mapping identified where wetlands were still intact and could be preserved, and other wetlands with varying levels of linear and cumulative disturbance. The authors discussed several levels of disturbance and concluded that only 0.16 percent of the wetlands in the Columbia Valley had more than four types of disturbances impacting them. The report identified wetlands with the greatest potential for restoration, and identified road/stream crossings, citing the opportunity to repair improperly installed or damaged culverts to improve fish passage at those sites. The authors pointed out that “there are thousands of isolated wetlands that have received little study, and these are widely recognized in other areas for their high habitat value.” Bayley et al. also suggest that since development is not as advanced in this area as in other regions, there are many opportunities to protect wetlands currently considered undisturbed.

Adams (2010) discusses conservation issues and management options for species at risk in Columbia River mainstem reaches and associated wetlands, suggesting that the major issues around connectivity

for aquatic, riparian and wetland species occur at Fairmont and Athalmer where habitat degradation and intensive use most affect these systems.

The Science Committee: Columbia Wetland Stewardship Partners (2010) suggests that "development in the Canal Flats to Edgewater area is limiting options for wildlife to move up and down the river and wetland system and, for terrestrial species, east to west across the valley from the mountain blocks on either side."

Utzig and Holt (2014) make recommendations on identifying and managing for connectivity within the broader region in the context of climate change. They identify north-south along the Rocky Mountain Trench as a key connectivity region, and suggest "increasing the protection and conservation management of riparian and wetland areas as these are known to provide a diversity of habitat types, and provide natural corridors across landscapes at multiple scales."

The issue of dams and their effect on aquatic habitat fragmentation was outside the scope of this project. It is worth noting, however, that several studies discuss the footprint impacts of BC Hydro Dams (Utzig and Schmidt 2011; FWCP 2012). Other documents consider the impact of aquatic habitat fragmentation on individual fish species: Kokanee (Arndt 2009); Rainbow Trout (Arndt 2009); and Whitefish, Westslope Cutthroat Trout, Cottids, Cyprinids and Catostomids (Ladell et al. 2011).

3.1.7 Fire

There are several documents within the database which refer to fires on forested lands, but very few discuss fire in the Columbia Wetlands and its episodic disturbance to wetland ecosystem functioning. Almost forty years ago, Keller (1979) wrote about effects of a controlled burn in the Willmer NWA, and thirty years ago, Demarchi (1987) wrote an article about prescribed burns in the Columbia Marshes.

Several documents discuss fire tangentially as either wildfires or fire suppression relate to the status of species at risk in the region. This is of some relevance as many of these species can be found for at least part of the year in riparian forests or wetlands. Carver (2017) discusses the impact of fire suppression on Basin forests and their increased vulnerability to wildfire. Wildfires can affect hydrologic processes by increasing peak flows, increasing sedimentation and decreasing channel stability.

Daniels et al. (2007) reported on the fire history of the southern Rocky Mountain Trench: 1540-2005, and about mixed-severity fire regimes in the Rocky Mountain Forest District (2006; 2007). Greene et al. (2014) investigated the effects of fire exclusion in the valley bottom of the Rocky Mountain Trench, while Klafki (2005) discussed the restoration of biodiversity lost as a result of fire suppression on the Hoodoo-Hofert property near Fairmont Hot Springs.

In terms of fire in the broader region, the EMBER project (Ecosystem Maintenance Burning Evaluation and Research) was conducted in the 1990s, and Anderson et al. (2006) wrote Blueprint for Action: Fire-

maintained Ecosystem Restoration in BC's Rocky Mountain Trench: Principles, Strategies, Progress. Berg (2005) discussed vegetation change following burning and/or thinning from 1995-2005.

3.2 Plant Communities and Species of Interest

3.2.1 Plant Communities

Information is very limited in the database regarding wetland vegetation in general, and plants and plant communities at risk. Both Ferguson (2004) and Cooper et al. (2004) list several Red- and Blue-listed plant communities in the region, some of which occur or might occur within the Columbia Wetlands and adjacent benchlands. Although their research occurred primarily outside our area of concern, Cooper et al. provide the following details regarding several communities of interest:

- *The Bluebunch wheatgrass / Junegrass plant association is a provincially Red-listed plant community (CDC 2004). In the Rocky Mountain Trench, community occurrences have been reported on the valley floor and lower slopes between Windermere Lake and Canal Flats.*
- *The Douglas-fir, Western Larch – Spruce / Pinegrass plant community is on the Provincial Blue-list (CDC 2004). Within the Trench, large expanses of valley bottom between Golden and the International border and along major tributaries, such as the Kootenay River, St. Mary's River, Wigwam River, and Findley Creek are suitable for this plant community.*
- *The Ponderosa pine – Trembling aspen / Rose [Solomon's seal] is a provincially Red-listed plant community (CDC 2004). The community is found in the southern regions of the Rocky Mountain Trench, between Skookumchuck Creek and the St. Mary's River and between Baynes Lake and Tobacco Plains (Braumandl and Curran 1992). The plant community typically occurs on fine-textured soils in depressional or level sites along the valley bottom.*

The Science Committee: Columbia Wetland Stewardship Partners (2010) mention willow-sedge systems and low elevation reed cedar stands as other provincially listed plant communities that occur in the wetlands.

Several authors mention the loss of cottonwood communities and lack of cottonwood recruitment on river levees within the wetlands. Historical use of the river, beaver, agriculture, development and natural causes have been variously implicated in their decline. Cottonwood communities are listed as a vegetation type of concern in BC and in many other jurisdictions.

While conducting an inventory within the Columbia National Wildlife Area, Dawe et al. (2012) found two potential Red-listed plant communities (Black cottonwood / Red-osier Dogwood / Nootka Rose; Bluebunch Wheatgrass / Junegrass) and two potential Blue-listed plant communities (Swamp Horsetail / Beaked Sedge; Common Cattail Marsh), noting that those required verification.

3.2.2 Plant Species

The Columbia Basin Rare Plant Guide (Nature Conservancy of Canada 2008) includes Red- and Blue-listed native vascular plants at risk that occur in the grasslands and open forests of the Columbia Basin. Although it does not specifically address wetlands or benchlands, the guide includes the area of Columbia Wetlands within its scope, and may therefore be considered of interest to this report. The Species at Risk in BC Field Guide (Environment Canada and Climate Change 2016) also includes information about at-risk plants, some of which occur in the Columbia Wetlands.

Further information about at-risk plant species potentially within the Columbia Wetlands was found in the Species at Risk BC website. The website suggests that there are nine vascular plants at risk in riparian habitats in the East Kootenay Regional District (two are Red-listed: Arrow-leaved Rattlesnake-root and Southern Maidenhair Fern), and there are eleven plants at risk in wetland habitats in the same district, one of which is Red-listed (Pink Water Speedwell). There are 15 vascular plant species at risk in wetland habitats in the Columbia-Shuswap Regional District (five are Red-listed: Long-leaved Pondweed, Bearded Sedge, Joe-pye Weed, Mexican Mosquito-fern, and Hairy Water-clover). Eight at-risk plants can be found in riparian habitats in the same district, one of which is Red-listed (Joe-pye Weed).

Dawe et al. (2012) identified several listed species during their inventory project within the Columbia National Wildlife Area, including: Hooker's Townsendia, Lakeshore Sedge, and Water Marigold.

Southern Maidenhair Fern:

The Southern Maidenhair Fern is provincially Red-listed, and its status in BC is S1 (2015). It is listed as Endangered by COSEWIC (2011). The Southern Maidenhair Fern Recovery Team identified several knowledge gaps relating to the fern, including: additional inventory for other populations of southern maiden-hair fern, or potential suitable habitat; research on reproduction requirements, and longevity, and habitat attributes such as water temperature, substrate type and pH, humidity, etc.; research on species biology, including demography, population trend, and genetics; research on ground water flow and geothermal characteristics of the habitat; and research on translocation methodology.

According to the Recovery Strategy for Southern Maidenhair Fern in Canada (Sadler 2013), abundance and distribution information shows one known extant population in Canada, at Fairmont Hot Springs, about 1000 km north of its main range. The Strategy also states that "Several rare plant species are associated with Southern Maidenhair Fern on the Fairmont Hot Springs property." In 2002, seven provincially rare plant taxa were inventoried at the site: Enander's Sedge (*Carex lenticularis* var. *dolia*), Beaked Spike-rush (*Eleocharis rostellata*), Giant Helleborine (*Epipactis gigantea*), Foxtail Muhly (*Muhlenbergia andina*), Marshy Muhly (*Muhlenbergia glomerata*), Little Bluestem (*Schizachyrium scoparium*), and Pale Bulrush (*Scirpus pallidus*).

3.2.3 Aquatic Vegetation

Floating and submerged vegetation provide critical habitat and other resources to fish, invertebrates, amphibians and birds, but very few documents within the CWSP database discuss open- or shallow-

water vegetation. McPherson et al. (2009; 2010) describe emergent vegetation within Columbia Lake inventory and mapping documents, and used GPS to map the presence of emergent vegetation along the foreshore of the lake. Carli and Bayley (2015) examined vegetation zones in the wetlands to determine the natural range of variation in plant communities.

Floodplain wetlands are dynamic and productive ecosystems, and wetland plants must be able to survive ever-changing conditions. Rooney at al. (2013) investigated the influence of the annual flood pulse on vegetation in the Columbia Wetlands and found four distinct assemblages of floating and submerged aquatic vegetation, each comprised of co-occurring species with similar or complementary adaptations to the direct and indirect effects of flooding.

3.2.4 Grasslands

In 2000, the Grasslands Conservation Council initiated the BC Grasslands Mapping Project – A Conservation Risk Assessment, a four-year effort to map the grasslands of the province and identify priority areas for grasslands conservation and stewardship (Grasslands Conservation Council of British Columbia 2004). The document includes a map of the grasslands within the "East Kootenay Trench" and tables listing species and plant communities found in the region. The discussion includes a summary of current and historical extent, land status, tenure, species at risk and non-native plants. The document outlined additional mapping and data needs, but nothing within this region. Appendices 8 and 10 outline methods for identifying priority grassland areas for conservation emphasis, including riparian areas within grasslands.

3.3 Hydrology

3.3.1 Streamflow

While there is a great deal of information available on peak flows and hydrological regimes across the province and the broader Columbia Basin, within the CWSP database there are very few documents describing the streamflow of the Upper Columbia River, or the hydrology of the Columbia Wetlands. There are currently three active stations providing real-time hydrometric data within the region, Spillimacheen (08NA011), Nicholson (08NA002) and Golden (08NA006).

Reksten (1987) provided peak flow data for the region and provided examples for estimating peak flow in ungauged watersheds. Using climate change models, Hamlet and Lettenmaier (1999) evaluated the effects of climate change on hydrology in the Columbia River Basin and estimated that "by 2045 the reduced snowpack and earlier snow melt, coupled with higher evapotranspiration in early summer, would lead to earlier spring peak flows and reduced runoff volumes from April-September ranging from about 75 percent to 90 percent of the base case."

Streamflow in the Kootenay Region (Obedkoff 2002) summarizes regional streamflow data including annual runoff, low flows, and peak flows. A more recent (and more regionally-specific) study estimated future flow, including extremes, of the Columbia River headwaters (Burger et al. 2011). Their predictions

include a shift of the hydrograph “toward a more rain-fed regime, with peak flows occurring in June instead of July.” Their results indicate that “Annual peak flow is projected to not increase, and August low flow decreases in all four models.” They also suggest that glacial melt has a negligible effect on peak flow.

Gobena et al. (2013) analysed the relationships between large-scale climate models and streamflow for the Columbia and Kootenay basins where BC Hydro operates. The primary objective of the study was to identify climate patterns that might be useful for forecasting water supply.

Brahney et al. (2016) discuss the potential for climate change to influence both the volume and timing of streamflow in the snowmelt-dominated tributaries of the Columbia River. Although nothing regionally-specific was highlighted within the document, they evaluated the relationship between climate indices and changing streamflow and concluded that climate change may be altering the historical relationship between climate indices and streamflow in the Canadian portion of the Columbia Basin. This change in the relationship is of concern because regional planners often use climate indices and historical relationships to predict annual or seasonal streamflow. They also suggest that streamflow and climate data records for the Canadian portion of the Columbia Basin indicate that annual stream flows have decreased since 1980. When comparing average annual streamflow for the cool Pacific Decadal Oscillation (PDO) phase which occurred from 1947 to 1976, to the more recent cool phase from 1999 to 2011, they found an eleven percent decline across the Canadian portion of the basin.

Carver (2017) presents the most comprehensive review of water monitoring and water resources within the Columbia Basin, including future projections of river flow. Predictions for the Basin include: Spring runoff to occur earlier in the year; the size and frequency of peak spring flows to increase; and lower low flows expected in late summer and early fall. Carver does not, however, specifically focus on the portion of our watershed that provides the flood pulse for the Columbia Wetlands, nor does he provide any predictions of hydrologic impacts to the wetlands.

Both Carver (2017) and Brahney (2014) suggest that groundwater resources in the basin are poorly understood due to a lack of mapping, monitoring and analysis. Little is known about regional aquifers, their sources, and their potential yields. This is of some consequence as groundwater may become a more valuable resource if surface water supply becomes limited due to lower seasonal flows, or poor quality.

3.3.2 Glaciers

Very little information is available on the status of glaciers and their contribution to wetland hydrology within the area of interest for this report. Carver (2017) notes that even though “glaciers contribute far less to annual runoff than does snowpack, where they occur, their late summer melt provides critical support to annual stream low flows and influences water quality by reducing stream temperatures and increasing turbidity.”

Jost et al. (2012) quantified the contribution of glacier runoff to streamflow in the Upper Columbia River Basin (which is this instance refers to the Canadian portion of the Columbia Basin). They concluded that glacier ice melt contributes up to 25 percent and 35 percent of streamflow in August and September, respectively, while the mean annual contribution of ice melt to total streamflow varied between three and nine percent.

Burger et al. (2011) suggest that the climate-induced predicted shift of the hydrologic regime is independent of glacier dynamics. They also discuss the role (and fate) of glaciers in the medium-term, concluding that, except for the late summer months, glacier melt contributes only marginally to the mean flow, and this is not likely to change in the future. They estimate a moderate glacier recession of about 10 percent for the 2050s. They further suggest that "glaciers will almost certainly still contribute to late summer flow and may in the meantime even increasingly do so because of intensified melting from the higher temperatures."

Brahney (2014) states that snow accumulation and glaciers are important contributors to the timing and volume of stream discharge in the (Canadian) Columbia Basin, and suggests that monitoring of the snowpack is reasonably well covered at lower elevations, but is "spotty" beyond 2000 meters above mean sea level. Snowfall at these elevations is important for glacial accumulation, and it is important to measure snowfall to predict the future contributions of glaciers to discharge. Brahney also states that "Data on glacial mass is almost completely absent." Inferences made from observed late season stream discharges suggest that for many streams in the Columbia Basin Trust area, the contributions of glacial melt to stream flow has peaked and is declining. Expanding the high elevation snowpack monitoring and conducting more detailed investigations into the changes in glacial mass and behavior will help to more accurately forecast changes in stream discharge.

Carver (2017) discusses glaciers and snow within his report on water monitoring and climate change in the Canadian Columbia Basin, and highlights current trends:

- Between 1950 and 2005, average snowpack declined by five to six percent
- Less snow is falling and accumulating at low elevations, and snowpack is disappearing earlier in spring
- As of 2013, glaciers covered 2.06 percent of the basin, down from 2.67 percent in 1985

Carver states that as a result of recent warming, glaciers are diminishing throughout the Basin with glacial area down 16 percent from 1986 – 2005, outpacing BC's overall rate of decline of eleven percent. Glaciers in the southern Basin are smaller and losing their extent faster than those in the north, and Carver further states that "some scientists are projecting a total loss of the Basin's glaciers by 2100." Carver also notes the lack of long-term glacial mass balance data, suggesting that it limits understanding of glacial decline and corresponding implications for Basin hydrology. Carver referred to the Columbia Basin Snow and Glacier Research Network formed in 2014 to "advance understanding of the Basin's glaciers, including their contribution to Basin water resources, but no further information could be found regarding their work.

3.3.3 Water Quality

Long-term water quality monitoring has been carried out at only one downstream site within the Columbia Wetlands (Nicholson Bridge), and there is consensus between documents in the CWSP database that there is an inadequate amount of water quality data for the wetlands and upstream reaches of the river.

After inventorying water quality and quantity data, Brahney (2014) commented that water quality data is less complete than the quantity data in the Columbia Basin in general, and recommended expanding the network of water quantity measurement stations, increasing the number of people trained to collect water quality samples, and supporting them to do so. Brahney further commented that there is limited data available to develop a comprehensive understanding of the changes that the dams have had on water quality and aquatic ecology. "Beyond the impoundments, there is almost no information on the natural aquatic habitats in the region, particularly in the headwater regions where changes can have cascading ecological effects downstream. Going forward, continuing and expanding monitoring efforts and data warehousing will be necessary to monitor the continuing evolution of the system, and to detect and as appropriate mitigate the effects of a changing climate."

By far, most of the documents relating to water quality in the CWSP database refer to Lake Windermere. The Lake Windermere Ambassadors community-based water quality monitoring program started in 2011 as an extension of the Lake Windermere Project (2005 – 2010). Water quality is measured at three sites on Lake Windermere, and bacteria levels are measured at three public beaches. Following recommendations set out by the BC Ministry of the Environment, the Ambassadors measure: water temperature; dissolved oxygen; conductivity; pH levels; turbidity and water clarity; and nutrients (phosphorus and nitrogen).

Lake Windermere 2015 Water Quality Monitoring Results (Peloso 2016) presents water quality data from 2015. The author reports that "Lake Windermere met objectives for temperature, dissolved oxygen, and turbidity throughout the summer. This means the water was clear, cool, and well oxygenated: all in line with historic levels. Beach monitoring results show that shoreline bacteria levels did not exceed the recommended guidelines for safe swimming on any of Lake Windermere's public beaches over the summer." Peloso notes however, that total phosphorus levels at ice-off exceeded the objective for the lake at two sampling stations in 2015, and a slight increasing trend in this nutrient has been observed in the lake in recent years. The author suggested that this warranted continued monitoring in conjunction with efforts on land to keep excess nutrients out of the lake. No invasive aquatic plant species were found in Lake Windermere in 2015, and no invasive mussels were detected through veliger sampling. The final report for the Lake Windermere Project (Leschied 2011) is available within the CWSP database, as is Water Quality Assessment and Objectives for Windermere Lake: Overview Report 1st Update (Neufeld et al. 2010).

Several additional studies refer to Lake Windermere. McDonald (2000) examined a sediment core from Windermere Lake and data suggest that water quality began to change around 1950, concurrent with population growth, and there is some evidence of slight eutrophication coupled with a change in composition of the phytoplankton community. In 2002/2003, a study was undertaken near the headwaters of the Columbia River to provide an overview of water quality in this area (Neufeld and Raggett 2010). Masse and Miller Consulting conducted a "review, summarization and consolidation of existing water quality literature on Lake Windermere," and provided the Regional District of East Kootenay with recommendations for future sampling (Masse and McGregor 2005).

Several studies of regional water quality were conducted for the BC Ministry of Environment in the late 70s. Rocchini et al. (1976), and Rocchini (1981) discuss water quality in the Upper Columbia Basin in Kootenay Air and Water Quality Study, Phase 1 and Phase 2 reports.

Water quality monitoring has been conducted on several creeks within the Columbia Wetlands area. Westcott et al. (2000) reported on the physical, chemical and biological characteristics of Windermere Creek, concluding: "The data from this monitoring program suggests that in general, water quality is fair, with bacteria levels exceeding Drinking Water requirements. Sediment and metal concentrations may have impacts on the aquatic life in Windermere Creek. Water quality clearly degrades along the length of the creek."

McPherson et al. (2014) examined water quality in Windermere Creek from 2009 to 2012. The only issues noted were turbidity and sedimentation, and the authors recommended developing prescriptions to stabilize eroding creek banks. In another study, Lotic Environmental (2014) investigated the health of three tributaries located in the Upper Columbia watershed: Horse Creek, Ventego Creek and Hospital Creek. This study determined that there was variability in the condition of the three tributaries over the monitoring period.

Golder Associates (2014) reviewed groundwater quality at five municipal wells and developed a groundwater monitoring plan for the Town of Golden. The report provided several recommendations, and according to the report, Golden has completed several measures to improve the security of its municipal supply. Golder (2014) also developed a Municipal Water Supply Contingency Plan for the town in the event of groundwater contamination or spills that pose a risk to the municipal water supply.

Carver (2017) provides a broad overview of water quality monitoring efforts and data providers within the Columbia Basin. Figure 14, p36, identifies the location of water quality monitoring sites within the Basin established by agencies and regulated industry. Carver suggests that many sites have been discontinued, but "the historic data are substantial." There is a noticeable lack of information, however, about water quality monitoring in the upstream reaches of the Columbia River and within the Columbia Wetlands outside of that carried out in Lake Windermere and Columbia Lake, and Carver states that understanding of the water quality of the Basin's wetlands "remains limited by the absence of long-term monitoring efforts." Carver does state that water quality in the tributaries of the Columbia River is highly

variable and is influenced the characteristics of the tributary and surrounding land uses. He also discusses how fire suppression can lead to high fuel loads in forests which can then result in significant hydrologic impact as wildfires burn through a region, and includes comments on the potential impact of forestry on water quality via increased sedimentation and damage to aquatic habitats, and increased temperatures caused by the removal of forest vegetation.

Carver also notes that there is little or no published data on water quality directly associated with snowpack and glaciers.

3.3.4 Columbia Lake

Columbia Lake is well represented in the CWSP database. In the late 1970s a study was conducted to evaluate environmental factors and land use in an area designated as Columbia-Windermere Lakes, bounded to the east and west by height of land within the Rocky Mountain Trench, to the north by Edgewater and to the south by Canal Flats (ELUC Secretariat 1978). Sellars (1990) conducted a floodplain mapping program for the Kootenay River at Canal Flats and Columbia Lake within which he delineated the 200-year floodplain, and the estimated normal and 200-year still water levels of Columbia Lake.

A number of studies were conducted in the late 1990s, including several designed to support management strategies. Urban Systems (1997) assessed the (then) current condition of the lake and its foreshore, and provided management recommendations. Marcoux et al. (1998) conducted 1:20,000 Terrestrial Ecosystem Mapping in the East Columbia Lake area. The report included a wildlife habitat management treatment overlay; dominant and/or diagnostic plant species listed by ecosystem and structural stage; ungulate forage listed by ecosystem unit and structural stage; and the suitability and capability of each ecosystem unit to support ungulates, bear and Red and Blue-listed species feeding and reproductive activities.

Allen (2002) developed a strategic plan to “improve the productivity and health of fire-maintained forests and rangelands by restoring stand structure and species.” This report covers the East Columbia Lake Wildlife Management Area from Canal Flats in the south to Fairmont Hot Springs in the north, and from the foreshore of Columbia Lake in the west to the height of land in the east. A Columbia Lake Ecological Reserve Management Direction Statement (BC Ministry of Water, Land and Air Protection 2004) was developed to “provide strategic management direction for protected areas that do not have a full management plan.”

McPherson et al. (2009) completed a foreshore inventory and mapping study on Columbia Lake, which included field survey and literature review. They identified that “the foreshore (and adjacent upland areas) of Columbia Lake is biologically diverse and important to numerous plant, fish and wildlife species. Several sensitive species have been reported to inhabit or potentially inhabit the area....” This study was followed by Columbia Lake Sensitive Habitat Inventory and Mapping (McPherson et al. 2010). Information was collected to aid decision makers overseeing foreshore and upland developments. The report was also intended to serve as a benchmark by documenting land use and

changes in riparian habitat. Inventory results and discussion are provided for both biotic and abiotic features. Recommendations for future actions are also included within the document, including: conducting species and habitats inventories, addressing modifications, developing a foreshore protection plan, conducting monitoring and further educating the community. Management Guidelines for the Shoreline of Columbia Lake (McPherson and Hlushak 2010) were developed using the technical results of the Sensitive Habitat Inventory and Mapping report.

Tipper (2015) assessed the impacts of recreation and recreational infrastructure upon the conservation values of Columbia Lake Provincial Park at Warspite Creek. Their biological surveys confirmed that species at risk use the park, that the study area possess the attributes to support other species at risk, that at least one rare plant is well represented, and that some diverse and productive plant communities appear to be on an upward trend in ecological condition. They also suggest that human activity has negatively impacted the conservation values of the study area.

3.3.5 Lake Windermere

In the late 1970s a study was conducted to evaluate environmental factors and land use in an area designated as Columbia-Windermere Lakes, bounded to the east and west by height of land within the Rocky Mountain Trench, to the north by Edgewater and to the south by Canal Flats (ELUC Secretariat 1978).

A Management Direction Statement for James Chabot Provincial Park (Stetski 2004) was developed to "provide strategic management direction for protected areas that do not have a full management plan." According to the authors, the park was designated "to allow for public day use access to the shores and beachfront of Lake Windermere, as well as to create opportunities for nature appreciation in a foreshore and wetland habitat. Furthermore, the park provides a seasonal refuge to many avian, vertebrate, and invertebrate species, some of which are rare or endangered." An appendix to the plan contains a list of Red- and Blue-listed species potentially occurring within the park.

McPherson and Michel (2007) conducted an inventory and mapping project for Lake Windermere. The objective of the inventory was to provide an overview of lake foreshore habitats, and data was collected on land use, riparian condition, foreshore morphology, and anthropogenic alterations. The report includes recommended actions including, among other things, the need to develop a foreshore protection plan; determine carrying capacity; identify critical areas for protection, restoration and enhancement; conduct additional inventories to determine sensitive species and habitats; protect critical and natural areas; and monitor habitat losses and gains to measure success.

The Windermere Lake Foreshore Fish and Wildlife Habitat Assessment (McPherson and Hlushak 2008) was conducted to gather information about important fish and wildlife habitats along the lake shore. The goal of the assessment was to support shoreline management guidelines using scientifically based rankings and identification of Zones of Sensitivity. Fish, bird, wildlife habitat/occurrence and aquatic

invertebrate presence/absence data was collected in the field, and was augmented with a literature review. Detailed appendices include tables, site descriptions, species summaries, and maps. Windermere Lake Shoreline Management Guidelines for Fish and Wildlife Habitats (McPherson et al. 2009) were developed using the technical results of shoreline assessments and fish and wildlife assessment reports.

The Lake Windermere Management Plan (Berris 2011) contains information on the biophysical and social characteristics of Lake Windermere and its surroundings. According to the author, the plan was initiated by the Regional District of East Kootenay in 2008 to address lake-related issues following the adoption of the Lake Windermere Official Community Plan (Board of the Regional District of East Kootenay 2008; 2015). The document provides numerous recommendations and identifies guidelines for foreshore development and enhancement, lake use, boating, winter use, public access, upland use, and environmental quality.

In 2011/2012, the Lake Windermere Ambassadors worked in collaboration with the District of Invermere to develop and implement the Kinsmen Beach Restoration Project, a restoration plan to stabilize the eroding bank and re-vegetate the lake shoreline (Lake Windermere Ambassadors 2012).

Darvill (2015) discusses the results of a multi-year project where aquatic plants were sampled along the Lake Windermere shoreline. According to the author, the major goal for Lake Windermere's Aquatic Invasive Species (AIS) program is to conduct on-going inventories to determine the presence/absence for AIS in the ecosystem, allowing for a rapid response for any detected AIS. In 2015 the program expanded to include sampling from a boat at offshore locations, and included veliger sampling for invasive mussels (quagga and zebra). In 2015 the provincial government also began sampling for invasive mussels on Lake Windermere.

3.3.6 Climate Change

Environment Canada has or has had climate stations at several locations throughout the Upper Columbia Valley including the wetlands and adjacent uplands. Though the records are not currently available within our database, it should be noted that the stations include: Spillimacheen (#1367), Brisco (#1343), Golden (#A 1355; #Airport 6597), Donald (#1347), Invermere (#1201), Windermere (#1227), and Canal Flats (#1182)). Records are discontinuous at some stations.

A number of reports within the database outline the current understanding of potential climate change impacts within the Columbia Basin. Two early reports discuss the effects of climate change on hydrology and water resource objectives in the Columbia Basin (Hamlet and Lettenmaier 1999) and on freshwater fish resources in BC (Tyedmers and Ward 2001).

The Columbia Basin Trust published several documents (ND; 2012) about impacts and adaptation to climate change in the Basin, including, among other thing, the need to "Increase riparian reserves to retain low water temperatures and quality fisheries habitats." Burger et al. (2011) discussed streamflow

projections, including extremes for the 2050s for the Columbia River headwaters above Donald BC. Murdock and Werner (2011) and Murdock and Obie (2013) discussed climate trends and projections, and provided a preliminary assessment of climate extremes in the Basin; and Greene et al. (2014) discussed resilience of forests and grasslands to future environmental change.

Major Impacts: Climate Change (Compass Resource Management 2007) outlined broad data gaps in biodiversity management in relation to climate change. Data gaps were identified, and the report concluded that "It appears that there has been much more consideration of potential climate change impacts in the terrestrial realm than in the freshwater (notwithstanding all of the attention on salmon). This implies that a general increase in the freshwater realm is in order."

In terms of more regionally specific studies, Utzig and Holt (2014) identified appropriate land use zoning to "contribute to biological conservation goals in the face of climate change." Two regional landscapes were included within the larger project; Windermere-Columbia Lakes, and Horsethief-Skookumchuck Creeks.

For this report, the most relevant Climate Change document is Water Monitoring and Climate Change in the Upper Columbia Basin: Summary of Current Status and Opportunities (Carver 2017). This study identifies both regional and local opportunities to strengthen understanding and stewardship of Basin water resources in a changing climate. The report suggests that within the Basin "the current network of stations monitoring water quantity represent only a small fraction of the sites that could be monitored to provide a well-rounded understanding of water quantity," and it identifies the need for developing a long-term backbone monitoring network to provide consistent baseline information across all hydrologic regions, land attributes and climates in the Basin.

Carver suggests that climate change threatens wetland longevity through accelerated evaporation and potential reduction of inflows. The report identifies water monitoring and research opportunities specific to the wetlands, including: improving the tracking of changes to wetlands and natural lake levels; and enhancing groundwater mapping, monitoring and analysis. In terms of water quality, Carver suggests that under projected climates, water quality concerns are expected to accelerate, adding that many of the water quality effects will be an indirect by-product of changing hydrology.

Harrison (2010) suggests that "The expected effects of climate change on hydrological resources paint a mostly negative picture for wetlands: predicted changes in temperature and precipitation will generally increase wetland outputs (e.g. via evaporation and evapotranspiration), decrease inputs (e.g. via reduced streamflow and snowpack/glacial recharge of wetlands) and alter hydrologic cycles (e.g. earlier spring runoff)." Harrison also suggests that wetlands will decline in area and number, and small, shallow and temporary wetlands at low elevations will dry the most. In addition to the drying trend, wetlands are also expected to change their thermal and chemical characters (e.g. become eutrophic due to an increase in primary productivity) and become ice-free earlier, and most wetland-dependent species will shift in range and abundance.

3.4 Animal Species of Interest or Importance

Studies of wetland specific at-risk species are somewhat limited within the CWSP database. Several reports discuss individual species within the broader context of species at risk in BC, the Canadian portion of the Columbia Basin, or the Upper Columbia Valley. Individual species are also well described in associated management and recovery plans. There are, however, several listed and non-listed species which may be considered important within the Columbia Wetlands and adjacent low elevation landscape. Those species considered of interest or importance are described below.

3.4.1 Fish

Bench lake and tributary reports:

Several dozen bench lake and creek inventory documents can be found in the CWSP database, spanning over 60 years of record keeping. Variously identified as "Fisheries Investigation," "Partial Reconnaissance Survey," "Reconnaissance Survey," or "Kootenay Fisheries Field reports," the intent and contents of the reports changed little throughout the 50s, 60s, and 70s. The overall objective of the inventories was to detail the presence of fish species, the location and bathymetric profile of the lake, and basic chemical characteristics. Chudyk (1971) may be considered a typical example of this type of report.

In the following decades, the reports expanded to include more information: Larsen and Cole (1992) and Griffiths (1994) provide good examples of these reports. These more-detailed inventories are valuable because they provide baseline data that either has been, or can be compared to subsequent surveys. The newer reports include some or all of the following information:

- The presence, relative abundance, and distribution of all fish species (both native and introduced stocks) in the study lakes and major tributaries to these lakes.
- The location, description, and photographic documentation of habitats, both within the lake and major tributaries (including inlet and outlet tributaries), that are important to the life history stages of resident fish.
- A bathymetric profile of the lake (where required). A description of the basic chemical characteristics of each lake.
- A professional assessment of the quality of existing fisheries in the lakes based on their physical, biological, chemical, and use characteristics.
- A professional assessment of existing fisheries management practices for the individual lakes within the study area, and a detailed description of any viable optional management strategies which could be implemented to create additional fishing opportunities.
- A professional assessment of enhancement or management methods which could be used to create additional fish habitat, fish populations, and/or fishing opportunities in selected lakes.
- The identification of specific fish stocks that may be detrimentally impacted by enhancement activities directed at target species.

The nature of the documents that relate to fish undergoes a change after the year 2000. In the late 90s and early 2000s, inventory and assessment shifts to creeks and reservoirs, and a great deal of attention was focused on key species and locations.

Focal and Sport Fish:
The Columbia Basin Species of Interest Action Plan (FCWP 2012) identified regional "focal species" which are considered a conservation concern, and have been impacted by dam construction or operation. Burbot, kokanee, bull trout, westslope cutthroat trout, and rainbow trout have all been identified as focal species within that document. Some of these are also regionally important sport fish, and have received attention from the provincial government. For this reason, they have been included within this report.

Burbot:
Columbia Lake Burbot were studied as part of the Upper Columbia Burbot Project (Arndt 2002). The study included six years of spawner enumeration at a tributary, tracking of post-spawning movement, surveys of juvenile abundance and habitat use, and estimates of angler harvest.

Due to concerns over declining burbot populations in the Kootenay Region, a study was initiated by the BC Ministry of Environment to provide better information on which to base regulations. Prince (2007) reported on the study to assess the abundance and biological characteristics of burbot populations in four East Kootenay Lakes: Moyie, St. Mary, Columbia and Windermere. The study concluded that "low relative abundance and poor condition of Columbia, Windermere, and St. Mary Lake burbot populations support severely restricted harvest regulations and the need for continued investigation of limiting factors affecting burbot growth and survival in these lakes."

There are several other documents in the database associated with early studies of burbot in Columbia Lake, including: Tagged Burbot Recaptured after Six Years Shows Slow Growth Rate in Columbia Lake (Arndt 2006), and Columbia Lake Burbot Population Estimate Program, Canal Flats, BC (Bissett et al. 2002).

The East Kootenay Integrated Lake Management Partnership commissioned a project that included the Columbia Lake Foreshore Inventory and Mapping study (McPherson et al. 2010). Within that study, Zones of Sensitivity were determined to be burbot spawning and rearing areas, kokanee staging/rearing areas, and areas of biological significance for wildlife. McPherson states that burbot has experienced significant declines in the Columbia System including Columbia Lake, and as a result, burbot are considered a species of regional concern in the Columbia River System.

McArthur et al. (2010) examined the impact of planned generation station shutdowns on fishes downstream of the Spillimacheen Generating Station. Target fish species were burbot and mountain whitefish. The study concluded that "the rates of change of the measured parameters were such that no adverse effect on fishes or fish habitat could be observed."

Burbot have been studied more recently as part of a three-year monitoring study of their life history and habitat use in Kinbasket Reservoir. A discussion of Kinbasket Reservoir is outside the scope of this report, however, Warnock et al. (2014) discuss the historical distribution of burbot within the Upper Columbia, and the impact of Mica Dam and the creation of Kinbasket on habitat connectivity. Kang et al. (2015) addresses some management questions regarding burbot populations in Kinbasket Reservoir.

Westslope Cutthroat Trout:
Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) is provincially Blue-listed and its status in BC is S3 (2004). In 2016, it was designated as a Species of Special Concern by COSEWIC. Westslope Cutthroat Trout was identified as a priority native sport fish species by the BC Freshwater Fisheries Program in need of a provincial fisheries management plan. A management plan was developed in 2013 and updated in 2014. The plan suggests that "Westslope Cutthroat Trout arguably supports the most popular fisheries for native species in the southeast area of the province. In the past, liberal fishing regulations, in combination with other factors such as habitat degradation, have resulted in significant declines for at least some populations."

The management plan outlines management objectives, including: maintaining the native distribution and genetic diversity of populations; maintaining wild populations at abundance levels that prevent at-risk status assessment so that the populations can provide sustainable societal benefits; maintaining, or rehabilitating, the capacity of natural habitat to meet abundance targets for populations; and optimizing sustainable recreational benefits. The plan also identifies threats to the population group within this broad region (Columbia), including: negative interactions with introduced salmonids; altered flow regimes from both non- consumptive and consumptive water use; road crossings that affect fish passage; and forestry-related riparian clearing and alteration, water quality issues (especially sedimentation), and culvert crossings that affect fish passage. (The plan identifies the need for more information regarding the impacts of fish road and culvert crossings on fish passage.) It should be noted that this region is considered "peripheral range" for this species, as compared to "core range," reflecting the extent to which native populations occur in this area. Peripheral range contains disjunct, sparsely distributed populations considered more in the periphery of the native range.

Rainbow Trout:
Footprint Impacts of BC Hydro Dams on Rainbow Trout in the Columbia River Basin, British Columbia (Arndt 2009) includes status of rainbow trout per dam unit, including Columbia Lake to Donald Station (Dam Unit C1). Arndt (and references therein) suggest that "Rainbow trout are present up to the headwaters including Columbia and Windermere lakes and the in the Columbia River between them. Tributaries in this unit that provide rearing habitat for rainbow trout include Dutch Creek (Hagen 1993), the Spillimacheen River below the dam (Edeburn 2001), Kicking Horse River, Horsethief Creek, and Frances Creek. The wetland areas of the Columbia River downstream of Columbia Lake likely provide only marginal habitat for juvenile and adult rainbow trout during the growing season due to shallow depth and warmer summer temperatures. Productivity and habitat suitability of the Columbia River and

some of the tributaries in this reach may also be limited by high glacial turbidity at other times of the year (Ahrens and Korman 2004)."

The report further states that "trout from Kinbasket Reservoir spawn in tributaries within this unit. Little information is available for these fish, but given the highly glacial nature and cold temperature of most of the tributaries that empty directly into the reservoir downstream in [Dam] unit C3, it is conceivable that Columbia River tributaries in unit C1 may provide a high proportion of the usable spawning and juvenile rearing habitat for these fish. An estimated 0.2 to 0.6 million kokanee from Kinbasket reservoir spawn in several tributaries in unit C1, as well as in limited sections of the Columbia River mainstem (Oliver 1995, Arndt 2009)."

Bull Trout:
Bull Trout (*Salvelinus confluentus*) is provincially Blue-listed and its status in BC is S3S4 (Aug 2011). In 2012, it was designated as a Species of Special Concern by COSEWIC. According to Weaver (2013), bull trout are vulnerable to a wide range of human disturbances because of their slow growth rate, late age at maturity, low fecundity, longevity, and high catchability. Weaver also suggests that bull trout will likely be vulnerable to several manifestations of climate change; "They have a demanding cold-water niche – especially for spawning and rearing – and low resistance to warming water."

When reporting on the impact of dam construction on bull trout, Hagen (2008, and references therein) state that "migratory bull trout populations have been identified in accessible reaches of the Dutch, Toby, and Horsethief Creek systems (Fielden et al. 1993), and in the lower Blaeberry River (Triton 1991). Bull trout are known to utilize the mainstem of the Columbia River and Windermere Lake (Westslope Fisheries 2001). Hagen also states that "Habitats utilized by bull trout in reach [Dam Unit] C1 are located upstream of the extent of flooding from Kinbasket Reservoir, and negative footprint impacts to their productive capacity are therefore not likely to have occurred. In contrast, seasonal abundance of kokanee adults and juveniles (Arndt 2008) probably represent an enhancement of the reach's productive capacity for fluvial bull trout populations, and for adfluvial bull trout utilizing Lake Windermere."

Mountain Whitefish:
In a dam impact review document, Ladell et al. (2011), reported that mountain whitefish (*Prosopium williamsoni*) occur in virtually every major reach of the Columbia and Kootenay rivers, and in many of the tributaries to these systems as well. They can be found both above and below natural barriers, and are highly adapted to the cold and turbid water that is found throughout the region. Adults live in both lakes and a wide variety of streams and rivers. Ladell et al. noted that there is little conservation concern for this species; it is not listed by either COSEWIC or the BCCDC; however, in BC, it is a locally important recreational species.

Adams (2009) identifies bull trout, westslope cutthroat trout, and chiselmouth (*Acrocheilus alutaceus*) as riverine species at risk known to occur or potentially occur in the Upper Columbia Valley. Chiselmouth is

Blue-listed in BC and its provincial status is S3S4 (May 2010). Radridge (1998) conducted a study to confirm historical reports of chiselmouth presence in Windermere Lake. No chiselmouth adults or juveniles were captured or observed at the 19 sites sampled in the study. The author suggests that the original report of their presence was based on misidentification.

Kokanee:
Kokanee is a species of interest in this region. According to the Riparian and Wetlands Action Plan (2014, and references therein), "Kokanee salmon (*Oncorhynchus nerka*), have expanded substantially in the system following the development of the Mica Dam. It is likely that the entire range of species that prey on kokanee as a food source have increased over time."

In 1995, 71 streams, including mainstem Columbia River sites, were observed during a kokanee spawner distribution survey (Oliver 1995). According to Oliver, since the introduction of kokanee into Kinbasket Reservoir in the early 1980s, the spawning population has become widely distributed in tributary streams throughout the Columbia Basin. Of the 71 sites surveyed, 18 key tributary or mainstem sites were identified with 1000 or more kokanee spawners present. Oliver stated that "without question, the two areas with the greatest concentrations of fish included the mainstem Columbia River at Fairmont, and the Wood River with estimates reaching 250,000 and between 200,000 and 300, 000 respectively." Oliver describes the presence of kokanee at many other locations within the report.

In 2008, the BC Ministry of Environment and BC Hydro began a 12-year study to monitor kokanee in two Columbia Basin reservoirs, Kinbasket and Revelstoke. The CWSP database includes annual reports of this study, including Sebastian and Weir (2015), which summarizes the results of the latest (seventh) year of this long-term project.

Arndt (2009) reviewed kokanee distribution in the Columbia Basin, summarized life history traits in relation to limiting factors and dam impacts, and assessed the status of populations before and after dams. The Basin was divided into survey sections, including C1: Columbia Lake to Donald Station; C2: Spillimacheen; and C3: Kinbasket. According to Arndt (and references therein):

Following their introduction into Kinbasket Reservoir, kokanee colonized suitable habitats in C1 for spawning, including sections of the upper Columbia River below Columbia and Windermere lakes, and lower reaches of some tributaries upstream as far as Dutch Creek. Aerial counts of spawning kokanee in C1 have been done since 1996 in six main index streams (Columbia River, Dutch, Toby, Horsethief, Forster, and Luxor Creeks). Total counts have ranged between 127,000 and 408,000 with the peak count occurring in 2001. A section of the Columbia River near the headwaters at Columbia Lake is by far the most important of the surveyed streams in C1, typically accounting for more than half of the index total. These numbers represent a single count of active spawners near the peak of the run rather than the total number spawning. Counts are typically expanded by a total fish:peak count factor of 1.5 to account for early and late spawners in which case the estimated numbers would range from about 200,000 to 600,000 spawners in this dam unit, not including streams with less than 1,000 fish. Status in C1 has

changed from probably not present to present for spawning. Number of spawning kokanee increased from zero to the hundreds of thousands."

McPherson et al. (2010) discussed kokanee within the sensitive habitat inventory of Columbia Lake, noting that upon emergence, kokanee fry move through Columbia Lake's north-end wetland to the Columbia River where they make their downstream migration to the Kinbasket Reservoir to reside as juveniles and adults. Within that study they designated a Zone of Sensitivity based upon its use as an important migratory corridor for kokanee during the sensitive spawning and post-hatch periods.

The results of numerous spawning surveys and progress reports are available within the database, most of which contribute to the reports discussed above. Surveys include, among others: Windermere and Luxor Creeks (Upper Columbia River Basin) Kokanee Spawning Survey 1998 (Wigle 1999), and Kinbasket Reservoir & Upper Columbia River Kokanee Spawner Index – 2005 (Manson and Porto 2006). Several reports also discuss fish passage through culverts, including Beswick (2009) and Masse Environmental Consultants Ltd (2016).

Sturgeon:
Although their habitat is outside the area of interest of this report, numerous documents in the CWSP database refer to white sturgeon, and they are worth mentioning. The Columbia River population of White Sturgeon (*Acipenser transmontanus*) is provincially Red-listed, and its status is S1 (2010) in BC because of a "relatively small population of individuals having little or no natural recruitment to the population." In 2012, it was designated as Endangered by COSEWIC. The ecology and status of white sturgeon are also discussed in the BC Ministry of Environment series: Wildlife in British Columbia at Risk.

The Upper Columbia White Sturgeon Recovery Plan (Upper Columbia River White Sturgeon Recovery Initiative 2002) describes objectives, targets, and strategies for stopping the decline of White Sturgeon in the Upper Columbia. This report states that "natural recruitment has failed for all Upper Columbia River subpopulations which now consist solely of aging cohorts of mature fish that are gradually declining as fish die and are not replaced." It also suggests that "The Upper Columbia White Sturgeon population will decline below critical thresholds from which recovery may be difficult without immediate, aggressive, and effective intervention."

Fisheries and Oceans Canada (2014) developed the Recovery Strategy for White Sturgeon in Canada. According to that document, "The recovery goal for White Sturgeon is to ensure that each of the populations are sustainable throughout their natural range, are self-sustaining through natural reproduction, and to increase or restore opportunities for beneficial use, if and when feasible." The document includes a discussion about the feasibility of recovery for dam-affected white sturgeon populations, including that of the Columbia River.

The BC Hydro Columbia River Project Water Use Plan – Columbia River White Sturgeon Management Plan Monitoring Programs and Physical Works Annual Report: 2015 (BC Hydro 2015) provides a

summary of the status and results of all projects relating to long-standing and ongoing efforts to reintroduce white sturgeon. Several reports within the CWSP database, including: Prince (2011) and Prince (2013) summarize studies conducted as part of that overall program.

White Sturgeon were identified as a recovery species within the Species of Interest Action Plan (FWCP 2012). FWCP identified many actions that they could undertake or support, including: clarifying threats and their relative risks (e.g., food supply, habitat); contributing to understanding the causes of recruitment failure; monitoring population status and trends; or protecting, maintaining, and enhancing important habitat.

Wetland and Lake Fish:
According to McPherson et al. (2010, and references therein), the ecosystem in and around Columbia Lake is known to provide good to excellent habitat for a variety of fish species, including 15 native, and two non-native species. They also report that "Columbia Lake provides habitat for many life history stages, which depending on the fish species, include spawning, rearing, feeding, migration and overwintering. The lake outlet, gravel shoals along the shoreline, and in particular, the shallow south end provide suitable spawning habitat for many species (Entech 1978) as does Dutch Creek and the alluvial fan (Westover pers. comm.). Since the majority of streams on the east and west side only run intermittently, they are not known to provide good spawning habitat (Westover pers comm.)."

McPherson and Hlushak (2008) report on fish species within Lake Windermere, stating that while the lake is known to support a high diversity of fish, despite that diversity, the total numbers of individual species are generally low in the lake, especially sport fish. The lack of success of sports fish in the lake has been attributed to many potential factors including: competition and predation by coarse fish, limited availability of spawning and recruitment habitat, improved angler access, overfishing, forest harvesting, exotic fish introductions, urbanization and water temperature increases. Sport fish potentially in Lake Windermere include: burbot, bull trout, kokanee, mountain whitefish, rainbow trout and westslope cutthroat trout. Eastern brook trout (potentially) and largemouth bass are the two non-native sport fish species in the lake.

According to the Science Committee: Columbia Wetland Stewardship Partners (2010), the status of non-game fish in the wetlands, and their use of seasonal wetlands connected to the river, is very poorly understood. They suggest that this has some implications for using fish species as indicators for climate change within the wetlands.

3.4.2 Birds
The Canadian Intermountain Joint Venture is a habitat program targeting the habitat needs of breeding, staging and migrating birds in the interior of BC. Their document, Implementation Plan: Wetlands and Associated Species (Harrison 2010), outlines priority bird species, population objectives, limiting factors, and habitat-species relationships. It also includes a discussion of wetland habitats, habitat drivers and trends, implications for bird populations, monitoring, research and critical challenges.

Environment Canada led the development of integrated all-bird conservation strategies to serve as the basis for implementing bird conservation across Canada. The Columbia Wetlands falls under the Bird Conservation Strategy for Bird Conservation Region 10 Pacific and Yukon Region: Northern Rockies (BCR 10) (Environment Canada 2013). The Bird Conservation Strategy includes sections on both wetland and riparian habitats. The wetland habitat class includes bogs, swamps, marshes, fens, and shallow open water, and the strategy states that while these areas cover only about 2.4 percent of BCR 10, they represent a very important habitat for birds, with 20 priority species using these habitats. They further state that wetlands are the only habitat class in BCR 10 to be utilized by priority species from all bird groups: land birds (four species), water birds (five), waterfowl (eight), and shorebirds (two).

The strategy did not provide an estimate for the total area of riparian habitats in BCR 10, however, the authors state that riparian areas are geographically restricted and form only a small part of the overall landscape in this region. They also suggest that despite their small representation, riparian areas are important in terms of biodiversity because they are used as breeding, wintering, and stopover habitat by many species, and serve as corridors connecting habitats and facilitating wildlife movement. Of the 12 priority species that are found in riparian habitats in BCR 10, eight are land birds and four are waterfowl (Environment Canada 2013). Summary tables within the strategy indicate:

- Priority species that use each habitat class, regional habitat subclass, important habitat features, population objectives and reason for priority status
- Identified threats to priority species
- Conservation objectives, recommended actions, threats addressed, and priority species affected

Waterbirds:

The Columbia Wetlands have been widely recognized as providing important habitat for birds (Caspell et al., 1979; Environment Canada, 2014; Harrison et al., 2010; Kaiser, McKelvey & Smith, 1977). These wetlands are considered a vital component of the Pacific Flyway and provide resting, feeding and breeding habitat for numerous bird species (Caspell et al., 1979; Darvill, 2017; Holmes, 2007). However, there had been a lack of recent data on bird species and their populations until the implementation of the Columbia Wetlands Waterbird Survey (CWWS) in 2015. The CWWS is a five-year coordinated bird count and project of the Golden Branch of Wildsight. In 2019, data from the CWWS will be used to nominate the Columbia Wetlands into the Canadian Important Bird and Biodiversity Area (IBA) program, which if achieved, will be a critical accomplishment for conservation planning and for global recognition of the wetlands in terms of its habitat importance to birds.

The CWWS collects baseline inventory bird data during periods of bird migration. Data is gathered utilizing citizen-scientists that count and identify birds at established ground-based survey stations (n=100) that cover approximately 40% or 8,000 hectares of the Columbia Wetlands ecosystem (Darvill, 2017). Through the efforts of the 2015-2017 CWWS, inventory data were collected on over 90 bird species, several which are priority bird species of the Canadian Intermountain Joint Venture. The highest single day count during the 2015-2017 CWWS occurred on October 15, 2016 with 20,796 individual birds recorded at 85 survey stations. There have been 14 designated species-at-risk recorded through the CWWS between 2015-2017, i.e. American Bittern (*Botaurus lentiginosus)*, Great Blue Heron

(*Ardea herodias herodias),* Western Grebe (*Aechmophorus occidentalis*), Tundra Swan (*Cygnus columbianus)*, Horned Grebe (*Podiceps auritus)*, Eared Grebe (*Podiceps nigricollis*), American White Pelican (*Pelecanus erythrorhynchos),* California Gull *(Larus californicus),* Long-billed Curlew *(Numenius americanus),* Rough-legged Hawk (*Buteo lagopus),* Barn Swallow (*Hirundo rustica),* Bank Swallow (*Riparia riparia),* Peregrine Falcon (*Falco peregrinus anatum)* and Surf Scoter *(Melanitta perspicillata)* (Darvill, 2017).

According to CWWS data, provincially red-listed Western Grebe (*Aechmophorus occidentalis*) concentrate at larger water bodies in the Columbia Valley, such as Columbia Lake, Lake Windermere, and Mulligan's Slough (located near Nicholson) (Darvill, 2017). Regular reports on eBird (world's largest biodiversity-related citizen science project) support this observation when relatively large (i.e. 220, 150, 100) and smaller flocks of Western Grebe (*Aechmophorus occidentalis*) have been recorded on Lake Windermere during migration periods. The Committee on the Status of Endangered Wildlife in Canada has listed the Western Grebe (*Aechmophorus occidentalis*) as a species of 'Special Concern' and has stated that "[t]hreats to Western Grebes during migration are mostly unknown. Migration routes are poorly understood, stopover sites have not been systematically documented, and virtually nothing is known about fidelity to stopover sites or habitat requirements at those sites" (COSEWIC, 2014). The data recorded by CWWS supplements the limited information database identifying the stopover sites utilized by the Western Grebe (*Aechmophorus occidentalis*) in the Columbia Wetlands.

McPherson, Hlushak, Adams and Polzin (2010) stated that "Columbia Lake is an important staging area for many migrating waterfowl and supports a diverse array of breeding waterfowl. The wetland areas at the north and south ends of the lake are particularly important." This report also noted that the remainder of the lake was much less utilized by migrant birds and that species of note on Columbia Lake were Tundra and Trumpeter Swan (McPherson, Hlushak, Adams & Polzin, 2010). The CWWS data indicates that middle sections of Columbia Lake (and Lake Windermere) are regularly utilized during migration periods by at-risk species such as Western Grebe (*Aechmophorus occidentalis*) and Horned Grebe (*Podiceps auritus*), and that middle sections of Columbia Lake and Lake Windermere are two of the most important staging areas within the Columbia Wetlands ecosystem for these grebe species (Darvill, 2017). Tundra and Trumpeter Swan occur throughout the Columbia Wetlands. An aerial swan survey over the Columbia Wetlands conducted by the Columbia Wetlands Waterbird Survey project on April 7, 2018 recorded 915 swans between Canal Flats and Golden.

The CWWS data from 2015-2017 suggests that American Wigeon (*Anas Americana*) are the most common waterbird found in the wetlands (Darvill, 2017). Mallard (*Anas platyrhynchos*) and American Coot (*Fulica americana*) have also been found in high abundance (Darvill, 2017). This finding concurs with a previous study from 1976-1977, when Canadian Wildlife Service conducted aerial surveys reporting that the "Columbia Marshes support one of the most dense populations of Mallards in British Columbia…" (Kaiser, McKelvey & Smith, 1977). Kaiser, McKelvey & Smith (1977) also highlight the large

number of American Coot (*Fulica Americana)* and American Wigeon (*Anas Americana*) that were seen during the 1976-1977 aerial bird surveys.

The CWWS project found that a high overall abundance of bird species is present in multiple geographical areas in the Columbia Wetlands during periods of migration, including at least one of the sites not previously observed during former research projects in the wetlands (i.e. large shallow open water patches located between Brisco and Spillimacheen) (Darvill, 2017). This wetland complex located just north of Brisco, as well as the south end of Lake Windermere and the Columbia National Wildlife Area (Wilmer Unit) may provide the most suitable migration stopover habitat conditions in the Columbia Wetlands, as these areas have consistently recorded the highest abundance of waterbirds during the CWWS survey dates (2015-2017). Preliminary data also suggests that there are additional geographical sites that regularly have high numbers of birds including the Althalmer Slough near Invermere, and Mulligan's Slough near Nicholson (Darvill, 2017).

Minimal population data has been published specifically relating to marsh bird populations in the Columbia Wetlands. The Columbia Wetlands Marsh Bird Monitoring Project (CWMBMP) project (2016-2019) was initiated in 2016 by Goldeneye Ecological Services in collaboration with Environment and Climate Change Canada Canadian Wildlife Service. The CWMBMP addresses information deficiencies for marsh birds (including several priority bird species of the Canadian Intermountain Joint Venture) by using repeated play-back calls to collect baseline data on targeted marsh bird species at 61 survey stations (Darvill, 2018). Prior to the CWMBMP, there had only been one known survey for a marsh bird species in the Columbia Wetlands, which targeted American Bittern (*Botaurus lentiginosus*) and was conducted in a low water year; only two bitterns were detected (Cooper & Beauchesne, 2003). Preliminary data from the CWMBMP has determined that there are significant breeding populations in the Columbia Wetlands for several elusive and inconspicuous marsh bird species (e.g. Pied-billed Grebe (*Podilymbus podiceps*), Sora (*Porzana Carolina*) (Darvill, 2018). "Data from the CWMBMP will be a critical support structure assisting the formulation of management recommendations for habitat-based conservation projects (e.g. nesting platforms or boxes, landowner outreach leading to habitat enhancement or restoration) to be implemented in the years 2018-2020" (Darvill, 2018).

McPherson et al. state that "Numerous shorebird species stage on mudflats and beaches of Columbia Lake and surrounding sloughs and wetlands during spring and fall migrations… Birds are found primarily on sand/mud beach and shallow water areas where they forage for aquatic invertebrates. Birds may spend up to a week in the area, depending on the weather." McPherson et al. further suggest that "few shorebird species nest in the East Kootenay. Those that do include Spotted Sandpiper (*Actitis macularia*), which probably nest on Columbia Lake shoreline and Solitary Sandpiper (*Tringa solitaria*) which is relatively unique among shorebirds as a species that utilizes abandoned songbird nests in trees and shrubs close to the shoreline." Unpublished data from the CWMBMP shows that Common Snipe (*Gallinago gallinago*) is a regular breeding shorebird in the Columbia Wetlands ecosystem, as well as Spotted Sandpiper (*Actitis macularia).* Long-billed Curlew (*Numenius americanus*) also breeds in the Columbia Valley, but is not common.

Great Blue Heron:
Systematic monitoring of heron colony size, breeding activity, nesting success and productivity was conducted within the Columbia Basin by the Fish and Wildlife Compensation Program from 2002 – 2009 (Machmer 2009). Data from that period indicated that while the total number of active heron nests fluctuates considerably from year to year, the population appeared to be stable. Monitoring data suggested that heron colony establishment, growth, abandonment and new colony formation are in constant flux in response to factors such as bald eagle and human-induced disturbance, and potential influences from other competing species (e.g., double-crested cormorants, osprey) breeding nearby. According to Dawe et al. (2012), Machmer and Steeger (2004) expressed concern about beaver activity at a Wilmer heronry as well as the presence of nesting bald eagles in the heronry, noting that eagle-heron interactions were frequently observed. In 2003, 10 of the 11 active nests were abandoned, thought due to bald eagle disturbance and predation on heron nestlings. In 2004, a bald eagle pair was still nesting near the heron colony.

Ferguson (2004) noted in his regional species at risk assessment that more than 75 percent of breeding sites were within 200 m of water, and more than 50 percent of heron nests were placed in black cottonwood trees. More recent data (Machmer 2009) suggest that heron are increasingly using conifers for nesting. “Approximately half of heron nesting sites were in coniferous or mixed stands, in sharp contrast to the pure deciduous stands (100 percent black cottonwood) reported in earlier surveys of the Kootenay Region (Forbes et al. 1985).” Machmer suggested that the numbers of known eagle nests in the Basin “had increased substantially since 2006, and the trend to increasing use of conifer-dominated and mixed stands may represent a shift toward less preferred nesting habitat due to a diminishing supply of highly suitable habitat and/or competitive displacement by increasing numbers of bald eagles, or an adaptive response to increase nest site concealment and hence reduce harassment and predation by eagles.” Machmer also stated that “Observations of herons building nests in stunted trees and willow shrubs in the Wilmer and Parson areas (after being displaced by eagles from previous rookeries) suggest that localized eagle impacts are occurring and may be causing herons to shift into more marginal breeding areas. They also support the need for periodic monitoring of both herons and eagles to track species overlap in habitat use, potential conflicts and broader population effects.” Machmer (2009) provided a prioritized list of both general and site-specific recommendations for future inventory, monitoring, management and stewardship pertaining to heron (and bald eagle).

The population goals for the Great Blue Heron under the Bird Conservation Strategy for Bird Conservation Region 10 Pacific and Yukon Region: Northern Rockies (Environment Canada 2013) are to “assess and maintain.” Recent increases in recreational use are of concern in some areas.

American Bittern:
American Bittern are provincially Blue-listed and their status in BC is S3B (2015). The species is not listed by COSEWIC. The BC Conservation Data Centre (2017) states that “Although this species is widespread, it is locally and sparsely distributed. It is restricted to dense stands of emergent vegetation in lakes and ponds for breeding. Their habitats are threatened by development in southern British Columbia.”

Cooper and Beauchesne (2003) found bittern at eight sites in the East Kootenays (Bummer’s Flats, Lillian Lake, Bittern Lake, Lavington Creek, Bear Lake, Saughum Lake, Twin Lakes, and near Parson). During the

2003 survey they noted that bittern were absent from areas where they had been previously recorded, and where suitable habitat was available, suggesting that fluctuating water levels might have affected the survey results. They concluded that, in general, "high quality bittern habitat is scarce in the Columbia Basin because of fluctuating water levels and lack of marshy wetlands in many areas. They suggest that further research should include surveys of wetlands with high habitat suitability for bitterns, especially those known to contain bitterns. Their management recommendations include the protection of wetlands from drainage, water quality erosion, fluctuating water levels, trampling of riparian and emergent vegetation by livestock, and human disturbances. The BC Conservation Data Centre (2017) suggests that nest sites within protected areas should be censused to determine numbers of breeding birds protected and that significant breeding sites should be monitored on a regular basis to determine population trends.

Sandhill Crane:
The Sandhill Crane is Yellow-listed in BC and its provincial status is S4B (2015). It is listed as Not at Risk by COSEWIC. Ferguson (2004) reported that breeding has been confirmed within the Bummers Flats Conservation Area and in the Moberly Marshes north of Golden, and stated that breeding is "suspected at a few other wetland sites in the Columbia Wetlands Wildlife Management Area (near Invermere) and in the Cherry Creek/Ta Ta Creek area."

Leighton (2005) discusses the taxonomy, origin, size, growth, habitat requirements, breeding chronology and conservation of the small population of sandhill crane which have become stablished in the East Kootenay. Leighton suggested voluntary stewardship as an important protection strategy for sandhill crane breeding in area surrounding Golden where cranes use both park and private lands.

Long-billed Curlew:
The Long-billed Curlew is on the provincial Blue list. It was designated as a species of Special Concern by COSEWIC in 1992. Subsequent status reviews (2002, 2011) suggested that populations have not changed significantly and its status did not change. (Long-billed curlew are not considered a priority species by the Canadian Intermountain Joint Venture.)

Ferguson (2004) discussed long-billed curlew in his assessment of species at risk for the Rocky Mountain and Kootenay Lake Forest Districts, stating that (at that time) the British Columbia population was estimated to be at least 500 birds of which 40-50 breeding pairs were in the East Kootenays. Gillies (2009) reported the presence of curlews in grasslands on the Shuswap Reserve near Invermere. According to the COSEWIC Status Appraisal Summary (Perkins and Gratto-Trevor 2011) for the long-billed curlew, there is very little survey or monitoring data available for BC, but there is no evidence to suggest a decline in population. They consider the previous estimate of 500 birds to be "reasonable."

Current threats to long-billed curlew are habitat loss and degradation, including development and forest ingrowth, spread of invasive species, ploughing, grazing, and livestock trampling. Curlew are also threatened by predation, energy development, localized off-road vehicle use, contaminants and climate change (increased drought). Ohanjanian (2004) states for that the most part, very little of known curlew nesting habitat is protected, and that there is a need for more information about population size and trend, and more research on brood rearing and rearing habitat requirements.

Lewis's Woodpecker:
This species was listed as Threatened under Schedule 1 of the *Species at Risk Act* (SARA) in 2012. Lewis's Woodpeckers are birds of open forest, riparian woodland or grassland with scattered trees. According to the Rocky Mountain Trench Ecosystem Restoration Program (2010), the benchlands above the western shores of Columbia Lake provide prime habitat and the Dutch-Findlay Range Unit between Canal Flats and Fairmont Hot Springs is a "hotspot" for Lewis's woodpeckers. The species formerly occurred in the Columbia Basin as far north as Golden and Revelstoke, but an extensive search of the Columbia Basin region in 2007 produced no records farther north than Fairmont (Beauchesne 2010). Based on surveys conducted between 2006 and 2013, the total population of Lewis's woodpeckers in BC is at least 371 pairs, and the East Kootenays have the fourth highest (of six) breeding populations in the province (Environment Canada 2016).

In 2013, Lewis's woodpecker surveys were conducted throughout the Tobacco Plains, St Mary's and Akisq'nuk reserve forest lands. Full habitat assessments were completed at 35 of the 43 survey locations to assess the potential suitability of the location for nesting (Harrison 2014). No Lewis's woodpecker were observed on-reserve in 2013, but the project was successful in meeting its objectives to establish baseline population numbers and habitat conditions. It was recommended that surveys be repeated following the implementation of fuel reduction/restoration treatments at regular three- to five-year intervals to evaluate and track the response of Lewis's woodpecker to restoration treatments (Harrison 2014).

Habitat augmentation has been occurring in the region for over a decade. Manning and Manley (2014) reported on results of wildlife tree fungal inoculation for habitat enhancement from 2007-2013, and Manning (2015) described the Kootenay Region 2015 Wildlife Tree Creation Project. In this project, wildlife tree enhancement treatments were conducted at three sites - Wigwam Flats, Akisqnuk and Duncan-Lardeau Flats - to increase nesting, roosting and feeding habitat supply for a variety of cavity dependent wildlife species, including Lewis's woodpecker.

In 2014, Environment Canada published a management plan for Lewis's woodpecker and in 2016, published a recovery strategy (proposed). The principal threats to Lewis's Woodpeckers are habitat loss and degradation (Beauchesne 2010; Environment Canada 2016). The recovery strategy identified several opportunities for research and monitoring with regard to Lewis's woodpecker, including: implementing a long-term monitoring strategy, limiting cutting of potential nest trees, and pursuing habitat augmentation and restoration.

Short-eared owl:
The short-eared owl *(Asio flammeus)* is Blue-listed in BC and its provincial status is S3B,S2N (2015). In 2008, it was listed as a species of Special Concern by COSEWIC (BC Conservation Data Centre 2017) because the owl "has suffered a continuing population decline over the past 40 years." The Short-eared Owl Assessment and Update Status Report further suggests that habitat loss and degradation on its wintering grounds are most likely the major threat, while continuing habitat loss and degradation on its breeding grounds in southern Canada and pesticide use are secondary threats. This species nearly meets the criteria for Threatened status.

Adams (2009) suggests that little is known of short-eared owl occurrence in the East Kootenay. An inventory in 2003 (Cooper and Beauchesne 2003) found no individuals, but there have been occasional sightings west of Invermere and in the WASA-Bummer's Flats area. Adams, and references therein, suggest that the only high-quality sites in the Columbia Valley were dry fields at either end of Windermere Loop Rd. "Fields and open areas in the Columbia Wetlands were considered either too heavily impacted by agriculture or too inundated by spring floods to rate as high quality Short-eared Owl habitat" (Adams 2009).

Cooper and Beauchesne (2003) suggest several possible conservation actions for the short-eared owl, including, among other things, conservation of grassland areas, increasing the amount of fallow field habitat in wildlife management areas, and minimizing disturbance in areas frequented by owls. Cooper and Beauchesne also identify the need for information about breeding and wintering localities, and the impacts of human recreational use of nesting areas on reproductive success.

Flammulated Owl:
Flammulated Owl is designated by COSEWIC as a species of Special Concern in Canada and is on Schedule 1 of Canada's Species at Risk Act. Provincially, it is Blue-listed and is a priority 2 under goal 2 (prevent species and ecosystems from becoming at risk) of British Columbia's Conservation Framework (Environment Canada 2013). Canadian populations are restricted to mature or old, dry Douglas-fir and ponderosa forest zones of south-central and southeastern BC. The BC breeding population is estimated at 600–1000 pairs (COSEWIC 2009). The number of known locations has increased due to increased inventory efforts, but population trends are unknown.

According to a species at risk assessment (Ferguson 2004) in the East Kootenays, flammulated owls are found primarily on the east side of the Rocky Mountain Trench, and nesting was confirmed as far north as Brisco, as well as between Canal Flats and Whiteswan Lake. Other probable nesting locations, based on the results of call/playback surveys and confirmed sightings, include the east side of Columbia Lake, near Radium Hot Springs, near Wasa Lake, Mause Creek, and between Fort Steele and Bull River. The Management Plan for the Flammulated Owl in British Columbia and Canada (Environment Canada 2013) includes management objectives and recommended actions, several of which were ranked as essential. These include: identifying populations, habitats and distribution; investigating cumulative impacts of threats; and protecting and/or managing priority nesting habitats.

Peregrine Falcon:
Documents discussing the peregrine falcon are not well represented in the CWSP database. A pamphlet, Peregrine Falcon: British Columbia's Wildlife at Risk (BC Ministry of Environment 1998) describes the ecology and status of BC's peregrines (at that time). Three subspecies of peregrine were originally recognized, but in 2007 the peregrine falcon in Canada was assessed as two separate units. In BC, the *anatum / tundrius* Peregrine Falcon occurs in the southern interior. The BC Conservation Data Centre lists *F.p. anatum* as Red-listed provincially, with an S2?B status (2010). Its COSEWIC status is Special Concern (Apr 2007).

Anatum peregrine falcons typically nest on rock cliffs above lakes or river valleys where abundant prey is nearby. Interior populations are typically associated with wetland habitats that support a sufficient prey

base (BC Conservation Data Centre 2017). Ferguson (2004) suggests that there are indications that peregrine falcon formerly bred in the East Kootenay (up to the early 1980s), but that more evidence of breeding in this area was lacking. No evidence of nesting was documented in a 1996 inventory in the East Kootenay, but only a small portion of the potential nesting sites was searched.

Olive-sided Flycatcher:
Few documents within the CWSP database are concerned solely with olive-sided flycatcher (*Contopus cooperi)*, but the species is mentioned in most discussions of species at risk in the province. The olive-sided flycatcher is on the provincial Blue list and its status in BC is S3S4B (Mar 2015). Its COSEWIC status is Threatened (Nov 2007). According to the Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada (Environment Canada 2016), the olive-sided flycatcher was designated as threatened because it has "shown a widespread and consistent population decline over the last 30 years; the Canadian population is estimated to have declined by 79 percent from 1968 to 2006 and 29 percent from 1996 to 2006. The causes of this decline are uncertain."

According to the BC Conservation Data Centre (2017), olive-sided flycatcher breeds in various forest and woodland habitats, including in forested wetlands, and along the forested edges of lakes, ponds, and streams. Most nesting sites contain dead standing trees, which are used as singing and feeding perches. Wells et al. (2009) investigated incidental take of nests and evaluated an approach to identify and protect the habitat of migratory birds in the East Kootenays. They concluded that "forested habitat of all ages near wetlands is expected to provide the most suitable habitat for olive-sided flycatchers," and further suggested that management focused on maintaining wetland integrity and forested areas adjacent to wetlands should be a priority for maintaining flycatcher habitat.

The flycatcher was found within the Columbia National Wildlife Area in 2004 when the Canadian Wildlife Service, Pacific and Yukon Region gathered inventory data (Dawe et al. 2012).

Common Nighthawk:
The Common Nighthawk is provincially Yellow-listed and its status in BC is S4B (2015). In 2007, it was designated as Threatened by COSEWIC because it has shown both long and short-term declines in population within Canada. Reductions in food sources have been implicated in its decline, as has a reduction in habitat availability (COSEWIC 2007).

Campbell et al. (2006) suggests that "we must be cautious when assessing population trends for the Common Nighthawk in British Columbia because long-term traditional surveys such as Breeding Bird Surveys and Christmas Bird Counts do not sample numbers or habitats of Common Nighthawks adequately."

In the spring of 2008, FWCP launched a program for web-based reporting of species at risk. One of the objectives of the program was to gather information on the distribution and nesting locations of the common nighthawk throughout the Columbia Basin. According to the summary of sightings reported by the public (Manley 2008), the Upper Columbia River between Fairmont and Radium had many nest sites and foraging observations. Manley concluded that the combination of dry open uplands close to

wetland or riparian areas that are productive foraging habitat, appeared to provide good habitat for the species.

Future Directions

A 2016 report entitled 'The State of North America's Birds' reported that even common bird populations were in decline and that one-third of all North American bird species require urgent conservation action (North American Bird Conservation Initiative, 2016). While the data available on birds using Columbia Wetlands habitat is growing, there is still relatively little known about bird species populations and their habitat use in the Columbia Valley. Beyond contributions to the eBird database, virtually nothing is known about bird populations using wetland and riparian habitat at elevations higher than the Columbia Wetlands. There is also little known about grassland bird species populations that have been documented in the Columbia Valley (Leung & Simpson, 1993). A monitoring and habitat restoration program that focuses on grassland bird species is warranted.

Further monitoring and survey data leading to more robust dataset is required to assist with the development of habitat-based action projects to conserve valuable bird stopover and breeding habitat in the Columbia Wetlands and Columbia Valley. In order to alleviate information deficiencies, help track long-term trends in species diversity and populations, and guide conservation, restoration, and management programs for Columbia River marshes, a long-term population (status and trends) bird monitoring project should be established for the Columbia Wetlands. Furthermore, in order to maintain, enhance and increase breeding habitat for cavity nesting waterfowl species, a waterfowl nesting box program should be implemented in the Columbia Valley. Leung & Simpson (1993) stated that "A monitoring program for cavity nesting waterfowl should involve local interest groups to educate volunteers and minimize costs."

Recently, there has been a substantial increase in non-motorized use of the Columbia Wetlands. A wide range of potentially detrimental behavioural patterns have been documented for waterbirds in response to recreationists. Examples include reduced foraging and resting periods, increased nest abandonment and egg loss, discouragement of late-nesting pairs from breeding and disruption of pair bonds and parent-offspring bonds (Liddle & Scorgie, 1980; Korschgen & Dahlgren, 1992). Repeat disturbances during critical breeding times eventually cause ducks to nest elsewhere or not at all (Korschgen & Dahlgren, 1992). Other studies have shown that human disturbance can cause increased flushing, flight times and energy expenditure by birds and reduce their overall energy intake. Birds are sensitive to disturbance wherever they are present during periods of migration when they need to rest and feed. Therefore, it is important to get an understanding for how pressures can be reduced from increased levels of human use. It would be useful to develop Best Management Practices (BMPs) for recreationalists of the Columbia Wetlands in order to help limit human disturbance in sensitive breeding habitats (e.g. stands of emergent vegetation). It would also be useful to learn more about the effects of rural development on avian behaviour and assess the usefulness of developing best management practices on private land.

There are a number of specific actions listed in a federal management plans or recovery strategy documents for at-risk bird species that should be implemented in the Columbia Valley. There are also a number of conservation actions listed in the Canadian Intermountain Joint Venture Implementation Plan: Wetlands and Associated Species, that could be implemented in the Columbia Valley to help restore, enhance or maintain bird habitat, e.g. cattle exclusion fencing, off-site livestock watering, riparian planting, environmental farm plan, demonstration projects, wetlands BMPs, education.

Bird research has shown that the Columbia Wetlands contain significant stopover and breeding habitat for numerous bird species. Through the Columbia Valley Bird Survey, Leung & Simpson (1993) recommended that the Columbia River marshes and adjacent forests be designated as a Provincial Wildlife Management Area. The Upper Columbia River floodplain currently contains 67.6% of conservation lands (BC Hydro, 2014); therefore future management action for the wetlands should include private land securement for conservation purposes.

3.4.3 Amphibians

Northern Leopard Frog:

The northern leopard frog was designated as Endangered by COSEWIC in 1998 and its status was re-examined and confirmed in May 2000 and in April 2009. In BC, the northern leopard frog is ranked S1 (critically imperiled) by the Conservation Data Centre and it is on the provincial Red list (Northern Leopard Frog Recovery Team 2012).

According to the Recovery Plan for the Northern Leopard Frog in British Columbia (Northern Leopard Frog Recovery Team 2012), biologically limiting factors impeding rapid recovery of northern leopard frogs in BC include extremely small population size, low egg mass production each year, low resistance to chytridiomycosis, and potential effects of reduced genetic diversity. Historically, the primary threat was habitat destruction resulting from wetland draining and reclamation in the early to mid-1900s. The recovery plan suggests that chytridiomycosis currently represents the single-most significant threat to the populations in BC.

Reintroduction at the Upper Kootenay floodplain (Bummer's Flats) from 2003 to 2005 and 2011 to 2015 was successful, and survival to metamorphosis, overwinter survival, and reproduction have all been observed in this site (Environment and Climate Change Canada 2016). In 2015, 19 males were recorded calling, compared to less than five in previous years, and the sporadic one or two prior to translocation in 2010 (Government of British Columbia 2016).

Northern leopard frogs were documented to occur historically in the Columbia Marshes before the population declined. It was confirmed that the Columbia Marshes provided suitable habitat (Ohanjanian and Carli 2010), and the marshes were selected as the highest priority reintroduction location. Captive-bred frogs were released into the Columbia Marshes in 2013, 2014, and 2015 (Environment and Climate Change Canada 2016). In 2015, over 3500 tadpole hatchlings were released from both the captive

breeding population and wild collected eggs (Government of British Columbia 2016). As of 2015, the success of this reintroduction was unknown. Survival of tadpoles to metamorphosis was confirmed in all these years, but overwinter survival had not yet been observed, and sufficient time for many of these frogs to reach maturity and deposit eggs had not yet passed.

The Recovery Strategy for the Northern Leopard frog states that "The immediate objective is to prevent extirpation of the existing populations of Northern Leopard Frog, including any reintroduced or newly-discovered populations." Adding that "The short-term objective of reintroducing two populations is an intermediate step in achieving the long-term objective of restoring the distribution toward historic levels, where feasible." The recovery team estimates a minimum of five years are required for each reintroduction attempt, and the creation of at least two additional populations (including completing the Columbia Marshes reintroduction) within a 10-year time frame is a "reasonable and feasible" short-term goal.

Objectives within the recovery plan include identifying, protecting and restoring suitable habitats; establishing additional populations, and addressing knowledge gaps. Those gaps include: population level impacts of chytridiomycosis and mitigation strategies; genetic constraints on population recovery; population dynamics; quantification of population level impacts of threats, including pollution and invasive species; and effectiveness of population augmentation, reintroduction, and habitat restoration strategies.

Western Toad:
The western toad was considered a single unit and designated as Special Concern by COSEWIC in 2002. It was subsequently split into two populations in 2012, and both the "calling" and "non-calling" populations were designated Special Concern in 2012. Calling toads occur in most of Alberta, extending into British Columbia in the Rocky Mountains, and non-calling toads are found within the remaining part of the species' Canadian range. The east-west geographic demarcation between the non-calling and calling designatable units is uncertain (Slough 2012).

In BC, western toads are threatened by urban development, road mortality, livestock impacts on wetlands, forestry practices, oil and gas developments, invasive species, disease epidemics (chytrid fungus), and climate change. The British Columbia Ministry of Environment initiated a Western Toad Population Monitoring Program with a pilot study in 2009, but according to the 2013 COSEWIC Status Report (Slough 2012), there have been few dedicated population surveys for western toads over most of their range and program results were not available for the status report. Slough also suggested that "most observations have been collected opportunistically and relatively few sites have been revisited to determine population persistence or trends."

Ohanjanian et al. (2006) visited 57 wetlands in the East Kootenays known to have western toads historically and found western toads breeding at less than a third of the sites. According to the authors, the study provides preliminary evidence that a decline in western toads may be underway in

southeastern BC, and they recommend that that a statistically sound, multi-year monitoring program be initiated. They also noted that the presence of toad tadpoles alone does not indicate successful reproduction, and future surveys should continue through to metamorphosis and beyond. They further recommended that the issue of chytridiomycosis be investigated, including tissue sampling and lab analysis.

In 2014, the Provincial Western Toad Working group released a Management Plan for the Western Toad in British Columbia. The plan includes all western toads in BC (both the calling and non-calling populations). The management plan identified data gaps and associated actions required to fulfil management objectives. The gaps fall into the following three broad categories: monitoring trends, protecting and restoring habitat, and managing the species and population.

Western Painted Turtle:

The Western Painted Turtle Intermountain - Rocky Mountain Population (*C. p. bellii*) is provincially Blue-listed and its status in BC is S2S3 (Jan 2012). In 2006, it was listed by COSEWIC as Special Concern because "The number of turtles is likely small and declining because of extensive loss of wetland habitats and proliferation of roads." Its status was re-examined and confirmed in November 2016. The Intermountain – Rocky Mountain Population is confined to lower elevations and valley bottoms in the southeastern portion of the province.

According to COSEWIC (2006), the turtle is found in the "shallow waters of ponds, lakes, sloughs, and slow-moving stream reaches. Suitable wetlands have muddy substrates, an abundance of emergent vegetation, and numerous basking sites." Its habitat also includes riparian zones bordering wetlands, and females nest up to 150 m away from water, in loose, warm, well-drained soils. The management plan for the painted turtle estimates its population is roughly 5000–10000 (BC Ministry of Environment 2017) and turtles are distributed within the province's interior over three distinct regional genetic units: the Cariboo, the Thompson-Okanagan, and the Kootenays. The total number of locations is suspected to be greater than 200 (BC Ministry of Environment 2017).

According to the management plan, within this region painted turtles are in Kootenay and Columbia River drainages in the Rocky Mountain trench north to Yoho National Park, including Cranbrook, Kimberley, Invermere, and Revelstoke. Painted turtles were found within the Columbia National Wildlife Area (CWNA) in 2004 when the Canadian Wildlife Service, Pacific and Yukon Region, inventoried species within the wildlife area (Dawe et al. 2012). Ferguson (2004) also discusses the occurrence of painted turtles in his assessment of species at risk in two regional forest districts.

The Columbia Lake Sensitive Habitat Inventory and Mapping report (McPherson et al. 2010) states that "Turtles are found as far north as Golden in the East Kootenay and are commonly seen around the Invermere area including Dorothy Lake and numerous ponds in the Columbia wetlands. At Columbia Lake, painted turtles are known from the small section of Columbia Lake in the southwest corner, isolated from the main lake by a CPR railway berm. Turtles are known from the Columbia River between Columbia Lake and Lake Windermere, but have not been confirmed in the wetland complex at the north end or in Columbia Lake Provincial Park, however they likely do occur where suitable habitat is available."

The management plan outlines several objectives, including: protecting habitat; mitigating road mortality and habitat destruction; completing an inventory across the range of the population, and monitoring significant populations; and addressing key knowledge gaps (potential impacts of agriculture/livestock; location of movement corridors; efficacy of road mortality protection and nest site enhancement projects; and potential impacts of invasive species).

Rubber Boa:
In BC, the northern rubber boa is ranked S4 (2012) by the BC Conservation Data Centre and is on the provincial Yellow list. It was designated as Special Concern in 2003 by COSEWIC. The BC Conservation Framework ranks the northern rubber boa as priority 1 under goal 2 (prevent species and ecosystems from becoming at risk).

In BC, rubber boas are found throughout the warmer valleys in the southern third of the province. According to the Management Plan for the Northern Rubber Boa (*Charina bottae*) in British Columbia (Gregory 2015), the overall threat impact is low, with the greatest threats to the species being agriculture and roads. The management goal for the northern rubber boa is to maintain its current area of occupancy and distribution within BC. There is also a management plan for the northern rubber boa in Canada.

St. Clair and Dibb (2004) examined the habitat of rubber boas in Radium Hot Springs and discussed monitoring and protection measures for the species. Ferguson (2004) discusses the status in his species at risk assessment report for the Rocky Mountain and East Kootenay Lake forest districts.

3.4.4 Ungulates

Elk:
According to the Science Committee: Columbia Wetland Stewardship Partners (2010), there are no listed mammal species in the system that are wetland dependent. However, many of them have at least a seasonal presence in the wetlands and adjacent benchlands so can be considered species of some importance to ecosystem dynamics.

In BC, elk are Yellow-listed and their status is S5 (2015). Since the mid-1970s, the number of interior Rocky Mountain elk in British Columbia has increased from about 15,000 to 40,000, including about 20,000 in the Kootenay region (Blood 2010). Elk are a regionally important species because their winter ranges include open forest, grassy benchlands, and floodplain marshes. Elk in this region migrate to subalpine and alpine basins and avalanche tracks in May and June, and remain at elevation until snowfall pushes them lower into the valley.

There is long history of elk conservation in the province and a broad range of elk inventory and management documents within the CWSP database. Szkorupa and Mowat (2010) conducted a review of the elk population in the Kootenay region as a precursor to developing the Kootenay Elk Management Plan for 2010-2014. The population review includes a summary of elk data with a focus on population size, composition, and adult survival. The report also includes a discussion of factors that might affect the population, including hunting, weather and predation.

The most recent Kootenay Elk Management Plan: 2010-2014 (BC Ministry of Environment 2010) suggests that populations of elk in this region (North Trench) are “healthy.” In 2009, special hunt zones were delineated at the southern reach of the zone because of concerns with elk depredation on

agricultural crops, and rangeland condition and forage availability on important winter range. In terms of management, the plan identified population stability, or a 20 percent decline, as recommended management alternatives for this area. Adding that "Although there is less agriculture and fewer concerns over crop depredation in these areas, compared to the southern Trench, there are conflicts with landowners, and the winter range may be overused if elk populations do increase."

An elk inventory was conducted in the northern Rocky Mountain Trench in 2011 (Szkorupa and Thornton 2011). The 1000 km2 study area included the Columbia River Valley from Radium north to Birchlands Creek (just north of McMurdo). The area was selected to include agricultural land along the Columbia Wetlands and adjacent hillsides, where elk may move up and down in elevation.

Survey results suggested a population of 377 elk, and the authors noted that the elk were most abundant in the wetlands in the southern part of the study area. The authors concluded however that their estimate was probably low, stating that "In the northern part of the study area, where snow was very deep, elk avoided the wetlands and used adjacent hillsides more than we anticipated." They summarized that the population estimate derived from the survey might have underestimated the population size slightly, and that the population was likely closer to 500.

No documents suggest habitat connectivity issues for elk within this region. The Columbia National Wildlife Area Management Plan: proposed (Gebhauer and Huntley 2016) states that as of 2016, the greatest threat to wildlife in general within the NWA is habitat degradation due to unrestricted and uncontrolled access by all-terrain vehicles. The plan suggests that completion of fencing and physical barriers to restrict vehicle access would greatly reduce wildlife management issues on the site. They also suggest that better education and posting of property boundaries could reduce inadvertent hunting in the area.

Bighorn Sheep:

Rocky Mountain bighorn sheep are provincially Blue-listed and their provincial status is S3 (2015). The most recent document available in the database concerning bighorn is the Status of the Rocky Mountain Bighorn Sheep in the East Kootenay (Teske 2015). The *oldest* document, An Ecological Study of Rocky Mountain Bighorn Sheep Winter Ranges in the East Kootenay Region of British Columbia, was written 50 years ago (Demarchi 1967). Dozens of status reports and discussions of range, conservation, and management have been published in the intervening years.

According to Stent et al. (2013), numerous aerial and ground-based surveys have been conducted for bighorn sheep in the Kootenay Region over the past decades, and Teske (2015) suggests that the Columbia Lake and Radium bighorn populations are stable. Teske also notes that the Hwy 93/95 area in Radium is a problem, with an average of 11 sheep killed per year between 2001-11. In 2008, provincial wildlife biologists estimated there to be between 5300 and 6600 bighorn sheep in BC.

Overharvesting was a historic threat, but current threats include habitat loss, degradation and fragmentation; livestock ranching (through disease transmission, range depletion and resource competition); and harassment by the public (BC Conservation Data Centre 2017). According to Demarchi et al. (2000a), bighorn sheep populations exhibit extreme periodic (approximately every 20-25 years) fluctuations. These severe die-offs are thought to be a natural phenomenon that occur when populations exceed their carrying capacity, "though it is likely that the mortality rates that typify these die-offs are now higher due to the introduction of exotic diseases and human-caused reductions in habitat."

Current management goals for the regional bighorn population include ecosystem restoration activities, invasive plant management, and protection of good quality habitats.

Moose:

Moose are provincially Yellow-listed and their status is S5 (2015). The most recent population review (2014) indicates a provincial estimate of 120,000 to 205,000 moose, and suggests that the population has declined by approximately 27,500 moose since 2011 (BC Ministry of Forestry, Lands and Natural Resources 2015). Population densities vary greatly from place to place, mostly in response to snow depth and the supply of winter browse.

Within the past decade, Poole et al. (2007) reviewed (then) current and historic population information about moose in the Kootenay Region, including analysis of what was known about population dynamics that could be used to set harvest and conservation objectives. Two years later, Stent (2009) conducted an aerial inventory to provide an estimate of moose numbers in the Spillimacheen drainage and surrounding watersheds (Management Unit 4-34). Stent suggested that the moose population in MU 4-34 is depressed, although suitable moose habitat was not limited. He added that hunter harvest data showed a decline in harvest and hunter success over the past 15 years, suggesting moose numbers had declined. The population decline was attributed to ingrowth of highly valuable habitats and possible increased predation rates from an increasing wolf population.

According to Blood (2000), moose usually migrate between winter-spring ranges in valley bottoms and higher-elevation summer ranges, but some moose remain in the valleys year-round. Poole and Stuart-Smith (2005) examined moose winter habitat, and suggested that managers wishing to improve late-winter forage for moose should enhance production of willow, dogwood and Saskatoon because these are preferred browse species. In winter, Moose need the dense browse stands that occur mostly along rivers, around wetlands, in burns and logged areas, on the lower parts of avalanche tracks, and in the subalpine Spruce-Willow-Birch Zone (Blood 2000). In terms of habitat management, Poole suggested that core forage areas could be in moister areas or riparian habitats for the greatest growth of preferred shrubs, and riparian floodplains could be managed to provide continual forage.

The provincial framework for moose management was developed by the Provincial Moose Management Technical Team in 2015. The purpose of the framework is to provide guidance on provincial direction for

moose management, outline an approach for preparing regional moose action plans, and establish the scientific basis for making moose harvest management decisions.

Deer:
Very few documents within the CWSP database concern themselves exclusively with deer, especially within the low elevation wetland landscape. A number mention deer peripherally in discussions of aerial surveys of moose, goats, elk or caribou, or in higher elevation winter range. Brydon (2011) discusses the issue of urban deer management in the District of Invermere and provides management recommendations. Other documents discuss wildlife damage on agricultural land (Bowden 1987; Closkey 1988) and "conflict between the ranching community and wildlife interest groups in the East Kootenay" (Gayton and Hansen 1998). The latter document provided numerous recommendations and management strategies for implementing them.

White-tailed Deer:
White-tailed deer are provincially Yellow-listed and their status is S5 (2015). According to Blood (2000), for most of the year, valley bottoms are the main habitat for white-tailed deer in British Columbia: "In the East Kootenay area, deer find winter range on south- to southwest-facing slopes and on fans and terraces where shrub stands have developed after wildfires, logging, or land-clearing for agriculture. They also use aspen, cottonwood, and willow groves along rivers and around wetlands in early winter before the snow gets too deep." Seasonal movements are mostly upstream or downstream along the major valleys, or cross-valley from north-facing slopes in summer to south-facing sites in winter. In summer, the deer migrate to floodplains and adjacent terraces, and the best summer ranges occur in well-developed riparian habitats – for example, along large rivers such as the Columbia.

Mule deer:
Mule deer are provincially Yellow-listed and their status is S5 (2015). Mule and black-tailed deer are both members of the same species, *Odocoileus hemionus*. In BC, the Coast Range largely separates the ranges of the two sub-species, particularly in winter, but where their ranges meet, the two sub-species will interbreed (Blood 2000).

Mule Deer Composition Surveys were conducted between 2009 and 2012 to measure changes in population demographics in response to hunting regulations (Stent and Szkorupa 2012). According to the authors of the survey report, the surveys could not detect changes in population size, and further research into factors limiting population growth was suggested to address mule deer population declines in the region.

The Ministry of Forests, Lands and Natural Resource Operations (FLNRO) developed the Kootenay-Boundary Mule Deer Management Plan 2014-2018 to "address stakeholder concerns with current hunting regulations and to establish appropriate management actions meant to increase mule deer abundance so hunting opportunity can be enhanced." The management plan outlines objectives and

actions including predator management, habitat management, access management, and hunter engagement.

Mountain Goats:
Although mountain goats are a regionally important species, they are not found within the lower elevation landscape of the wetlands and adjacent uplands, and are outside the scope of this report. However, many documents within the CWSP database discuss the status and management of mountain goats (Poole 2006; Wilson 2005). They have been provincially Blue-listed (2015) by the BC Conservation Data Centre, and the provincial population is estimated at 41,000-66,000 animals. According to the BC Conservation Data Centre (2017), mountain goats are widespread in the province with a large population size, but they face threats throughout much of their range and have undergone some decline in population, with continuing declines in some areas of the province, especially in the south.

Caribou:
Caribou in this region are part of the "Southern Group." This group predominantly uses high elevation mature and old subalpine forests in mid and late winter where they forage on arboreal lichens, but in early winter, and during spring, they use lower elevation mature and old forests, with some subpopulations moving down into cedar/hemlock forests in valley bottoms (Environment Canada 2014).

This group is Red-listed in the province, its provincial status is S1 (2017), and it is listed as Endangered by COSEWIC (2014). The current estimate for the population is 1,356 mature individuals, which has declined by at least 45 percent in the past three generations, and 27 percent since the last COSEWIC assessment in 2002. According to the proposed Recovery Strategy (Environment Canada 2014), the primary threat to most local population units of southern mountain caribou is unnaturally high predation rates as a result of human-caused and natural habitat loss, degradation, and fragmentation. Apps and McLellan (2005) also suggested that habitat fragmentation across their range may be affecting caribou population connectivity and conservation.

Dozens of reports have been written about caribou since 2000, including the proposed Recovery Strategy. Studies range from habitat selection (Apps 2001) and the role of predation (Wittmer et al. 2004), to spatial factors related to mortality and population decline (Apps et al. 2013) and management options and related actions (Mountain Caribou Science Team 2006).

3.4.5 Predators

Cougar:
Cougar are Yellow-listed in BC and their provincial status is S4 (2015). No reports within the CWSP database refer solely to cougars, however, cougar are frequently mentioned in documents that discuss wildlife predation e.g., Apps et al. (2013) and Wilson (2009). One document, Inventory Methods for Wolf and Cougar (BC Ministry of Environment 1998) discusses the status of both wolves and cougar and provides standard methods of conducting inventories for both species. In 1991, the population of cougar

in BC was considered to be stable to increasing, with an estimated population of 3000 animals (BC Wildlife Branch 1991).

It has been suggested that cougar distribution in BC is governed by the distribution of its major prey species, deer. Summer observations are scanty, but as the snow recedes cougar probably spread out from the lower slopes and valley bottoms to inhabit virtually all elevations within their general distributional boundaries. During winter months, cougar follow the deer down to the lower elevations. "They seem to prefer the rough, rocky, semi-open areas surrounding the major deer winter ranges (in the Interior), but they do not confine their activities exclusively to this type of habitat, and cougar signs can be found anywhere within a game winter range."

Lynx:
The provincial status of the Canada Lynx is S5 (2015) and it is provincially Yellow-listed. Its COSEWIC status is Not at Risk (2001). According to the BC Conservation Data Centre (2017), lynx populations exhibit distinct cycles, and are tied to population cycles of snowshoe hares. Provincial estimates range between 20,000 and 240,000 from lowest to peak population, "although these figures are very rough and difficult to validate."

Lynx are mentioned in very few studies listed in the CWSP database, probably, in part, because their preferred and typical habitat is at higher elevation than the Columbia Wetlands and adjacent benchlands. Lynx ecology and conservation requirements were examined in the southern Canadian Rockies as part of the multi-year Southern Canadian Rockies Lynx Project (Apps 2000). Within that study the author suggests that concern for lynx conservation relates primarily to intensive forest management and human-caused habitat fragmentation at several scales. Apps et al. (2007) consider the resilience of lynx is the southern Canadian Rockies to be low in light of their "specialized habitat and prey adaptations, low productivity of local populations, and the continued importance of regional-scale movements to population persistence."

Bobcat:
The provincial status of the bobcat is S5 (2015) and it is provincially Yellow-listed. Its COSEWIC status is Not at Risk (2001) (BC Conservation Data Centre 2017).

There is very little mention of bobcat within the CWSP database. Apps et al. (2007) consider the overall resilience of bobcats to be moderate in the southern Canadian Rockies. They further suggest that bobcats are more flexible in their foraging behaviour than lynx, and are thus expected to be more resilient to population fluctuations of various prey species. They also suggest that bobcat distribution is restricted by winter snow and temperature conditions. According to E-Fauna BC, British Columbia has the largest amount of bobcat habitat in Canada, and bobcat prefer woodlands but does not depend exclusively on forested sites. In winter, it is primarily found in lowland mature forest habitats.

Grey Wolf:
The Grey Wolf is provincially Yellow-listed and its status is S4S5 (2015). Its COSEWIC status is Not at Risk because it has a widespread, large population with no evidence of decline over the last 10 years (Wilson 2014).

Wolves are discussed peripherally in several documents within the CWSP database with regard to their role as predators (Wilson 2009; Stent 2009). Callaghan (2002) studied the ecology of the wolf, but the study area was confined to the central Rockies and outside the area of the interest for this report. Inventory Methods for Wolf and Cougar (BC Ministry of Environment 1998) discusses the status of both wolves and cougar in the province and provides standard methods of conducting inventories for both species.

The Management Plan for the Grey Wolf (*Canis lupus*) in British Columbia (Wilson 2014), states that the abundance and distribution of ungulate prey, human-caused mortality, space/intraspecific strife, and disease limit and/or regulate the distribution and abundance of wolves in BC. The management plan also states that hunting and trapping are considered the only measurable threats to the grey wolf, and that these threats have a low impact on this species because of the wolf's natural resilience, adaptability, and expanding population. There is currently no evidence that there are significant conservation concerns for wolves in BC. "The goal of wolf management in BC is to ensure a self-sustaining population throughout the species' range and to ensure that, within the biological limits of the species, wolves are available in sufficient abundance to fulfill their ecological role, and to meet the cultural, recreational, and economic needs of society" (Wilson 2014).

Bears:
Riparian areas are important for bears during spring because they provide fresh vegetation, however, most studies of bears within the region focus on sub-alpine and alpine environments, which are outside the scope of this report.

Several studies have been conducted on transportation corridors in and around the Columbia River valley bottom, but very few details have emerged regarding their use of wetland and riparian habitat. It is believed that both black and grizzly bears may be susceptible to habitat fragmentation, however, research findings suggest that black bears are more resilient than grizzly bears and show more tolerance to human-associated disturbances, such as roads and settlements than do grizzly bears (Munro 1999). Adams (2010) suggested that while grizzly and black bears "do not necessarily have conservation concerns," well-planned corridors are needed to direct individuals away from human activity, and there are connectivity concerns for both species at the larger cross-valley scale.

Grizzly bears:
Grizzly bears are classified as a species of Special Concern by COSEWIC (2012) and are ranked as S3 (Vulnerable; 2012) in BC by the Conservation Data Centre. Population estimates for grizzly bears in BC have changed over the years, as new and more sophisticated methods for estimating populations have

become available; the 2012 estimate was 15,000. Although populations are considered stable, habitat fragmentation at the southern extent of grizzly Bear range is occurring, and it has been suggested that there is a continuing decline in area, extent and/or quality of habitat in southern Alberta and BC (COSEWIC 2012). The COSEWIC Status Report also suggests that there is strong evidence of genetic fragmentation in the southern parts of its range where some populations are increasingly isolated.

Numerous studies have examined grizzly bears through the Eastern Slopes Grizzly Bear Project, which began in 1994 and continued until the early 2000s. No studies in the database specifically mention grizzly bear in the Columbia Wetlands. Apps et al. (2004) studied grizzly bear distribution and abundance within the Upper Columbia River basin to evaluate relationships of grizzly bear detections with landscape variables of habitat and human activity. In very general terms, grizzly bears were generally not detected with wetland complexes of the Columbia Valley, due to habitat and/or human influence. According to Apps et al. (2004), study results lend support to the contention that grizzly bear persistence is determined by three general factors: habitat quality, the number of humans within that habitat, and the behaviour of those humans. Further to that study, Apps (2010) provided general direction and strategy for planning and funding future programs of grizzly bear population inventory and monitoring across BC. Adams (2009) stated that grizzly bears are seldom observed at lower elevations in the Rocky Mountain Trench and the species is generally restricted to the surrounding benchlands and higher elevations. He further notes that while there is very limited east – west movement of grizzly bears between Purcell and Rocky Mountain systems, “there are greater opportunities for cross-trench movement of grizzly bears north of Radium Hot Springs.”

According to COSEWIC (2012), the grizzly bear is a habitat generalist, found in diverse habitats from sea level to high elevation alpine environments. Grizzly bear habitat associations are strongly seasonal and typically reflect local plant development and prey concentrations. Proctor et al. (2007) examined the abundance and density of grizzly bears in southeastern BC. In terms of habitat use, they found that in June and July bears selected habitats that were higher elevation, rugged terrain, in alpine or avalanche chutes. Interestingly, wet areas were avoided. The authors suggest that this is likely due to their association of wet areas with valley bottom roads. Riparian habitats associated with parks were selected while riparian habitats associated with roads were avoided.

According to the BC Ministry of Forestry, Lands and Natural Resources (2012), grizzly bear populations in this region of the province remain viable. The cumulative effects of human development are the greatest threat to grizzly bears in BC. Proctor et al. (2007) suggest that key areas of the province, where humans and grizzly bears extensively overlap should be considered for periodic surveys of grizzly bear abundance. Note: In August, 2017, the BC government enacted a ban on grizzly bear trophy hunting. The ban will be effective as of Nov. 30, 2017.

Black Bears:
According to the BC government (Blood 2001) black bears inhabit all areas of the province except most urban cores. They are relatively numerous and tolerant of human activities and as a result are the most commonly encountered large carnivore in the province. The 2001 estimate of the black bear population in British Columbia was 120,000–160,000. Although bear numbers vary from year to year and habitats available to them are slowly shrinking due to land development, the species is not currently rare, threatened, or endangered in British Columbia. It is Yellow-listed, and provincially ranked as S5 (Feb 2015). COSEWIC status is "Not at Risk" (1999).

The habitats that black bears use are as varied as the food they eat – forests, wetlands, subalpine meadows, avalanche chutes, riparian habitats, and beaches. The five-year Western Slopes Bear Research Project (1994-1999) assessed population characteristics, habitat use and movement of black bears and grizzly bears in the west slopes of the Rockies and east slopes of the Columbia Mountains near Golden, BC. A progress report was published in 1997 (Woods et al. 1997), but no final report was available. Reynolds (2002) concluded that neither the Columbia River nor the TransCanada Highway acted as barriers to black bear movement and were therefore not responsible for fragmenting the Upper Columbia River region black bear population.

Mowat (2007) collated existing data for large carnivores in the Kootenay region including that of kill levels and hunter success. Mowat concluded that there may have been modest declines in black bear numbers in the last three decades but a major decline in numbers was unlikely, adding that more certain conclusions were not possible with current data. He also restated the conclusions of others that black bears occur at higher densities in low elevation densely forested areas compared to more rugged mountainous areas, likely because competition with grizzly bears is greater in upper elevation areas where there are few trees to provide refuge from grizzly bear aggression.

Wolverine:
Although wolverine have been well studied in the past decade, very little is known about the size of the population of wolverine in British Columbia, and even less is known about wolverine in this region. There are few reports about wolverine within the Upper Columbia Valley, and they inhabit terrain that is outside our area of focus. The western Canadian population of Wolverine (*luscus* subspecies), those found in BC, are listed as a species of Special Concern by COSEWIC (2003). Their provincial status is S3 (2015) and they are Blue-listed in BC (BC Conservation Data Centre 2017). Lofroth and Krebs (2007) estimated a population of 3,530 wolverines in BC based on habitat modeling, and Weir (2015) suggests that the Columbia Mountains in southern BC represent the bulk of the southeastern occurrence of the species in the province.

Apps et al. (2007) studied core areas and connectivity for carnivores (including wolverine) in the southern Canadian Rockies, stating that "across our regional study area, wolverines are expected to be distributed at low densities, but are more likely to be associated with cooler, montane to subalpine forested ecosystems." Weaver (2013) defined critical wildlife landscapes in the southern Canadian

Rockies for vulnerable fish and wildlife, including the wolverine. A recent study on the abundance and distribution of wolverine in the Kootenay Region (Hausleitner and Kortello 2016) examined wolverine in the central Purcell Mountains where they estimated a population of 7-12 individuals, less than half of the expected population size of 24. The study area was outside the area of interest of this report, however it provides a basis for management recommendations in the region. Another regional study, Clevenger et al. (2016), examined landscape and human effects on wolverine abundance, distribution and connectivity in the Canadian Crown of the Continent (CCoC) ecosystem.

Weir (2004) provides species information as well as recommendations for management of wolverine habitat and conservation planning. Weir (2015) suggests that insufficient information on the effects of habitat fragmentation is hampering our ability to determine "the sustainability of [wolverine] populations, mitigate effects of development, and determine the harvest that these populations can sustain, which may result in diminished population sustainability over the long term."

3.4.6 Other Species

Badger:

All badgers in BC belong to the *T. taxus jeffersonii* sub-species, and are designated as endangered by COSEWIC (COSEWIC 2012). Provincially, badgers are ranked S1 (critically imperilled) and Red-listed, receiving the highest conservation priority under the province's Conservation Framework. As few as 100 mature badgers live in the East Kootenay region where they are vulnerable to increasing threats from roadkill and loss of habitat. (In 2008 the total BC population was estimated to be 230 – 340 individuals.) Habitat loss results from various sources, primarily urban development, forest ingrowth and encroachment into open forest and grassland ecosystems, fire suppression, intensive agriculture, and highway rights-of-way. There is no hunting or trapping season in BC, however, killing badgers on private land in defence of property is legal in the province.

The *jeffersonii* Badger Recovery Team produced the Recovery Strategy for the Badger in British Columbia in 2008. The long-term goal is to achieve and ensure a viable population of badgers throughout their historic range in BC. The five-year goal is to increase the total badger population in BC to a minimum of 400 adults (*jeffersonii* Badger Recovery Team 2008). In 2008, the Science Recovery Implementation Group (*jeffersonii* Badger Recovery Team) identified areas in which additional information was needed to effectively recover *jeffersonii* populations. The team suggested that data is needed on mortality factors, prey ecology, diet, distribution and abundance, population ecology, monitoring, atypical habitat, and stewardship. In addition to identifying areas of need, the team generated a detailed list of questions to be answered, some of which have now been at least partially answered. Studies in the last decade include: Badger Roadkill Risk in Relation to the Presence of Culverts and Jersey Barriers (Kinley and Newhouse 2009), Badger Wildlife Habitat Decision Aid (Weir and Almuedo 2010), and Badger Resource Selection in the Rocky Mountain Trench of British Columbia (Kinley et al. 2013). Many other studies on habitat fragmentation and regional wildlife mention badgers within their discussions.

Beaver and Muskrat:
Several other species of mammals inhabit the Columbia Wetlands and adjacent low elevation lands. Beaver (*Castor canadensis*) is found throughout the area where suitable food sources are found close to water and where water levels are deep enough to avoid freezing to the bottom during winter. According to McPherson et al. (2010), beavers are especially important to ecosystem functions through water containment by dam building.

Beaver have been implicated as an agent of change in levee vegetation and levee breaks on the wetlands, and both beaver and muskrat as agents of vegetation change in riparian areas (Jamieson et al. 2009; Science Committee: Columbia Wetlands Stewardship Partners 2010). This is an important topic, but it is not well represented in the CWSP database. The proposed management plan for the Columbia National Wildlife Area (Gebhauer and Huntley 2016) mentions beaver as a threat to cottonwood stands and riparian areas. According to McPherson et al. (2010), muskrat are abundant throughout the wetland areas, but they are mentioned only peripherally in the database, once as prey for badgers (Hoodicoff 2006) and at other times in association with reviews of other wildlife and habitat. Muskrat feed on aquatic and emergent vegetation as well as occasional animal sources including mussels.

McPherson et al. (2010) suggest that low elevation riparian habitats are also important to otters, small rodents and bats. “Emergent insects from adjacent water bodies are often more abundant over warmer lakes and wetland areas, and adjacent roosting opportunities in cliff fissures, dead or dying trees or human-built structures likely makes wetland areas important bat habitat.”

Invertebrates:
Few documents within the CWSP database refer solely to the status or ecology of invertebrates within the region. Several studies included sampling for benthic invertebrates, including Columbia Lake Sensitive Habitat Inventory and Mapping (McPherson et al. 2010), and Westcott et al. (1999), who collected benthic invertebrates from two sites on Windermere Creek. McPherson et al. (2014) reviewed the health of Windermere Creek using the results of benthic invertebrate and water quality monitoring from 2009 to 2012, and another study by McPherson et al. (2014) reviewed the health of three Columbia River tributaries using the results of benthic invertebrate and water quality monitoring from 2009 to 2012.

Dragonflies have received some attention within this region. Cannings (2000; 2001) discusses the presence of dragonflies in the Columbia Basin and in James Chabot Provincial Park (Athalmer), noting that 26 species of Odonata are known from the park (30 percent of BC’s 87 species), and another 16 species “are not yet known, but expected to occur in the park’s marsh or along the lakeshore.” Cannings (2002) further discusses rare dragonflies in a pamphlet created for the BC Ministry of Water, Land and Air Protection series, British Columbia Wildlife at Risk. Cannings et al. (2010) reports on fireflies in BC, including one species which is restricted to the East Kootenay region.

Scudder (1996) stated that "No ecoregion, biogeoclimatic subzone, ecosystem, or habitat in British Columbia has been thoroughly surveyed for invertebrates. In fact, many have yet to be studied for the first time." More recently, Heron (2004) suggested that data on the distribution of many invertebrates in the province is nonexistent, old, or lacking and that "there is a strong need for expertise and specialization on a local, regional, and provincial scale for all invertebrate groups. Heron (2004) provides a list of 16 terrestrial and freshwater at-risk invertebrates assessed by COSEWIC which occur in BC.

Freshwater Mussels:
The Science Committee: Columbia Wetland Stewardship Partners (2010) states that there are "significant freshwater mussel beds" in Columbia and Windermere Lakes, and that these species are sensitive to water quality issues. Gelling et al. (2008) provides brief notes on a short survey carried out in the Upper Kootenay and Columbia watersheds by the Conservation Data Centre. No listed species were found.

3.5 Invasive Species

Invasive species have received considerable attention within the region in the past decade. Documents within the database range from aquatic invasive species surveys (Darvill 2015) and survey methods (Inter-Ministry Invasive Species Working Group 2015), to planning documents such as the Columbia Shuswap Invasive Species Society Strategic Plan 2013 to 2018 (Columbia Shuswap Invasive Species Society 2013), Canadian Columbia Basin Regional Framework for an Aquatic Invasive Species Program: 2015 to 2020 (Craig 2016), Akisqnuk First Nation Invasive Plant Management Plan (Kaisner 2016), and East Kootenay Invasive Plant Council 2013-2018 Regional Strategic Plan (East Kootenay Invasive Plant Council 2013).

Several year-end reports provide updates on the status of invasive species within the region. Hooper et al. (2016) describe in detail the activities undertaken by the Columbia Shuswap Invasive Species Council. These activities included, among other things, responding to 136 invasive species reports and noxious weed complaints; completing 278 new site surveys, 986 invasive species surveys, 28 biological dispersal monitoring surveys and 12 mechanical treatment sites; and completing 148 new plant surveys of the high priority invasive species knotweed. The Columbia Shuswap Invasive Species Society also published an updated priority species list, including those species for which there is insufficient information on their "distribution, impacts, potential for spread, and/or feasibility of control" (Columbia Shuswap Invasive Species Society 2017).

The East Kootenay Invasive Species Council published a report discussing invasive plants in different regions of the East Kootenay and what is being done to manage them (East Kootenay Invasive Species Council 2016). A portion of the Columbia Wetlands fall under their jurisdiction, and within that report they included a regionally-relevant invasive plant priority list.

Darvill (2015) discussed sampling results and provided recommendations within her report on aquatic invasive plant sampling in Lake Windermere. According to Darvill, no aquatic invasive plants been found to date within the entire Columbia Wetlands ecosystem. However, due to the severe negative consequences of Eurasian Milfoil, zebra/quagga mussels and other aquatic invasive species, Darvill recommends that a permanent boat washing station be established at the lake, and that the monitoring program continue, and be expanded to include sampling by boat. The provincial government has established seasonal boat-washing stations at several locations within the region to control the spread of aquatic invasive species.

The Columbia Basin Riparian and Wetlands Action Plan (FWCP 2014) suggests that while aquatic invasive species have not had a major impact on ecological processes in the wetlands, terrestrial invasive plants are a concern in many adjacent areas. The plan states that Wild rice (*Zizania sp*.) is present in at least one marsh in the wetlands, but it does not appear to be invasive to date, and is heavily used by waterfowl. They also suggest that there is minimal data on the presence of reed canary grass or other invasive grass/reed species that may have an impact on wetland and riparian function.

Craig (2013) states that border areas between invasive plant committee areas are high priority for annual surveys to detect new invasive species, and Highway 95 south of Parson has been identified as a priority in the Columbia Wetlands region. Craig also states that the primary focus of invasive plant management in the Invasive Plant Management Area (IMPA) within which part of the Columbia Wetlands falls (Golden IPMA), is "the protection of ecological values, agriculture and forestry, keeping the region as invasive plant-free as possible since it borders Alberta and the Regional District of East Kootenay which both have active treatment programs." This document includes maps which illustrate the location of invasive species in the region.

The Science Committee: Columbia Wetland Stewardship Partners (2010) identified the potential for the diatom didimo (rock snot) to invade the wetland system because it has caused concern in nearby watersheds. They also identified other potentially invasive species, including: tamarisk, a species of crayfish, and a water flea, which are all regarded as species of concern in watersheds within the region.

4.0 Mapping in the Wetlands: Available Resources and Sources

4.1 Database Resources

The Biodiversity Atlas of British Columbia is a good "first stop" for mapped information regarding species and spaces in the province. The Atlas includes sixty descriptive maps and accompanying text, and provides a broad overview of the province's range of terrestrial and freshwater biological diversity (Austin and Eriksson 2009). The web-based *Columbia River Basin* Biodiversity Atlas provides interactive maps and background information on species and ecosystems within the Columbia Basin.

A number of mapping projects have been described elsewhere within this report, including the Columbia River Wetlands Inventory Report (Worgan 2004); and Machmer's 2004 small wetland

literature review and mapping project, which focused on the classification, significance, inventory and conservation of wetland habitats in the Columbia Basin Fish and Wildlife Compensation program area.

Darvill (2016) conducted an inventory and mapping project on six wetlands located on the West Bench of the Columbia Valley, above the west side of the Columbia River Wetlands Wildlife Management Area. According to Darvill, the goal of the project was to start gathering information about different wetland classes, site units, and plant associations found in the region, and to identify unique or rare features, and disturbances or threats to the wetland ecosystems. The report also provided recommendations for restoration or conservation initiatives. The author noted that invasive plant species were present in all surveyed wetlands.

Both Columbia Lake and Lake Windermere have had shoreline mapping and inventories completed within the past decade, some of which have been mentioned previously. Summary maps are available in Windermere Lake Foreshore Inventory and Mapping (McPherson and Michel 2007); Windermere Lake Foreshore Fish and Wildlife Habitat Assessment: Appendix E (McPherson and Hlushak 2008); Columbia Lake Foreshore Inventory and Mapping (McPherson et al. 2009); Columbia Lake Sensitive Habitat Inventory and Mapping (McPherson et al. 2010); and Columbia Lake Shoreline Management Guidelines for Fish and Wildlife Habitats (McPherson and Hlushak 2010).

The BC Grasslands Mapping Project compiled existing information and inventories to create a GIS to "identify, analyze and model BC's grasslands, specifically those areas considered high value or threatened." According to the authors, most of the grasslands in the East Kootenay Trench occur along meandering river breaks and on the benches above the Kootenay, Columbia and St. Mary's rivers. The report includes maps of the region, and discussions about land status and tenure, historical extent, non-native invasive plants, and species at risk in grassland and associated habitats in the East Kootenay.

Several older mapping projects were carried out in the Columbia Wetlands or adjacent benchlands. Habitat and Terrain Mapping (1:20000 scale) was done for the Columbia River Marshes between Canal Flats and Edgewater, and Edgewater and Donald Station (Clement and Maynard 1982). The maps were created through a combination of air photo interpretation, field survey, and soil and vegetation analysis. Pedology Consultants created maps to accompany Opportunities for Wildlife and Recreation Development Within the Columbia River Marshes (1983) based on that habitat and terrain assessment. Efforts were also made to map floodplains, including: Columbia River: Columbia to Windermere Lake - Floodplain Mapping (BC Water Surveys Unit 1980); Columbia River: Windermere Lake - Radium Floodplain Mapping (BC water Surveys Unit 1982); and Floodplain Mapping Program Kootenay River at Canal Flats and Columbia Lake (Sellars 1990).

The database also includes various terrain and ecosystem mapping projects done to support the forestry industry.

4.2 Web-based Mapping Resources

Table 2. Annotated list and links to provincial mapping programs and resources

iMapBC	The BC Conservation Data Centre (CDC) maps known element occurrences (an area of land and/or water where a species or ecosystem is known to occur) of red- and blue-listed species and ecosystems. The CDC database includes the best available information and is updated on a regular basis.	http://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc
BC MoE EcoCat	The Ecological Reports Catalogue	http://a100.gov.bc.ca/pub/acat/public/welcome.do
BC Species & Ecosystems Explorer	Use the BC Species and Ecosystems Explorer to search for data and information about plants, animals and ecosystems in BC.	http://a100.gov.bc.ca/pub/eswp/
Satellite Imagery	Satellite Imagery from Government of Canada Open Maps	http://open.canada.ca/en/open-maps
Digital Imagery	The BC Government's digital imagery warehouse has several series of images in its inventory, including those taken by Canadian satellites RADARSAT-1 and RADARSAT-2.	http://www2.gov.bc.ca/gov/content/data/geographic-data-services/digital-imagery/satellite-imagery
1:20,000 Base Map	Terrain Resource Information Management (TRIM) provides the base data for the Province of British Columbia. TRIM is a set of three-dimensional digital files that support development and management of land-related information.	http://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/terrain
Orthophotos	Orthophotos available for selected areas of BC in black & white or colour. Most images have a pixel resolution of 1 metre, with some colour orthophotos available at 0.5 metre resolution.	http://www2.gov.bc.ca/gov/content/data/geographic-data-services/digital-imagery/orthophotos
The Freshwater Atlas	Designed to be the definitive source for mapping freshwater features in BC. The atlas provides a consistent base and coding system, ensuring the province's various freshwater-related inventories are tied to a common base.	https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-wetlands
BECweb: Biogeoclimatic Ecosystem Classification (BEC)	Access point for current and historical reports, maps, software, and other products of the program. Field maps are designed for field applications where a detailed base map is required. The maps show the Biogeoclimatic Units (Zone, Subzone, and Variant --and Phase if applicable) and a full NTS 1: 250,000 base including contours with 100-meter intervals.	https://www.for.gov.bc.ca/hre/becweb/resources/maps/index.html
BC Grassland Mapping Project	A BC grasslands Geographic Information System (GIS) and associated 1:20 000 scale maps for the whole province.	http://bcgrasslands.org/index.php/what-we-do/conservation-a-mapping/bc-grasslands-mapping-project
Broad Ecosystem Inventory (BEI)	A method of classifying and mapping broad ecosystem habitats, their suitability (existing productivity with present vegetation) and capability (potential productivity with optimal vegetation for a species) of the land to support various wildlife species.	http://www.env.gov.bc.ca/ecology/bei/base_data.html
Describing Terrestrial Ecosystems	Access to the Resources Information Standards Committee (RISC) approved field inventory methodology "Field Manual for Describing Terrestrial Ecosystems" (DTEIF) and companion material. The objective of the DTEIF standard is to assist field surveyors in the collection of ecological data and to ensure all data is collected in a consistent and standardized method throughout BC.	http://www.env.gov.bc.ca/ecology/dteif/index.html

5.0 Current Management and Action Plans

Table 3. Management, Strategy and Recovery Plans (Species)

Mammals	A Strategy for the Recovery of Mountain Caribou in British Columbia	The Mountain Caribou Technical Advisory Committee	2002
	Management Options and Related Actions for Mountain Caribou in British Columbia	Mountain Caribou Science Team	2006
	Recovery Strategy for the Woodland Caribou, Southern Mountain Population (*Rangifer tarandus* caribou) in Canada (proposed)	Environment Canada	2014
	Kootenay Elk Management Plan 2010 to 2014	BC Ministry of Environment	2010
	Kootenay-Boundary Mule Deer Management Plan 2014-2018	BC Ministry of Forests, Lands and Natural Resource Operations	2014
	Management and Protection of Badgers in the East Kootenay of British Columbia - Draft	Newhouse	2001
	National Recovery Strategy for American Badger, *jeffersonii* subspecies (*Taxidea taxus jeffersonii*) draft paper	*jeffersonii* Badger Recovery Team	2003
	Recovery Strategy for the Badger (*Taxidea taxus*) in British Columbia. British Columbia Recovery Strategy Series	*jeffersonii* Badger Recovery Team	2008
	Management Plan for the Grey Wolf (*Canis lupus*) in British Columbia	Wilson	2014
	Provincial Framework for Moose Management in British Columbia	BC Ministry of Forests, Lands and Natural Resource Operations	2015
Birds	Bird Conservation Strategy for Bird Conservation Region 10 Pacific and Yukon Region: Northern	Environment Canada	2013
	Management Plan for the Flammulated Owl (*Otus flammeolus*) in Canada and in British Columbia	Environment Canada	2013
	Management Plan for the Lewis's Woodpecker (*Melanerpes lewis*) in Canada	Environment Canada	2014
	Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada	Environment Canada	2016
	Recovery Strategy for the Lewis's Woodpecker (*Melanerpes lewis*) in Canada (Proposed)	Environment Canada	2016
At-risk, Invasive, and Pest Species	CSRD Pest Management Plan. Mosquito Control Management Plan for Golden, Revelstoke & Scotch Creek	Columbia-Shuswap Regional District	2016
	A Management Strategy for Species at Risk in a Semi-Urban Landscape on the Shuswap Reserve Invermere, BC	Jamieson et al.	2009
	Conservation Framework Conservation Priorities for Species and Ecosystems Primer	BC Ministry of Environment	2009
	Akisqnuk First Nation Invasive Plant Management Plan	Kaisner	2016
	Columbia Shuswap Invasive Species Society Strategic Plan 2013 to 2018	Columbia Shuswap Invasive Species Society	2013
	East Kootenay Invasive Plant Council 2013-2018 Regional Strategic Plan	East Kootenay Invasive Plant Council	2013
	Operational Plan for Terrestrial Invasive Plants in the Columbia Shuswap 2014-2019	Craig	2013
	Recovery Strategy for the Southern Maidenhair Fern (*Adiantum capillus-veneris*) in British Columbia	Smith et al.	2007
	Recovery Strategy for the Southern Maidenhair Fern (*Adiantum capillus-veneris*) in Canada	Sadler	2013

Table 3. Management, Strategy and Recovery Plans (Species cont')

Fish	Management Plan for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in British Columbia	BC Ministry of Environment BC Freshwaters Program	2014
	Columbia River White Sturgeon Management Plan. Monitoring Program and Physical Works Annual Report: 2015	BC Hydro	2015
	Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada. In Species at Risk Act Recovery Strategy Series	Fisheries and Oceans Canada	2014
	Upper Columbia White Sturgeon Recovery Plan	Upper Columbia White Sturgeon Recovery Initiative	2002
Reptiles and Amphibians	Management Plan for the Northern Rubber Boa (*Charina bottae*) in British Columbia	Gregory	2015
	Management Plan for the Painted Turtle – Intermountain–Rocky Mountain Population (*Chrysemys picta* pop. 2) in British Columbia	BC Ministry of Environment	2017
	Management Plan for the Western Toad (*Anaxyrus boreas*) in British Columbia	Provincial Western Toad Working Group	2014
	Recovery Plan for the Northern Leopard Frog (*Lithobates pipiens*) in British Columbia	Northern Leopard Frog Recovery Team	2012
	Recovery Strategy for the Northern Leopard Frog (*Lithobates pipiens*), Rocky Mountain Population in Canada (proposed)	Environment and Climate Change Canada	2016

Table 4. Management, Strategy and Action Plans (Land and Water)

Guidelines and Plans	Develop with Care: Environmental Guidelines for Urban and Rural Land - Kootenay Boundary Region	BC Ministry of Forests, Lands and Natural Resource Operations	2014
	The Columbia Wetlands Wildlife Management Area: Operational Plan - 1998-2002	Jamieson and Hennan	1998
	Management Plan for the Columbia National Wildlife Area (Proposed)	Gebhauer and Huntley	2016
	Implementation Plan: Wetlands and Associated Species	Columbia Intermountain Joint venture	2010
	Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia	Cox	2009
	Spillimacheen Project Water Use Plan	BC Hydro	2005
Action Plans	A Wetland Action Plan for British Columbia	BC Wetland Stewardship Partners	2010
	Columbia Basin Plan – Draft	BC Hydro	2012
	Columbia Basin Large Lakes Action Plan – Draft	FWCP	2012
	Columbia Basin Species of Interest Action Plan – Draft	FWCP	2012
	Riparian and Wetlands Action Plan – Draft	FWCP	2014
	Upland/Dryland Action Plan – Draft	FWCP	2012
Lake Plans	Columbia Lake Management Strategy	Urban Systems	1997
	Columbia Lake Shoreline Management Guidelines for Fish and Wildlife Habitats	McPherson and Hlushak	2010
	Lake Windermere Management Plan	Berris	2011
	Lake Windermere Official Community Plan	Board of the Regional District of East Kootenay	2008; 2015
	Windermere Lake Shoreline Management Guidelines for Fish and Wildlife Habitats	McPherson et al.	2009

Table 5. Status Reports

Biodiversity	Taking Nature's Pulse: The Status of Biodiversity in British Columbia	Austin et al. (eds)	2008
Mammals	Status of Rocky Mountain Bighorn Sheep in British Columbia	Demarchi	2000
	Status of Rocky Mountain Bighorn Sheep in the East Kootenay	Teske	2015
	Status of the Badger in British Columbia	Rahme	1995
	Status of the Least Chipmunk (*Tamias minimus*) subspecies *T. m. oreocetes* and *T. m. selkirki* in British Columbia	Nagorsen	2010
Birds	Status of the Bald Eagle in British Columbia	Blood	1994
	Status of the Flammulated Owl in British Columbia	van Woudenberg	1999
	Status of the Lewis's Woodpecker in British Columbia	Cooper	1998
	Status of the Sandhill Crane in British Columbia	Cooper	1996
Fish	Status Report East Kootenay Angling Management Plan	East Kootenay Angling Management Plan Committee BC Water, Land, and Air Protection	2003
	Status of Chiselmouth (*Acrocheilus alutaceus*) in the Windermere and Columbia Lake Watersheds	Radridge	1998
	The Status of Bull Trout in British Columbia: A Synthesis of Available Distribution, Abundance, Trend, and Threat Information	Hagen	2011

Table 6. COSEWIC Assessments and Status Updates

Plants	COSEWIC Assessment and Status Report on the Limber Pine *Pinus flexilis* in Canada	Achuff	2014
	COSEWIC Assessment and Update Status Report on the Southern Maidenhair Fern *Adiantum capillus-veneris* in Canada	COSEWIC	2000
Mammals	COSEWIC Assessment and Status Report on the American Badger *Taxidea taxus* in Canada	COSEWIC	2012
	COSEWIC Assessment and Status Report on the Caribou *Rangifer tarandus:* Northern Mountain population, Central Mountain population, Southern Mountain population in Canada	Cichowski	2014
	COSEWIC Assessment and Update Status Report on the Grizzly Bear *Ursus arctos* in Canada - Prairie population, Northwestern population	Ross	2002
	COSEWIC Assessment and Status Report on the Grizzly Bear *Ursus arctos* Western population in Canada	McLoughlin	2012
	COSEWIC Assessment and Update Status Report on the Wolverine (*Gulo gulo*) Eastern population, Western Population in Canada	Slough	2003
Birds	COSEWIC Assessment and Status Report on the Flammulated Owl *Otus flammeolus* in Canada	Cannings	2010
	COSEWIC Assessment and Status Report on the Lewis's Woodpecker *Melanerpes lewis* in Canada	Beauchesne	2010
	COSEWIC Status Appraisal Summary on the Long-billed Curlew *Numenius americanus* in Canada	Perkins	2011
Fish	COSEWIC Assessment and Status Report on the Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* British Columbia population, Alberta population in Canada	Costello	2006
Amphibians and Reptiles	COSEWIC Assessment and Update Status Report on the Northern Leopard Frog *Lithobates pipiens* Rocky Mountain population in Canada	Taylor	2009
	COSEWIC Assessment and Status Report on the Western Painted Turtle	COSEWIC	2006
	COSEWIC Status Report on the Western Toad	Slough	2012

6.0 Knowledge Gaps and Opportunities Identified Within Reports

6.1 Reports

Data gaps and recommended actions were occasionally included in species- and topic-specific documents found within the CWSP database. The following section briefly outlines gaps and actions considered of relevance to Columbia Wetland species of interest and wetland ecosystem elements and processes. As noted previously, these have been included for informational purposes only; the CWSP is not recommending them as actions for the Partners to undertake.

6.1.1 Water Quality and Quantity

There is consensus between documents in the CWSP database that streamflow and groundwater are poorly or inconsistently monitored in the Upper Columbia River system, and that water quality data is lacking for the wetlands and upstream reaches of the river. This lack of information has implications for conducting future research. Carli and Bayley (2015) highlight a lack of information on floodplain inundation and main channel flow rates, and the difficulty this presents when trying to interpret the relationship between fluctuating water depth and vegetation. Other authors suggest that a lack of baseline flow and quality data will hamper efforts to determine changes to the wetlands system in the future. This inability, and lack of data to document changes in habitat, means that the CWSP will be unable to know if a healthy wetland ecosystem is being maintained. This makes it difficult to fulfil CWSP's stated objectives.

Brahney (2014) identifies basin-wide knowledge gaps relating to water monitoring, groundwater resources, wet and dry deposition of atmospheric contaminants, impacts of invasive species, sources and levels of pharmaceuticals and other introduced compounds, impacts to water quality as the source of stream water changes to rain from snow and glacial melt, and understanding the cumulative effects of changes to the hydrologic system. Brahney ties opportunities to these gaps, including (among others):

- Conduct research to understand and evaluate the effects of increased evaporation on lakes, streams, and snowpack
- Conduct research to further the understanding of regional groundwater resources
- Educate local communities on the socio-economic importance of hydrometric monitoring
- Support the training of water quality testing expertise in citizen science groups

Carver (2017) also outlines opportunities to strengthen our understanding of water resources. The report identifies the need for developing a long-term backbone monitoring network to provide consistent baseline information; and the need for enhanced groundwater mapping, monitoring and analysis. In addition, Carver identifies opportunities specific to the wetlands, including: mapping and tracking small wetlands, and improving the tracking of changes to wetlands and natural lake levels. Carver further suggests that "Monitoring the extensive and relatively less-disturbed Columbia River Wetlands would be beneficial given their international status and ecological significance."

6.1.2 Climate Change

Carver (2017) suggests that, in addition to strengthening our knowledge about water resources in general, increased monitoring could improve our understanding of water storage and reliability under future conditions, and the potential impacts of climate change on wetland processes, species and habitats. Stating that "the details of how and to what extent climate change will affect groundwater resources remains unclear," Carver suggests that more work is required to evaluate the potential effects of climate change on groundwater resources.

Brahney (2014) lists specific recommendations to fill knowledge and data gaps with regard to climate change:

- Organize workshops and/or research networks to identify the needs for climate and hydrometric projections, environmental effects analyses and monitoring, engineering, natural resource management, and resource allocation
- Educate local communities on the socio-economic importance of climate monitoring
- Engage end-users to collect data that meets their needs while contributing to the provincial and federal data base e.g., support/encourage local farmers, land-owners, businesses, and industry to install automatic climate stations
- Support data collections that have the highest potential for improving both climate and hydrologic projections in the region, including paired studies of areas subject to and not subject to development
- Work with citizen science groups to incorporate measurements of ice on, ice off, and ice thickness in their protocols

Brahney also suggests that high elevation snowpack monitoring and conducting more detailed investigations into the changes in glacial mass and behavior will help to more accurately forecast changes in stream discharge.

6.1.3 Riparian and Wetland Habitat

There is a recurring theme throughout the reviewed documents that riparian and wetland habitat types have been inadequately mapped and studied throughout the Columbia Basin. This is not just a regional issue; the first goal of BC's Wetland Action Plan is to "Develop a comprehensive and reliable wetland information base to support effective planning, law-making, and policy development."

Several documents within the database suggest that we need to develop a better understanding of the critical processes that drive the presence of riparian habitat, and understand the causes of its loss. Very little information is available in long-term trends in wetland composition and distribution, and even less is known about potential changes and impact to riparian habitat and wetland-dependent species that might result from climate change.

Some reports also suggest the need to identify and document the status of fish and wildlife that are critical to maintaining habitat (e.g., beaver, muskrat), or altering the nutrient status of the wetlands (kokanee), while others indicate the need to identify cottonwood dominated areas with the greatest decline or loss and work towards maintaining existing riparian vegetation. Both the proposed Management Plan for the Columbia National Wildlife Area (Gebhauer and Huntley 2016), and Carli and Bayley (2015) discuss the possible role of beaver as modifiers of channel morphology and agents of change in the loss of marsh and shrub wetlands, and identify this idea as a topic for future research. Machmer (2009) stated "The FWCP should continue to place a strong emphasis on the inventory, management and conservation of riparian cottonwood habitat as part of its program mandate. The development of a basin-wide cottonwood management and recruitment strategy should be undertaken, to ensure that adequate densities and distributions of these habitat elements are maintained through time."

6.1.4 Ecosystem Services

The Ecosystem Services Toolkit (Preston and Raudsepp-Hearne 2017) provides guidance on conducting ecosystem services assessment – assessment that typically "requires biophysical measures and descriptions of the ecosystems and the dynamics involved in the production of ecological services."

The authors state that the primary objective of ecosystem services assessment is to support evidence-based decision making to improve human well-being and ensure environmental sustainability. The need for "measures and descriptions" suggests an opportunity to contribute to the valuation of ecosystem services within the valley.

6.1.5 Biodiversity

According to Gayton (2007) there is a great deal to be learned about the impacts of climate change on the full range of biodiversity endpoints. When identifying current gaps in existing knowledge, the author notes that research in the freshwater realm is under-represented.

The Technical Subcommittee Report: Biodiversity Safety Net Gap Analysis (Long 2007) lists areas of biodiversity that should be addressed by a provincial Biodiversity Action Plan. Experts suggested a wide range of ideas for the Action Plan:

- Ecosystem / landscape level planning and conservation that would help reduce fragmentation of key habitats and protect species
- A focus on freshwater and non-commercial species
- A focus on rapidly developing specific issues, such as climate change adaptation and alien species introductions
- Communicating to elected officials and the public the value provided by biodiversity and its importance relative to other, more short-term competing resource management objectives

Taking Nature's Pulse: The Status of Biodiversity in British Columbia (Austin et al. (eds.) 2008) states that the classification and mapping of ecological communities is incomplete in BC, adding that the classification and mapping of freshwater ecosystems is far less advanced than terrestrial ecosystem mapping. In a summary of data gaps related to diversity of species, the authors suggest that there are significant gaps in knowledge relating to population trends, distribution and conservation status of many species, and even taxonomic groups. They also suggest that little is known about the status of genetic diversity in BC, adding that while some species of fish and birds have been studied extensively, "genetic data are rare to nonexistent for amphibians, invertebrates, bryophytes and vascular plants other than trees."

Appendix B within Austin et al. summarizes information gaps (and the state of knowledge) for the major taxa of native terrestrial and freshwater organisms at that time (2008). An excellent and still largely up-to-date resource, the table lists "major taxa of extant, native, free-living terrestrial and freshwater organisms in BC, with tabular summary of the availability of up-to-date species checklists, handbooks or systematic monographs, computerized geo-referenced distributional databases, and local (British Columbia) taxonomic/systematic expertise."

The Columbia Basin Biodiversity Atlas includes data on primarily terrestrial species, with information on some amphibian and aquatic species. According to the website, when choosing species to profile and map, the authors "most often select species whose survival is in question. The Atlas is an evolving initiative which will change over time, with the addition of more species layers and information." This suggests an opportunity for groups to contribute to the Atlas.

6.1.6 Wetland and Riparian Birds

Knowledge gaps and priority actions are identified within individual management plans for species at risk. Several reports within the database also identify data gaps and opportunities for research.

The Columbia Intermountain Joint Venture Implementation Plan: Wetlands and Associated Species (Harrison 2010) outlines six critical challenges related to interior wetlands and the birds they support, as well as potential research and outreach activities to address those challenges:

- tracking populations of priority wetland birds via expanded monitoring programs
- understanding limiting factors affecting waterfowl through improved knowledge of vital rates and population dynamics
- improving habitat objectives by linking landscape changes to habitat-species models
- tracking changes in wetlands over time at fine- and landscape-scales
- expanding and targeting stewardship and policy activities, and evaluating their effectiveness
- increasing overall funding and capacity through partnership

Machmer (2009) provided a prioritized list of both general and site-specific recommendations for future inventory, monitoring, management and stewardship pertaining to great blue heron (and bald eagle). These include (among others):

- Track breeding site activity and success at known heron and bald eagle breeding sites
- Conduct periodic monitoring (every 4-5 years) of heron nest activity and reproductive success (per active and successful nest) at known and newly discovered active heron breeding colonies in the Columbia Basin. Opportunistically document any incidences of eagle incursions or adult/chick injury or mortality during visits, as well as any human or habitat related disturbances
- Develop a basin-wide cottonwood management and recruitment strategy to ensure that adequate densities and distributions of these habitat elements are maintained through time
- Undertake tree screening projects at active heron breeding sites, to protect them from beavers

6.1.7 Fish

There have been significant changes in the fisheries and nutrient flows in the Upper Columbia River since the construction of a series of dams beginning in the 40s. Several authors have also noted a lack of data on biophysical indicators that could indicate climate change within the wetlands and its impact on the abundance and distribution of fish.

Burbot are at risk within the Columbia Wetlands. Sensitive habitats have been identified in Columbia Lake and Lake Windermere, but there is a lack of information about sensitive spawning and rearing habitats in other areas of the wetlands.

According to the Riparian and Wetlands Action Plan (2014, and references therein), kokanee have expanded substantially in the system following the development of the Mica Dam. The exponential increase in kokanee has undoubtedly had implications for the populations of species which prey on kokanee, and for nutrient flow within the wetlands and river as hundreds of thousands of kokanee add nutrients to the system.

A series of knowledge gaps were identified within the Western Cutthroat Trout (WCT) Management Plan (BC Ministry of Environment 2014). These include recommendations relating to population conservation e.g., confirming the status of populations in unknown areas including peripheral areas; habitat protection and restoration e.g., identifying key habitats for migratory and resident WCT populations; and sustainable and diverse recreational opportunities e.g., determining information needed to better understand and define WCT harvest opportunities. The Columbia Basin Species of Interest Action Plan (FWCP 2012) identified WCT as a focal species: defined within the context of FWCP planning as those species that have a high conservation concern and/or local interest and a strong linkage to footprint impacts. Habitat restoration is listed as a Priority 1 action for WCT. Priority 2 actions are: habitat creation; habitat stewardship; and monitoring and evaluation.

Within the document, The Status of Bull Trout in British Columbia: A Synthesis of Available

Distribution, Abundance, Trend, and Threat Information, authors Hagen and Decker (2011) suggest that "Conservation and management of bull trout (*Salvelinus confluentus*) in British Columbia have been hindered by the lack of a systematic, province-wide assessment of distribution, abundance, trends in abundance, and threats to the species' long-term persistence." The status document attempts to rectify that by providing a comprehensive review of existing bull trout distribution and abundance data for BC, but there are limited data specific to this region. The Columbia Basin Species of Interest Action Plan (FWCP 2012) identified bull trout as a focal species and indicated several Priority 1 actions (assessment; habitat restoration) and Priority 2 actions (inventory; habitat creation; and monitoring and evaluation) within the broader region.

Rainbow trout are also identified as focal species within the Columbia Basin Species of Interest Action Plan (FWCP 2012). Within that document, recommendations are made for Priority 1 and 2 actions. Assessment and habitat restoration are ranked as Priority 1; and inventory, habitat creation, and monitoring and evaluation are Priority 2 actions.

According to Fisheries and Oceans Canada (2014), studies have begun to address the lack of data on various issues of interest to white sturgeon recovery, but there are still significant data gaps. The Recovery Strategy for white sturgeon (*Acipenser transmontanus*) in Canada outlines research and management activities needed to meet population and distribution objectives. These include the need to: clarify and mitigate threats; address basic biological information gaps that inhibit conservation; increase stakeholder and public awareness of white sturgeon and its conservation needs; and protect critical habitat.

7.0 Knowledge Gaps and Opportunities Identified in Over-arching Plans

7.1 Over-arching Plans

Several management and action plans reviewed for this report include summaries of broad data gaps that need to be addressed to improve the understanding, management, and stewardship of the Columbia Wetlands. The following section includes a summary of those gaps and opportunities identified within "over-arching" plans. These have been included for informational purposes only; the CWSP is not recommending any specific actions.

Management and recovery plans for individual species also provide detailed lists of knowledge gaps, but needs and recommended actions have not been included here; the reader is encouraged to review those documents for more information about species-specific needs and potential actions.

7.1.1 Wetland Action Plan

The Wetland Stewardship Partnership (WSP) is a group of organizations and government agencies committed to wetland conservation in BC. (This group is *not* the Columbia Wetland Stewardship Partnership.) The WSP has proposed that a comprehensive *Wetland Action Plan* (BC Wetland Stewardship Partnership 2010) be implemented cooperatively by governmental and non-governmental

organizations to protect British Columbia's remaining natural wetlands, and to restore important wetlands that have been severely damaged. Goal number one within the plan is to "Develop a comprehensive and reliable wetland information base to support effective planning, law-making, and policy development."

The Wetland Action Plan identifies objectives and actions. Broadly speaking, their objectives include:

- Creating a comprehensive and reliable wetlands information base
- Assessing the current and historical extent of wetlands and of each wetland type
- Studying wetland functions, status and trends to improve understanding of wetland values and establish priorities for wetland protection and restoration

Specific actions are detailed under each objective, including:

- Assess and improve the capability of existing tools and resources for mapping, documenting, monitoring, and managing wetlands and conducting scientific research about wetlands
- Investigate the hydrological functions of how wetlands contribute to maintaining/enhancing drinking water quality and the hydrological connectivity of wetlands to the broader watershed/sub-watershed
- Assess the function and measure the relative effectiveness of wetlands as carbon sinks in all regions of the province
- Develop standards for wetland conservation evaluation to establish and justify priorities for wetland conservation and restoration of habitat and function

7.1.2 Riparian and Wetlands Action Plan (FWCP)

The Columbia Basin Riparian and Wetlands Action Plan (FWCP 2014) is an excellent resource. In addition to providing comprehensive background information on the region, the plan identifies important knowledge gaps:

- There is little long-term monitoring of ecological processes
- There remain significant gaps in knowledge of the distribution and abundance of threatened and endangered species
- There is very little information on numbers and status for songbirds and other migrants in the system. Monitoring of waterfowl use during migration no longer occurs and there is minimal data on use during the breeding season

The Columbia Basin Species of Interest Action Plan (FWCP 2012) and Riparian and Wetland Action Plan also set out priorities for the Fish and Wildlife Compensation Program to guide projects in support of fish and wildlife. FWCP considers projects targeting inventory species as priorities for consideration "where clear outcomes leading to habitat, land or species-based actions are practically achievable." Actions identified as Priority 1 - Upper Columbia Valley:

- Inventory, map and monitor the seral stage distribution of riparian habitat (including but not limited to cottonwood, aspen and cedar)
- Map the abundance and distribution of riparian habitats. Riparian habitat types are poorly mapped throughout the Basin
- Establish a reference condition for wetland and riparian areas. Expected local impacts of climate change and other influences will impact wetland and riparian areas
- Restore and create wetland and riparian area habitat in this focal area, where feasible to address impacted, degraded or lost habitat (including but not limited to gravel pits where they exist on the floodplain, oxbows and side channels)
- Compile, assess and document the effectiveness of completed wetland and riparian restoration projects. Documenting past restoration actions will strengthen knowledge management

7.1.3 Columbia Wetlands Wildlife Management Area: Operational Plan: 1998-2002

This plan (Jamieson and Hennan 1998) provides direction for the long-term management of the Wildlife Management Area (WMA). It consists of:

- An overview of the resources of the area, with reference to more detailed descriptions in other reports
- A vision, goals and guiding principles for the WMA, potential enhancement options and strategies for managing human activities
- An appendix describing public input into the development of the document
- An appendix describing the status of rare and endangered species that use the wetlands (at that time)
- An appendix with 1:100,000 scale maps of the WMA

The plan identified management strategies (and their rationale) for the WMA, several of which are still of interest, and which have been re-iterated within other regional management documents. These include:

- Establishing baseline data on the vegetation of the wetlands
- Monitoring water quality
- Documenting the ecological and human history of the wetlands
- Baseline surveys of fish populations
- Status of cottonwoods stands
- Songbird surveys
- An assessment of habitat management options on alluvial fan sites
- Browse rejuvenation by slashing or burning
- Identification of “special habitats” and an inventory of species using such sites
- Management of cross-valley movement corridors

7.1.4 Columbia National Wildlife Area Management Plan (Proposed)

The proposed management plan for the CNWA (Gebhauer and Huntley 2016) includes goals and objectives to "maintain or create conditions that would occur under natural ecological processes." Priority one and two management actions include:

- Increase local awareness by holding annual public open houses
- Monitor invasive species
- Map and restore degraded areas
- Survey species at risk and participate in reintroductions

One goal of the CNWA is that **"**marsh, riparian and upland habitat is maintained in a natural state, or restored for the benefit of wildlife, especially marsh-dependent water-birds and species at risk." Objectives for cottonwood and other riparian habitats include:

- Engage community volunteers to participate in habitat management initiatives and to help identify and reach rehabilitation targets for the management of riparian and cottonwood areas
- Support the maintenance of existing riparian vegetation, including significant mature Black Cottonwood stands (particularly at Spillimacheen). (This is a priority of the management plan)
- Identify Cottonwood-dominated areas with greatest decline or loss with habitat mapping and site visits to help direct and prioritize habitat restoration activities. Factors in riparian habitat loss also need to be identified
- Support the protection of cottonwood stands and riparian areas and maintain natural conditions if significant threats are identified (e.g., beavers and possible fires from camp fires in the area)

The management plan also describes an interest in research where the results support management plan objectives. Topics of specific interest include:

- Protecting, maintaining, restoring or enhancing naturally occurring habitats
- Understanding the causes of riparian habitat loss potentially related to a lack of recruitment, beaver activity, changes to the hydrological regime
- Understanding fuel loads and fire regime assessment to better understand risk from wildfire and feasibility and effects of prescribed burning
- Recovering species at risk or conserving migratory birds, particularly waterfowl
- Reducing the encroachment of invasive species in the NWA
- Assessing the trends in species populations (especially species at risk) and habitats of concern
- Maintaining wetlands in a state most beneficial to wetland-dependent wildlife

7.1.5 Bird Conservation Strategy for Bird Conservation Region 10

Environment Canada led the development of all-bird conservation strategies in each of Canada's Bird Conservation Regions. The Bird Conservation Strategy for Bird Conservation Region 10 Pacific and Yukon Region: Northern Rockies (Environment Canada 2013) outlines actions to address threats facing priority species in both wetland and riparian habitats (among others). The actions are clearly described and

outlined in Table 16: Wetlands (p61) and Table 20: Riparian (p74) within that document. Actions within riparian habitat include:

- Remove unneeded dams, dikes, or levees to re-establish hydrological connections between riparian and floodplain habitats
- Maintain, restore, and where possible, expand existing riparian buffers in agricultural and developed areas
- Manage livestock distribution to prevent cattle lingering in and overusing riparian areas, by providing offsite water and placing feed, salt blocks and shelter away from riparian areas
- Where riparian areas have been degraded by livestock activity, restore and enhance habitat through fencing, livestock management, and planting native riparian species

Recommended actions for wetlands include, among others:

- Protect and maintain a diversity of wetland habitats on the landscape, including small and seasonal wetlands
- Maintain/restore suitable vegetated riparian buffers around wetlands to reduce erosion and avoid siltation
- Use a combination of buffer zones and seasonal closures to prevent disturbance of nesting and foraging priority waterfowl and water birds
- Increase public awareness of the impacts of human disturbance on priority species, and methods to minimize such disturbance

7.1.6 Columbia Wetland Stewardship Partners

In 2010, the Partners developed a ten-year strategy for monitoring, inventory and science in the Columbia Wetlands system (Science Committee Columbia Wetlands Stewardship Partners 2010). The strategy provides a thorough overview of perceived threats to the Columbia Wetlands and highlights the need to maintain habitat quality, biodiversity and ecosystem function.

The document was reviewed to identify previous recommendations and action items: some items on the original list have been addressed, and others, for various reasons, have not. As previously noted, the primary objective of the Columbia Wetland Stewardship Partners (CWSP) is “to maintain the functional processes that drive the Columbia Wetland system, all the present habitat elements in the system, and the entire range of historically present species in the wetlands and the river system.” CWSP has limited capacity to conduct research and monitoring activities, and recommendations and action items which do not clearly support the stated objectives, or those that do not contribute to “knowledge of the natural range of variation of natural processes so that they can detect changes that may be affecting the ecosystem” may have, by necessity, been ranked as lower priority.

8.0 Conclusions

Several recurring themes emerged through the evaluation of what is currently in the database, and what authors suggested is needed to better understand and manage the Columbia Wetlands. The following list (coarsely grouped, and not prioritized) briefly summarizes the most frequently mentioned and recognized knowledge gaps:

- Water quality data for the wetlands and the Upper Columbia River
- Streamflow of the Upper Columbia River and the wetland water regime, including minimum flow requirements for wetland ecosystem maintenance
- Regional groundwater resources
- Implications of climate change to wetland ecosystem function
- Mapped riparian and wetland habitats
- Critical geomorphic and hydrologic processes that drive the presence of riparian habitat, and the causes of its loss
- Aquatic and terrestrial plants, and plants and plant communities at risk in the wetlands
- Status of cottonwood habitat in the wetlands
- Wetland-specific connectivity or habitat fragmentation
- Beaver and muskrat as agents of change
- Fire in the wetlands and its impact on wetland ecosystems
- Freshwater biodiversity
- Implications of the increase of kokanee in the system
- At-risk bird inventory, sensitive or critical habitat, and population status
- At-risk amphibian inventory, sensitive or critical habitat, and population status
- At-risk fish inventory, sensitive or critical habitat, and population status
- Game fish inventories, spawning data and abundance
- The seasonal use of wetland and riparian habitat by bears and other large mammals
- Identification and impact of both aquatic and terrestrial invasive species

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10.0 Appendices

Appendix A: BC List Status

Species are assigned to provincial lists depending on their Provincial Conservation Status (see table below). The lists are as follows:

Extinct: Species that no longer exist. This status is only assigned if the Global Conservation Status rank is GX.

Red: Includes any indigenous species or subspecies that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation.

Blue: Includes any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in British Columbia. Taxa of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened.

Yellow: Includes species that are apparently secure and not at risk of extinction. Yellow-listed species may have red- or blue-listed subspecies.

Exotic: Species that have been moved beyond their natural range as a result of human activity. Exotic species are also known as alien species, foreign species, introduced species, non-indigenous species and non-native species. Exotic species are excluded from the Red, Blue and Yellow Lists as a Provincial Conservation Status Rank is not applicable (i.e. SNA)

Accidental: Species occurring infrequently and unpredictably, outside their usual range. Accidental species are excluded

from the Red, Blue and Yellow Lists as a Provincial Conservation Status Rank is not applicable (i.e., SNA)

Unknown: Includes species or subspecies for which the Provincial Conservation Status is unknown due to extreme uncertainty (e.g., S1S4). It will also be 'Unknown' if it is uncertain whether the entity is native (Red, Blue or Yellow), introduced (Exotic) or accidental in BC. This designation highlights species where more inventory and/or data gathering is needed.

No Status: Includes species that have not been ranked (i.e., Provincial Conservation Status Rank is SNR). No Status is also assigned to an animal when all subspecies or populations of a species are assigned to either the Red List or the Blue List. For example, there are two populations of Western Painted Turtle in BC; one population is on the Red List, the other is on the Blue List. The species record for Western Painted Turtle is therefore not assigned to a list.

Conservation Status and BC List

	Red List	**Blue List**	**Yellow List**
Animals* **(Regularly Occurring)**	SX, SH, S1, S1S2, S1S3, S2, S2?	S2S3, S2S4, S3, S3?, S3S4, S3S5	S4, S4?, S4S5, S5
Plants	SX, SH, S1, S1S2, S1S3, S2, S2?	S2S3, S2S4, S3, S3?	S3S4, S3S5, S4, S4S5, S5

S-Rank —sub-national (provincial or territorial) ranks, S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; and S5 = Secure