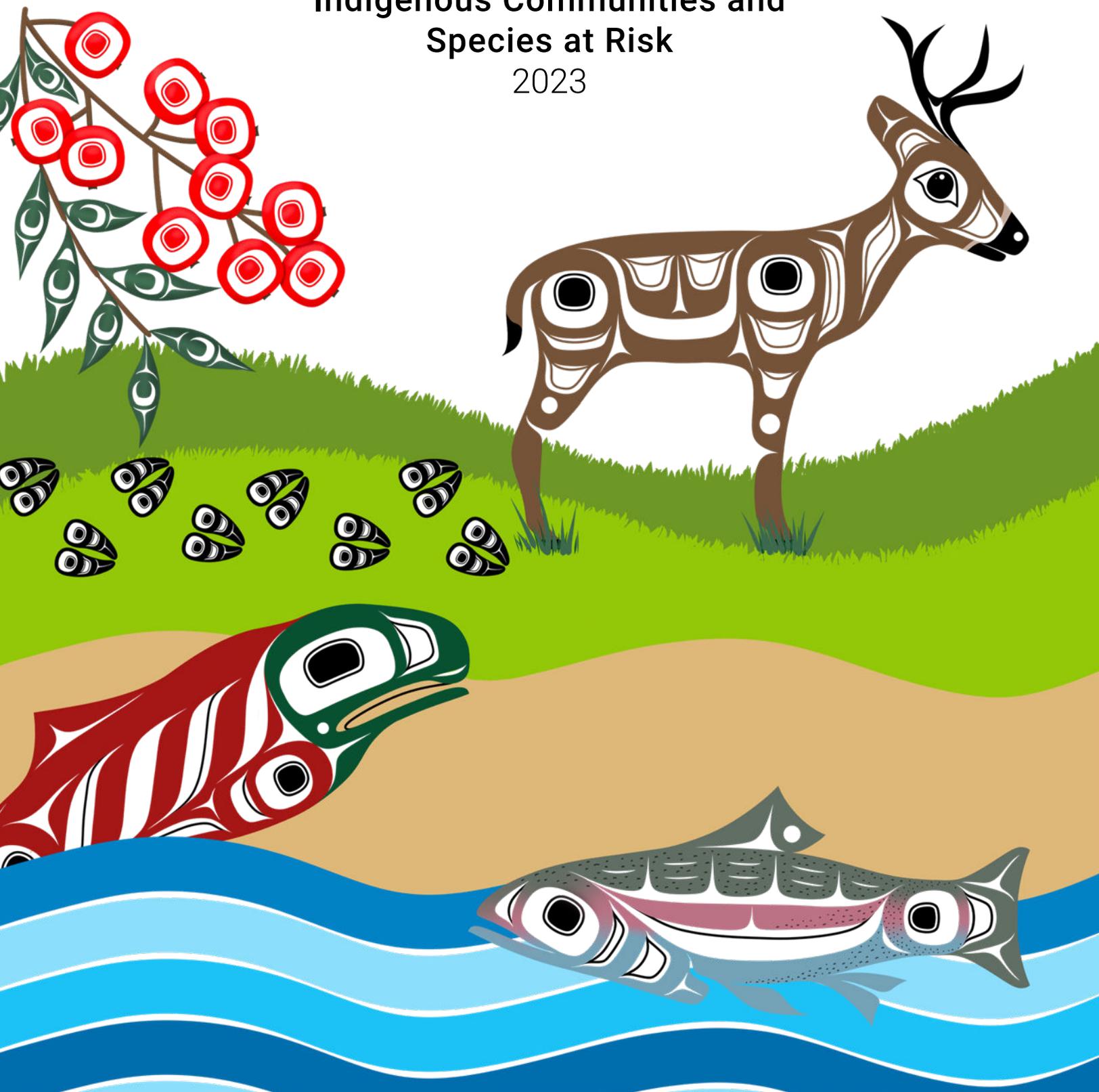


In Their Own Words: The Impact of Invasive Species on Indigenous Communities and Species at Risk

2023





The Invasive Species Council of BC is a registered charity and non-profit society making a difference in the lives of people across British Columbia by helping diverse parties work together to stop the spread of invasive species. We engage people, businesses, government and industry in adopting simple, but important practices that have a huge impact. Our goal is to protect the places we love from the detrimental environmental, social, and economic effects of invasive species.

Indigenous partners have a significant role in our work. They guide training and resource development and identify opportunities for collaboration. ISCBC coordinates the Indigenous Invasive Species Network to support communication and knowledge exchange on invasive species prevention and management practices and other initiatives.

We recognize and value the critical importance of Indigenous leadership in ecological stewardship and we are committed to reflecting this in all aspects of our work.

ARTISTIC CONTRIBUTIONS BY



Shawna Kiesman
NORTHWEST COAST ARTIST

Shawna Kiesman was born in Prince Rupert, BC and was raised in Victoria, BC. Her mother is Tsimshian/Nisga'a and her father is Haida/German. Shawna graduated from Freda Diesing School of Northwest Coast Arts (First Nations Fine Art Diploma). Kiesman continued her education at Emily Carr University of Art + Design to gain her Bachelor of Fine Arts and further develop her artistic skills. While in school, Kiesman received several awards including the Audain Entrance Scholarship and BC Arts Council Scholarship. Since graduating, Shawna's career as an artist has continued to thrive, having successfully received a grant from First Peoples' Cultural Council and she was chosen to attend RBC Audain Museum Emerging Artist Program, Banff Centre for Arts and Creativity and Bonnie McComb Kreye Studio residencies. Kiesman's work

is included in the permanent collections of the Nisga'a museum, Wii Gyemsiga Siwilaawksat and Coast Mountain College. Her work has been featured in Creative Review and Canadian Architect magazines. Shawna continues to explore her art practice using the mediums of digital art, textiles, drawing and painting.

“As a Female First Nations artist, I create artwork that expresses my individual story and shares my ancestors' stories. Every piece I create, I look at it as opportunities to learn and fully understand the complexities of my culture's visual language. My teachers have shared the foundations of the traditional art form, now I can continue the journey to share my voice through my artwork and honour my ancestors.”



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Executive Summary

Invasive species seriously impact ecosystems, economies and society, and can have particularly devastating impacts on species at risk in British Columbia (BC). Invasive species can also have significant impacts on infrastructure, economic activities, and health and cultural practices in Indigenous communities. Many species currently listed (2023) on national and provincial endangered species lists are culturally significant species to Indigenous groups in BC. This report presents the values, expertise, and traditional knowledge of members of several Indigenous communities across BC, focusing on the impacts of invasive species on culturally important species at risk. The Invasive Species Council of British Columbia (ISCBC) recognizes that Indigenous cultures are distinct, as each have their own

histories, languages, practices and beliefs, and that traditional foods, medicines, and practices differ greatly across nations. ISCBC respects the inherent right to Indigenous ownership of all traditional knowledge and has taken precautions to provide accurate information without compromising ownership, specific locations, or cultural practices.

Note to readers: These shared stories are not exhaustive nor exclusive but provide a spotlight on invasive species that have impacted Indigenous communities, cultural practices, and economies. ISCBC is very grateful to and acknowledges all participants in the interviews, videos, and document reviews.

Acknowledgments

ISCBC would like to recognize the First Nations who shared their invaluable experience, perspectives, and cultural teachings. This contribution is especially valued and appreciated considering the severe impacts of the COVID-19 pandemic on Indigenous communities. Many thanks to each of you.

Lennard Joe

*Chief Executive Officer of BC First Nations
Forestry Council*

**Dave Feil and the Northern Shuswap
Tribal Council**

Fisheries Resource Manager

**Michael Zimmer and the Okanagan
Nation Alliance**

*Biologist, Okanagan Nation Alliance Eastern Territory,
Columbia-Kootenay*

**Tracy Wimbush and the Scw'xmx
Tribal Council**

*Nicola Watershed Stewardship and Fisheries Authority
Department Manager*

Brian Holmes and the Upper Nicola Indian Band
Councillor with the Upper Nicola Indian Band

**Jonathan (JJ) Holmes and the Lower Nicola
Indian Band Development Corporation**

*Operations Supervisor with the Lower Nicola Indian
Band Development Corporation*

Thank you to Fisheries and Oceans Canada for support of this project through the Canada Nature Fund for Aquatic Species at Risk.

Introduction

Invasive species are of significant concern throughout BC. With the ability to out-compete native species for resources, and their lack of natural predators, invasive species pose serious threats to native species, ecosystems and economy. This report highlights examples of how invasive species pose a threat to both species at risk and Indigenous cultural practices, including harvesting and hunting, through the words and experiences of several First Nation members. Cultural practices play an important role in the lives of Indigenous peoples throughout BC, and the protection of both species at risk and culturally important species through invasives species management is vital.

What are Invasive Species?

A *native species* is one that has lived and evolved in a place for a long time (e.g. thousands of years) and is part of a natural, balanced ecosystem. In contrast, *invasive species* are plants, animals, or other organisms that are not native to a region and whose introduction and spread have negative impacts on native species, the environment, the economy, and/or human health and society. Invasive species may impact species at risk through monopolizing resources, direct competition for food, shelter and space, predation, altering food webs and by introducing new diseases/pathogens (Dueñas et al., 2018). Invasive species also impact First Nations communities and cultural practices in many ways.

INDIGENOUS VOICES

“ I think that invasive plants have an opportunity to adversely impact traditional plants, medicinal plants, food plants. They also can impact the economics of doing projects and trying to plan for projects on the landscape. ”

Samantha Peters, Chawathil First Nation and Fraser Valley Invasive Species Council

What are Species at Risk?

Species at risk are plants, animals, and other wildlife that are at risk of extinction. The federal government works to develop a list of at-risk species each year, some of which receive legal protection. Identifying and protecting species at risk is crucial for British Columbia, which has the highest biodiversity in Canada, and also the most endangered species (Westwood et al., 2019).

In 1977, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created to assign risk categories for native species across the country. A few of COSEWIC's risk categories include extinct, extirpated, endangered, and threatened statuses. In 2003, the federal *Species At Risk Act* (SARA) was created to legally protect wildlife species; this Act includes prohibitions against the killing, harming, capturing, possessing, buying, selling or trading of listed species. As of 2022, there are 278 COSEWIC listed species present in BC, and 214 of those are listed federally under SARA. The status of many of these species have worsened



or failed to improve, even with recovery efforts (Westwood et al., 2019). Invasive species are the second biggest threat to biodiversity after habitat loss (Government of Canada, 2017). This indicates the need for more research and knowledge about invasive species and species at risk, including partnering with and learning from Indigenous communities, to support effective actions in the future.

Relationship to the Land

Indigenous peoples have an intrinsic relationship to the land. This relationship is built on respect, reciprocity, and the fundamental understanding that people are intimately connected to all other beings. Stewardship of the land is caring for oneself and one's community.

Indigenous peoples have always stewarded and cared for land and waters, sourcing everything

needed for life — from foods and medicines, to materials for building homes and making clothing, canoes and tools — from the lands and waters. Land and waters hold an important place in ceremonies and act as a reminder that all living things must be treated with respect, and that the principles of honorable harvest are followed, ensuring that only what is needed is taken, and nothing is wasted. The belief is that one does not inherit the land from one's ancestors, but borrows it from one's children.

Plants and animals are not only important sources of materials and foods, they also have great cultural, spiritual, and traditional significance. Culturally important species are defined as species that are significant for Indigenous communities, with roles in food, materials, and medicine. They have cultural meaning and spiritual value (Freitas et al., 2020; Garibaldi & Turner, 2004).

INDIGENOUS VOICES

“ Those values of love and respect...the air doesn't charge us money for having oxygen in it to sustain us but we should be thankful for that anyways. Nature provides food animals for us, but the forest never says you must thank us for this. But we should be grateful in our hearts anyways. I think if we can do that for nature, we can appreciate each other a lot more and treat each other with more respect. ”

Latash-Maurice Nahanee, Squamish Nation



Impacts of Invasive Species on Indigenous Communities

Invasive species are a leading cause of threatened species declines (Dueñas et al., 2018). Notably, invasive species can have significant negative impacts to species at risk, many of which are culturally significant to Indigenous groups and cultures. Invasive species also impact Indigenous communities, cultural practices, and economies. This can include blocking access to hunting and harvest sites, decreasing abundance and diversity of native species, changing ecological processes (such as by increasing erosion or fire frequency), and impacting infrastructure.

INDIGENOUS VOICES

“ Invasive species management is important to deal with because it can adversely affect the enjoyment of your rights and the enjoyment of your land. It can restrict access to harvesting sites, it can restrict access to berry-picking sites, it can destroy native species and plants that you rely on and it can destroy wildlife habitat and affect your ability to go harvest moose and deer. It's a very important issue to tackle. So make it a priority. ”

Jake Archie (1976 – 2020),
Canim Lake First Nation

Jake worked as the Indigenous Liaison for ISCBC for several years: ISCBC honours his many contributions and accomplishments.

Land Management and Indigenous Communities

Indigenous peoples have been land stewards for millennia. Some harvesting and hunting sites are intergenerationally managed and have been cared for by families for thousands of years. Invasive plants can have many negative impacts on traditional harvesting sites by outcompeting native species for space, nutrients, and light. This results in decreased biodiversity including a loss of culturally important plants used for food, medicines, materials, and in ceremonies. Invasive species, such as Himalayan blackberry and knotweeds, can form dense impenetrable thickets, limiting access to harvesting and hunting sites, out-competing forage species, and restricting movement of deer and other wildlife.

The Invasive Species Council of BC is proud to work with Indigenous communities across the province to identify, observe, report and manage invasive species. ISCBC collaborates with Indigenous communities to share knowledge, learn from the communities about invasive species and ecological stewardship, and support restoration activities to ensure that culturally important species remain healthy and bountiful for future generations. Members of the Indigenous Land Guardians, Coastal Guardians, Métis Nation BC, and many other Nations participate in online and in-person invasive species management training to share their experiences and traditional knowledge. Indigenous communities are critical partners in helping to protect lands, waters and biodiversity in BC, including culturally important species and species at risk.



Graphic illustration created during a workshop (January 2022) presented by the Invasive Species Council of BC to Métis Nation BC on the topic of how invasive species impact Indigenous communities and ways to help stop the spread of invasive species.



In Their Own Words: Stories of Resilience and Action

ISCBC worked with Lennard Joe, a member of the Nlaka'pamux First Nation and Chief Executive Officer of BC First Nations Forestry Council, to connect with several Indigenous community partners across BC to share their experiences with invasive species. Direct experiences with invasive species, species at risk, and actions taken to manage impacts and protect their lands and waters were explored.

Northern Shuswap Tribal Council



Representative:

Dave Feil, Fisheries Resource Manager

Invasive Species of Concern:

Smallmouth bass (*Micropterus dolomieu*)

Impacted Species at Risk:

Sockeye salmon (*Oncorhynchus nerka*) and
White sturgeon (*Acipenser transmontanus*)

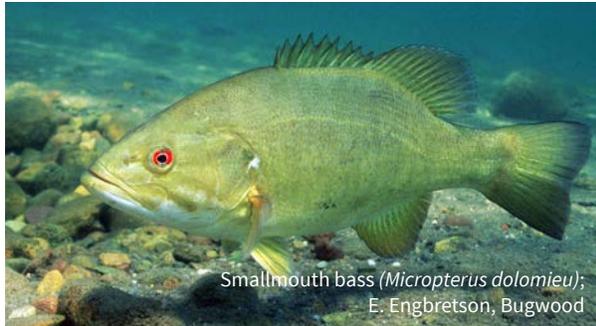
Impacted Culturally Significant Species:

Sockeye salmon (*Oncorhynchus nerka*), White sturgeon (*Acipenser transmontanus*), Rainbow trout (*Oncorhynchus mykiss*), Kokanee salmon (*Oncorhynchus nerka* var. *kokanee*), Brook trout (*Salvelinus fontinalis*), and Bull trout (*Salvelinus confluentus*)

The role of the Fisheries Resource Manager with the Northern Shuswap Tribal Council (NSTC) Fisheries Department is to manage the fisheries resource for the Northern Secwepemc te Qelmucw (NSTQ), a coalition of four communities (Stswexem'c Xgat''tem (Canoe/Dog Creek First Nations), T'exelc (Williams Lake First Nation), Tsq'escem' (Canim Lake Band), and Xats'ull (Soda Creek First Nation)). The NSTQ have experienced first-hand the devastating impacts of Smallmouth bass (*Micropterus dolomieu*) on the surrounding watersheds. This invasive fish has been on the NSTC's radar since 2006. The NSTC's ultimate goal is to continually protect native fish in the NSTQ traditional areas, and increase NSTQ's involvement in their management. Smallmouth bass are native to Eastern and Central North America, but have been introduced into waterways in BC as a sport fish. They were first found in the Beaver Valley watershed in 2006 and have since dispersed throughout regional river systems.

The Northern Shuswap peoples' history has always been intertwined with fish and the local watersheds, particularly salmon. Dave Feil states that "salmon is used for food, ceremonies, and social values. Salmon has also always had a commercial value and was traded before [the] western world and its

values were introduced to our people.” Sockeye salmon (*Oncorhynchus nerka*), Chinook salmon (*Oncorhynchus tshawytscha*), Pink salmon (*Oncorhynchus gorbuscha*) and Coho salmon (*Oncorhynchus kisutch*), as well as White sturgeon (*Acipenser transmontanus*) and Rainbow trout (*Oncorhynchus mykiss*), make up the key food fisheries of the NStQ communities.



Smallmouth bass are predators and feed on smaller fish including young salmon, amphibians, and aquatic insects. They have been known to deplete waterways of smaller fish, thereby altering the food web. Smallmouth bass are considered a serious threat to native species in the waterways they inhabit, including juvenile salmon. In the NStQ, Smallmouth bass have negatively impacted Sockeye salmon (*Oncorhynchus nerka*) and White sturgeon (*Acipenser transmontanus*) populations, both of which are listed as species at risk. Sockeye salmon populations within the region are listed as endangered under COSEWIC, whereas White sturgeon populations within the region are deemed to be critically imperiled within the province of BC and are listed as endangered under both SARA and COSEWIC. Smallmouth bass have also impacted cultural practices by depleting key food fishery species like Rainbow trout (*Oncorhynchus mykiss*), Kokanee salmon (*Oncorhynchus nerka* var. *kokanee*), Brook trout (*Salvelinus fontinalis*), and Bull trout (*Salvelinus confluentus*).

The NSTC has developed a Smallmouth bass eradication program in response to these issues. Dave Feil notes that the eradication by rod, reel, and gill netting has resulted in a reduction in Smallmouth bass populations but the program will need to be continued for years to come. This program provides an excellent learning opportunity as the NSTC has learned when and where to catch the most fish each season, the best time being when they gather to spawn and start moving towards the creeks. The NStQ Elders and community members support the program and are happy to see local community members involved. Four NStQ Community Fisheries Representatives — one from each of the Northern Secwepemc te Qelmuw First Nations — have been hired by the communities through an agreement with the NSTC fisheries program. The intent of these positions is to improve communication between NSTC fisheries staff and NStQ community members. As this program continues, the capacity of the members will grow and information will be shared with the communities.

NSTC’s Smallmouth bass eradication program was funded by the Department of Fisheries and Oceans Canada and the B.C. Ministry of Environment under the Aboriginal Fisheries Strategy Funding. However, Dave notes that funding is limited and only allows for a few weeks per year for the project. The NSTC feels that they would greatly benefit from additional funding opportunities so that the program can run for a longer period of time each year and members can have greater involvement in fisheries activities within their traditional territory. They would like to incorporate more of their efforts into the Coho/Chinook spawning and catch monitoring to monitor the health of native fish populations.



Northern pike (*Esox Lucius*); Spinsta

Okanagan Nation Alliance

Representative:

Michael Zimmer, Biologist, Okanagan Nation Alliance Eastern Territory, Columbia-Kootenay

Invasive Species of Concern:

Northern pike (*Esox lucius*)

Impacted Species at Risk:

čamtus (White sturgeon; *Acipenser transmontanus*) and Columbia sculpin (*Cottus hubbsi*)

Impacted Culturally Significant Species:

x^wəx^wmína? (Rainbow trout; *Oncorhynchus mykiss*), sčwin (Sockeye salmon; *Oncorhynchus nerka*), čamtus (White sturgeon; *Acipenser transmontanus*), Cutthroat trout (*Oncorhynchus clarkii clarkii*)

As the fisheries department lead within the Okanagan Nation Alliance's (ONA) Eastern Territory, Michael Zimmer has been monitoring the effects of Northern pike (*Esox lucius*)

incursion in the Columbia and Pend d'Oreille rivers of the Kootenay Region. In this region, invasive species are showing up in numbers and places that are very concerning to the Syilx Nation. Invasive species, such as the Northern pike, pose significant threats to several species at risk. Localized examples include impacts to the culturally important x^wəx^wmína? (Rainbow trout; *Oncorhynchus mykiss*) and potential impacts to the at-risk sčwin (Sockeye salmon; *Oncorhynchus nerka*) within the Columbia River system and adjoining Okanagan River.

Northern pike is native to northeast BC and is commonly found throughout central and eastern Canada, including Quebec, Ontario, the Prairie provinces, and northern territories. They have been introduced in many regions as stock for sport fishing and are spreading into southern BC. Northern pike is an apex predator that mainly consumes fish of varying sizes — it will eat anything that can fit into its mouth. Large adult



Northern pike can easily consume a fish weighing three to four pounds! These invasive fish have been known to deplete prey species from waterways, pushing out local large fish and altering food webs.

Invasive Northern pike populations were first discovered in the U.S. Pend d’Orielle River system in 2004. Later, in 2010, they were discovered in southeastern BC; efforts to reduce the population were initiated in 2014 through focused gill netting. There were two main areas impacted by Northern Pike, the Pend d’Oreille system which is primarily made up of two reservoirs in the short section within Canada — Seven Mile and Waneta Reservoirs; and the Lower Columbia River from Hugh Keenleyside Dam in Castlegar south to the United States (U.S.) border. Other areas at heightened risk of new incursions include the Arrow Lakes reservoir system upstream of Hugh Keenleyside Dam, and the Okanagan River system and chain of lakes (including Osoyoos, Vaseaux, Skaha and Okanagan Lakes). One Northern pike was documented as being caught in Christina Lake in 2017, but the lake was not included in the gill netting program until 2019. Michael highlights the importance of collaboration when managing invasive species through suppression and monitoring, stating that “this program is only successful due to the hard work and relationships developed with the U.S. Tribes sharing lessons learned and helping improved efficiencies. Tribal groups involved are Colville Confederated Tribes, Kalispel Tribe, Spokane Tribe of Indians & Coeur d’Alene Tribe.”

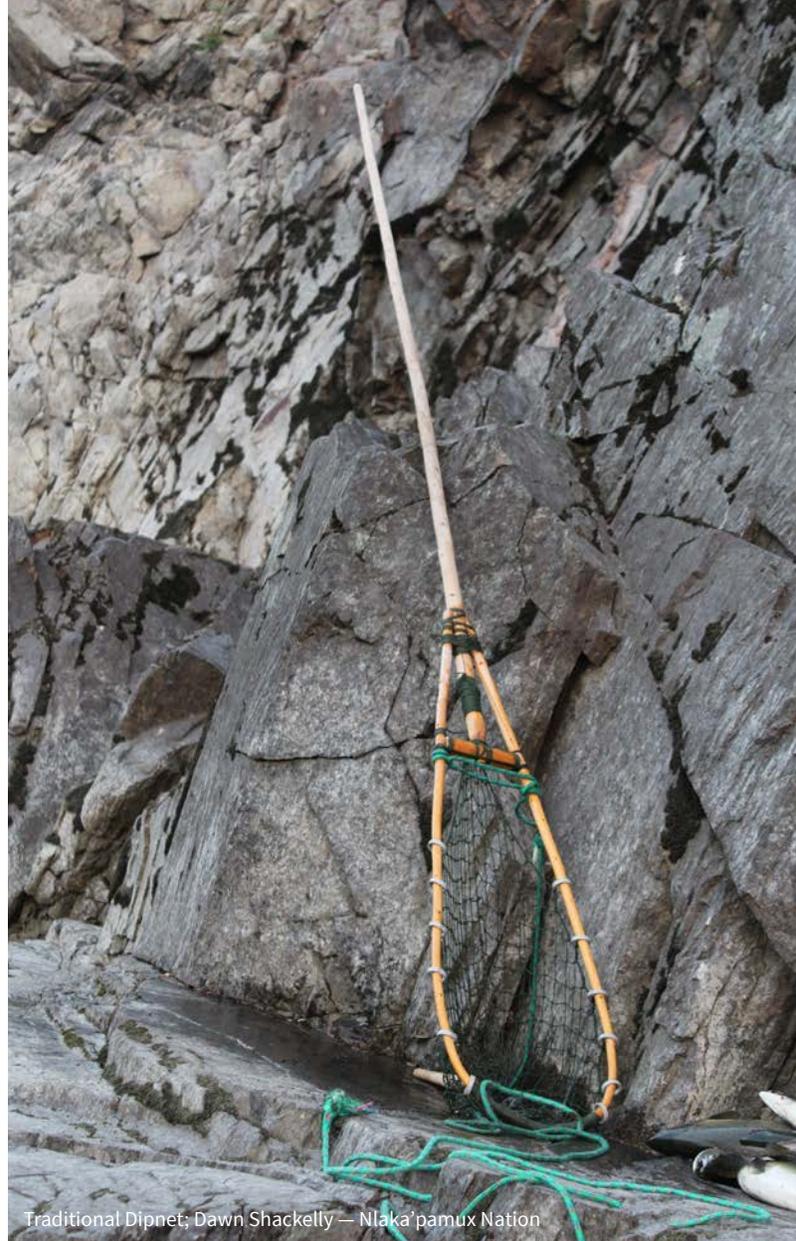
The Columbia River system was once rich in salmon, however, the creation of dams and the relocation of many of Indigenous peoples altered the composition of native species within the river system. In the Columbia-Kootenay region, Northern pike negatively impact the ecosystem by competing for habitat and resources while directly preying on more common fishes such as Redside shiners (*Richardsonius balteatus*), miml̓t (Mountain whitefish; *Prosopium williamsoni*), and xʷəxʷmínaʔ (Rainbow trout; *Oncorhynchus mykiss*). Northern pike also pose a predatory risk to čəmtus (White sturgeon; *Acipenser transmontanus*) and the Columbia sculpin (*Cottus hubbsi*), Umatilla dace (*Rhinichthys umatilla*), westslope Cutthroat trout (*Oncorhynchus clarkii lewisi*), and Bull trout (*Salvelinus confluentus*) populations, all of which are listed as species at risk or have elevated levels of conservation concern within the Lower Columbia River or Pend d’Oreille reservoir system.

sčwin (Sockeye salmon; *Oncorhynchus nerka*) populations have recovered within the Okanagan system, but are extirpated along with n̓ty̓tyix (Chinook salmon; *Oncorhynchus tshawytscha*), in the Columbia mainstem and lake system, which has led to the Indigenous-led Columbia River Salmon Reintroduction Initiative. čəmtus (White sturgeon; *Acipenser transmontanus*) populations within the region are deemed to be critically imperiled and are listed as endangered under both SARA and COSEWIC. Regional Columbia sculpin (*Cottus hubbsi*) populations are of special concern under both SARA and COSEWIC. The Syilx and other First Nations are currently working hard in Canada to reintroduce sčwin (Sockeye salmon; *Oncorhynchus nerka*) and n̓ty̓tyix (Chinook salmon; *Oncorhynchus tshawytscha*)

to the blocked portions of the Columbia River system as they are an important food source for the communities.

Michael states that full eradication of the population of Northern pike is unlikely due to the vast area of the waterways that have been invaded. However, a vigilant suppression program can keep the population in check. An important measure is the “Catch per Unit Effort” which measures the number of Northern pike captured over a standardized unit of effort. Michael points out that this measure decreased from 2014 to 2018 and has since reached a consistent, or year-after-year, low point indicating that the suppression efforts appear to be working. He also noted that annual suppression efforts need to be maintained as pike are very prolific at producing offspring and, if left unchecked for a single spawning season, could result in a dramatic rebound in numbers. It was also noted that the effectiveness of capturing Northern pike has increased through experience as the program learns over time; the crews have learned the best time of year, the best locations and the best techniques that yield the best results for catching and removing Northern pike.

Focussed effort on suppression of Northern pike has also led to key observations regarding other non-native species and their relative abundance. For example, in the Pend d’Oreille, captures of Yellow perch (*Perca flavescens*), Walleye (*Sander vitreus*), and Lake trout (*Salvelinus namaycush*) have become more common. And in the Lower Columbia River, in specific locations, Michael has seen an increase in Tench (*Tinca tinca*). Michael notes that “as the suite of invasive species



Traditional Dipnet; Dawn Shackelly — Nlaka’pamux Nation

appears to be growing, we can use our pike suppression program to expand to other invasive species of concern.”

The Northern Pike Suppression Program has seen core funding from the federal department of Fisheries and Oceans Canada and the Columbia Basin Trust. Other funders include Teck Metals, Fortis, BC Hydro, the BC Ministry of Environment and BC Ministry of Forests. When asked how the program could be further supported, Michael stated that the ONA would like the Province of BC to follow suit with Washington State by prioritizing Northern pike management with annual funding dedicated to the Suppression Program.



Eurasian watermilfoil (*Myriophyllum spicatum*); A. fox, UGA

Scw'exmx Tribal Council

Representative:

Tracy Wimbush, Nicola Watershed Stewardship and Fisheries Authority Department Manager

Invasive Species of Concern:

Yellow perch (*Perca flavescens*) and Eurasian watermilfoil (*Myriophyllum spicatum*)

Impacted Species at Risk:

Interior Fraser Coho salmon (*Oncorhynchus kisutch*), Lower Thompson Chinook Salmon, Spring population (*Oncorhynchus tshawytscha*)

Impacted Culturally Significant Species:

Interior Fraser Coho salmon (*Oncorhynchus kisutch*), Lower Thompson Chinook Salmon, Spring population (*Oncorhynchus tshawytscha*)

The role of the Department Manager for the Nicola Watershed Stewardship and Fisheries Authority (NWSFA), is to provide recommendations to leadership and communities within the Nlaka'pamux Nation. During his time in this role, Tracy Wimbush

worked diligently to prevent and manage invasive species within the Nicola watershed.

The Coldwater River and the Nicola River are the spawning grounds and incubation areas for young salmon and fish species in Nlaka'pamux traditional territories. Salmon are a culturally significant food species for the area. Tracy also notes that “when salmon runs are poor, the people supplement their diet with lake trout, spookaleech (Burbot), and other foods.” Invasive species have impacted all these traditional food sources by impacting spawning grounds and outcompeting native species. The Scw'exmx Tribal Council (STC) noted that Yellow perch (*Perca flavescens*) and Eurasian watermilfoil (*Myriophyllum spicatum*) have been confirmed within the Nicola system, and Goldfish (*Carassius auratus*) and Asian carp are suspected to have invaded the area. The impacts of Eurasian watermilfoil and Yellow perch are of particular concern to the Interior Fraser Coho salmon (*Oncorhynchus kisutch*), listed as threatened (likely to become endangered if limiting factors are not reversed) under COSEWIC, and the Lower

Thompson Chinook Salmon, Spring population (*Oncorhynchus tshawytscha*), assessed as endangered by COSEWIC in 2020 though they are not SARA listed.

Eurasian watermilfoil is an aquatic plant which has been released from aquariums or traveled from other infested waterways on watercraft and trailers. It thrives in still or slow-moving water with a silty or sandy bottom. It spreads by roots, seeds, buds, and stem fragments. Eurasian watermilfoil decreases water flow and causes sluggish water that attracts mosquitos and changes water composition and habitats. Recreation and esthetic values are also altered as waterways become congested and swimming, boating, and other recreational activities are no longer safe or appealing. Tracy notes that fish habitats are altered where Eurasian watermilfoil is found, making it hard for native fish species to flourish.



Yellow perch are native species from Alberta to Nova Scotia and North to the Northwest Territories. They have been intentionally released in BC as stock fish and from aquariums and private ponds, and have been accidentally spread by anglers, on boats, and in bait buckets.

Yellow perch are predators of other fish species, insects, and tadpoles. They reproduce quickly and may overwhelm and outcompete native fish for food and habitat. The STC has seen the impacts of Yellow perch within the Nicola Watershed as they prey on young smolts, like juvenile Interior Fraser Coho salmon.

The STC is participating in a variety of programs monitoring the Nicola watershed to assess fish populations. These programs include both electronic data collection sites as well as hands-on programs such as dead pitch counts of salmon in the fall. Tracy stated that the STC wants to do more with controlling Eurasian watermilfoil but they are lacking the funds; specifically, they would like to develop a Clean Drain Dry station for boaters, but lack the funds needed to operate it. Additional Eurasian watermilfoil projects included scuba divers gathering the invasive plants around boat launches within Nicola Lake, but this was found to be an ineffective management technique. As for Yellow perch, previously obtained fish samples and stomach contents will be used for future eDNA testing in other areas to track their spread.

Tracy believes that STC Elders are happy to see that NWSFA has the capacity and traditional knowledge and values to advocate for food security within the community, as well as employing local band members. The majority of NWSFA' funding comes from the federal Department of Fisheries and Oceans and other fisheries related programs. When asked how their programs could be further supported, Tracy stated that the NWSFA needs to have secure long-term funding to ensure food security within the community. Tracy also expressed interest in funding for Steelhead recovery and habitat programs. The NWSFA has also been advocating to add the Thompson and Nicola system Steelhead trout (*Oncorhynchus mykiss*) to the SARA list.



Upper and Lower Nicola Indian Bands

Representatives:

JJ Holmes, Operations Supervisor with the Lower Nicola Indian Band Development Corporation

Brian Holmes, Councillor with the Upper Nicola Indian Band

Invasive Species of Concern:

Yellow perch (*Perca flavescens*), Blueweed (*Echium vulgare*)

Impacted Species at Risk:

Burbot (*Lota lota*)

Impacted Culturally Significant Species:

Kokanee salmon (*Oncorhynchus nerka* var. *kokanee*) and Mule deer (*Odocoileus hemionus*)

JJ Holmes (Operations Supervisor with the Lower Nicola Indian Band Development Corporation) and Brian Holmes (Councillor with the Upper Nicola Indian Band) came together to voice their concerns about invasive species within the Nicola River.

Lake. Yellow perch are very adaptable, meaning that they are able to survive in varying water conditions. Since the discovery of Yellow perch in Douglas Lake, the Upper Nicola Band has focused on evaluating the size and age distribution of the Yellow perch population, and testing standard and experimental methods for population control. This is of great concern to Brian as Yellow perch are able to adapt to the warmer water temperatures associated with climate change, while salmon species may have a harder time. He notes that Yellow perch have affected key sustenance species including Kəkñi? (Kokanee salmon; *Oncorhynchus nerka* var. *kokanee*) and Spqʷlic (Burbot; *Lota lota*), which is provincially listed as critically imperiled. Brian is proud of the work that the Upper Nicola Indian Band has done to manage invasive species; he believes that individual actions do make a difference and encourages everyone to do their part.



Brian Holmes voiced his concern for the health of a sustenance fisheries and destruction of habitat for native species within the Nicola watershed. In 2018, Yellow perch (*Perca flavescens*) were found within Douglas and Sanctuary lakes, in the upper Nicola River region of the Thompson drainage. High spring flows have since moved this invasive species further downstream into Nicola

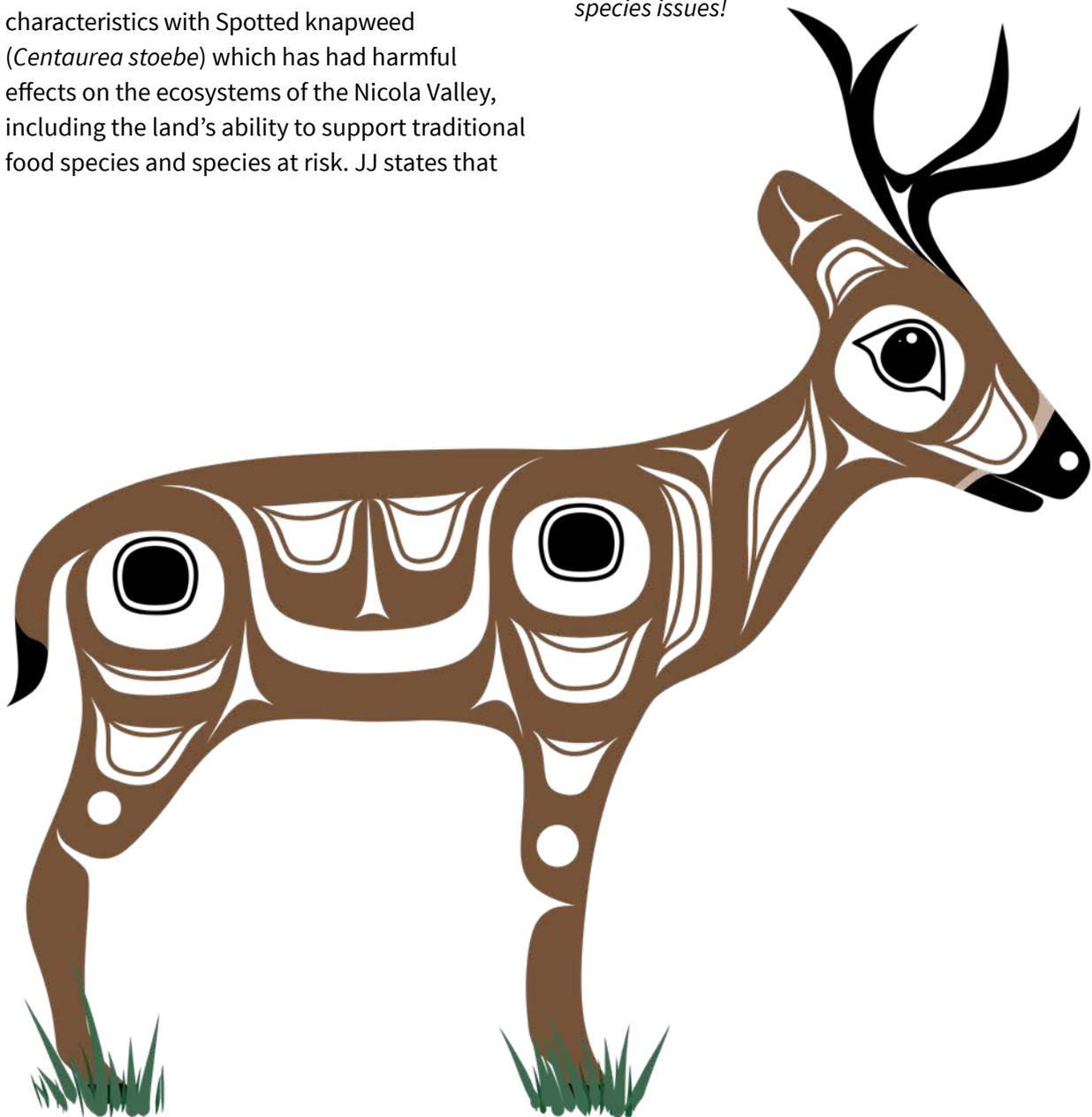


JJ Holmes shared his concerns about the widespread effects of noxious Blueweed (*Echium vulgare*) within the Lower Nicola region. Blueweed is a groundcover weed that is toxic to horses, cattle, and wildlife. This reduces forage quality in rangelands and pastures, resulting in economic losses for ranchers. The First Nations communities in the Nicola Valley are very concerned about

heavy infestations of Blueweed impacting their traditional hunting and gathering areas. JJ notes that Blueweed became increasingly abundant in the region following the 2017-2018 wildfires, sharing his concern that large infestations of Blueweed will affect traditional food species such as Mule deer (*Odocoileus hemionus*) by out-competing and reducing their forage sources. Blueweed shares similar infestation characteristics with Spotted knapweed (*Centaurea stoebe*) which has had harmful effects on the ecosystems of the Nicola Valley, including the land's ability to support traditional food species and species at risk. JJ states that

“we would traditionally hunt the Mule deer in those areas and now they have moved on because there is no ecosystem left for the deer to come back to during annual migration.”

JJ Holmes is a member of ISCBC's Board of Directors where he has offered critical feedback and initiated positive changes. We are so grateful for his commitment to addressing invasive species issues!





Indigenous Youth

Engaging youth through training and skill development opportunities is a cornerstone of ISCBC's work: we have an active and well-recognized Youth Volunteer network that includes over 650 youth in 73 communities across BC. Through ISCBC workshops and outreach programs, Indigenous youth have opportunities to learn more about the native species in their territories and the impacts of invasive species, and share their own perspectives on ecological stewardship with their peers.

School, community, and youth volunteer programs and summer camp sessions have been delivered to hundreds of Indigenous youth across BC through community partnerships over the past decade. Through the ISCBC's Indigenous Invasive Species Network

(comprised of nearly 200 individuals from 89 Nations across BC) youth outreach, training and educational resources are reviewed to ensure cultural relevancy. Professional development sessions for educators develop skills and introduce tools to extend learning.

INDIGENOUS VOICES

“Engaging the youth to address these issues [of invasive species] is probably one of the most powerful ways that we can stop the invasion of invasive species and that we can preserve our native species and culturally important species for generations to come.”

Caitlyn Therrien Iannone, Sto:lo, Sylix Nation

Many Indigenous youth, including some representing the Métis Nation of BC have joined the ISCBC Youth Volunteer Program, which has collectively contributed over 24,000 hours and restored and enhanced over 100 sites across BC.

INDIGENOUS VOICES

“ I feel like we need more youth involved, more volunteers, and more awareness. We have a responsibility to the environment, to protect it. ”

Sasha, Indigenous Youth Volunteer

“ My elders have taught me that I should seek to walk with respect for both the people of this land and the land itself. We have much to learn from all the Indigenous people of Turtle Island, I have much to learn myself, so I say thank you to those who have been and continue to be my teachers. ”

Justin Perry, Metis, Speaker at the 2020 ISCBC Youth Summit

“ As an Indigenous person it's really nice to start to see other people view and understand. And seeing other people curious about it and wanted to learn about it is really nice. ”

Ali Gallant, Indigenous Youth who attended ISCBC's Mini Summit

“ Initially I was drawn to action as I wished to take palpable measures to maintain the habitats of the plants, animals and fungi that share the spaces I occupy along with a desire to further my education in the ecology field. It has been nothing short of inspiring thus far! ”

Joshua Ralph, Indigenous Youth Volunteer

“ We gotta care for the environment to learn how to care for it for the future. ”

Ziyah, Indigenous Youth Volunteer

Discussion

The case studies presented in this report highlight how invasive species can impact culturally important species at risk, resulting in the loss of biodiversity, traditional practices, and food security. The essential involvement of Indigenous communities in species at risk research, ecosystem management and traditional food practices is discussed.

Invasive Species, Species at Risk, and Cultural Practices

Invasive species can have significant impacts on both species at risk and Indigenous traditional practices, as highlighted by these four case studies. Many species currently listed on national and provincial endangered species lists are found on traditional Indigenous territories in BC, and are culturally significant to Indigenous nations. Therefore, it is imperative that Indigenous peoples are included in species at risk research, monitoring and endangered status designation. Laws and policies around SARA and COSEWIC dictate a necessity to include Indigenous people in recovery plans (Hill et al., 2019). However, a review of species at risk recovery documents conducted in 2018 found that 52% of the reports had no indication of Indigenous involvement in conservation initiatives. Additionally, studies of species from less iconic and economically valuable taxa (e.g. mosses) also tended to omit Indigenous involvement (Hill et al., 2019). This lack of Indigenous involvement in federal species at risk recovery plans may mean that certain relationships between species, traditional ecological knowledge and invasive species impacts that have been observed by Indigenous peoples are not included, omitting potentially critical information to support their recovery.

The value of traditional ecological knowledge is a key element to include when managing species at risk and studying the impacts of invasive species, biodiversity and habitat loss, and climate change. Failure to include Indigenous knowledge

contributes to the promotion of research that focuses solely on the species, where the complex ecological structures that are necessary for species at risk recovery are not fully realized. The Intergovernmental Panel on Climate Change (IPCC) stated that “Indigenous, local and traditional knowledge systems and practices, including Indigenous peoples’ holistic view of community and environment, are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts” (2014). Culturally significant species are also critical for Indigenous self-determination and governance as they represent key aspects of Indigenous-led economic natural infrastructure and cultural manifestation.



Traditional Dipnet; Dawn Shackelly — Nlaka'pamux Nation

Traditional Food Species and Shared Recipes

As illustrated in the four case studies, invasive species have the potential to impact traditional food sources of Indigenous communities across BC. In Canada, Indigenous peoples already face disproportionately high levels of food insecurity, therefore, it is imperative that traditional food sources and culturally important species are conserved through the ongoing management of invasive species (Elliot et al., 2012; Islam and Berkes, 2016; Gendron et al., 2017). Some of the traditions and cultural significance of these key food species are shared below through oral histories and shared recipes.

The Northern Shuswap Tribal Council, Okanagan Nation Alliance, Scw'exmx Tribal Council, and the Upper and Lower Nicola Indian Bands all identified salmon species to be important and traditional food sources. Salmon is also a culturally important species for Indigenous communities throughout BC

as it is significantly tied to cultural identity, ceremony, sustenance, and practices of reciprocity. In some cultures, the salmon is a sacred being, given by the creator to feed the people. Salmon remains an important food and is caught to feed families and community members, it is often given to Elders, and is even traded or sold. Salmon is an important part of the economies of many Indigenous and non-Indigenous communities in BC, and is eaten cooked, smoked, dried, and canned.

Several species of trout — Rainbow trout, Cutthroat trout, Steelhead trout, and Brook trout — were also identified as important traditional food species. Trout is a food species that many people enjoy catching as well as eating. It provides important nutrients and has great flavour, especially when smoked. Trout can also be dried and stored.

RECIPE

Fire Smoked Trout

Shared by Caitlyn Therrien Iannone

Ingredients:

- Hardwood
- Hardwood chips
- Trout
- Salt

Tools:

- Campfire
- Knife
- Large grill
- Foil

Directions:

Start a small fire in a closed fire pit (with a pit ring), using local hardwood if available. Burn wood down to coals and spread thinly to reduce heat and encourage smoking. Sprinkle in some hardwood chips to the coals. Place grill approximately 1 foot above coals. Clean and butterfly trout, then sprinkle with coarse sea salt. Once coals cool down enough, place butterflied trout on the grill skin side down. Cover the entire grill with foil. Move coals or add a few hardwood chips occasionally; pit should stop smoking.

Cooking time: 2-3 hours.

As JJ Holmes mentioned, mule deer make up an important food species for the Lower Nicola Indian Band, as it has been throughout history. Traditionally, for many Indigenous peoples in BC, deer was an important source of raw materials in addition to food (this varied for each community). Every part of the animal was used, a practice that is still often observed today. Bone, antlers and hooves could be used for tools, carvings, and toys. Tanned hide and fur could be used for clothing and hide could be tanned and used for drum making. For some cultures, deer was a main component of their diet while for others it was an important supplement. Deer

was available throughout the year but was often hunted in seasons in which other food sources were less available.

Throughout the province, deer, elk and moose are still important sources of food for both Indigenous and non-Indigenous communities. Some rural communities largely rely on hunting wild game, which is often shared with family, community members, and Elders. Many people in more urban communities also enjoy eating wild game as a preferred food source and because of the cultural connection.

RECIPE

Venison Stew

Shared by Caitlyn Therrien Iannone

Ingredients:

- 2 tablespoons canola, olive or vegetable oil
- 2 pounds venison stew meat
- 3 large onions, coarsely chopped
- 2 garlic cloves, crushed
- 1 tablespoon Worcestershire sauce
- 1 bay leaf
- 1 teaspoon dried oregano
- 1 tablespoon salt
- 1 teaspoon pepper
- 3 cups water
- 1 pound carrots, cut into 1-inch pieces
- 3 russet potatoes, peeled and chopped into 1-2-inch chunks
- ¼ cup all-purpose flour
- ¼ cup cold water
- 1 tablespoon brown sugar

Directions:

Heat oil in a Dutch oven. Brown meat. Add onions, garlic, Worcestershire sauce, bay leaf, oregano, salt, pepper and 3 cups water. Simmer, covered, for 1 and ½ to 2 hours or until meat is tender. Add potatoes and carrots. Continue to cook until vegetables are tender, about 35-40 minutes. Mix flour and cold water, stir into stew. Add brown sugar and stir into stew. Cook and stir until thickened and bubbly. Remove bay leaf.

Cooking time: 3 hours.



Conclusion

Invasive species seriously impact ecosystems, economies and society with particularly devastating impacts to species at risk in British Columbia, many of which are also culturally significant to Indigenous groups and cultures. In this report, five representatives of four Indigenous communities in BC (the Northern Shuswap Tribal Council, the Okanagan Nation Alliance, the Scw'xmx Tribal Council, and the Upper and Lower Nicola Indian Bands) shared their experiences of the impacts of invasive species on species at risk and culturally significant species. These representatives identified that invasive Smallmouth bass (*Micropterus dolomieu*), Northern pike (*Esox*

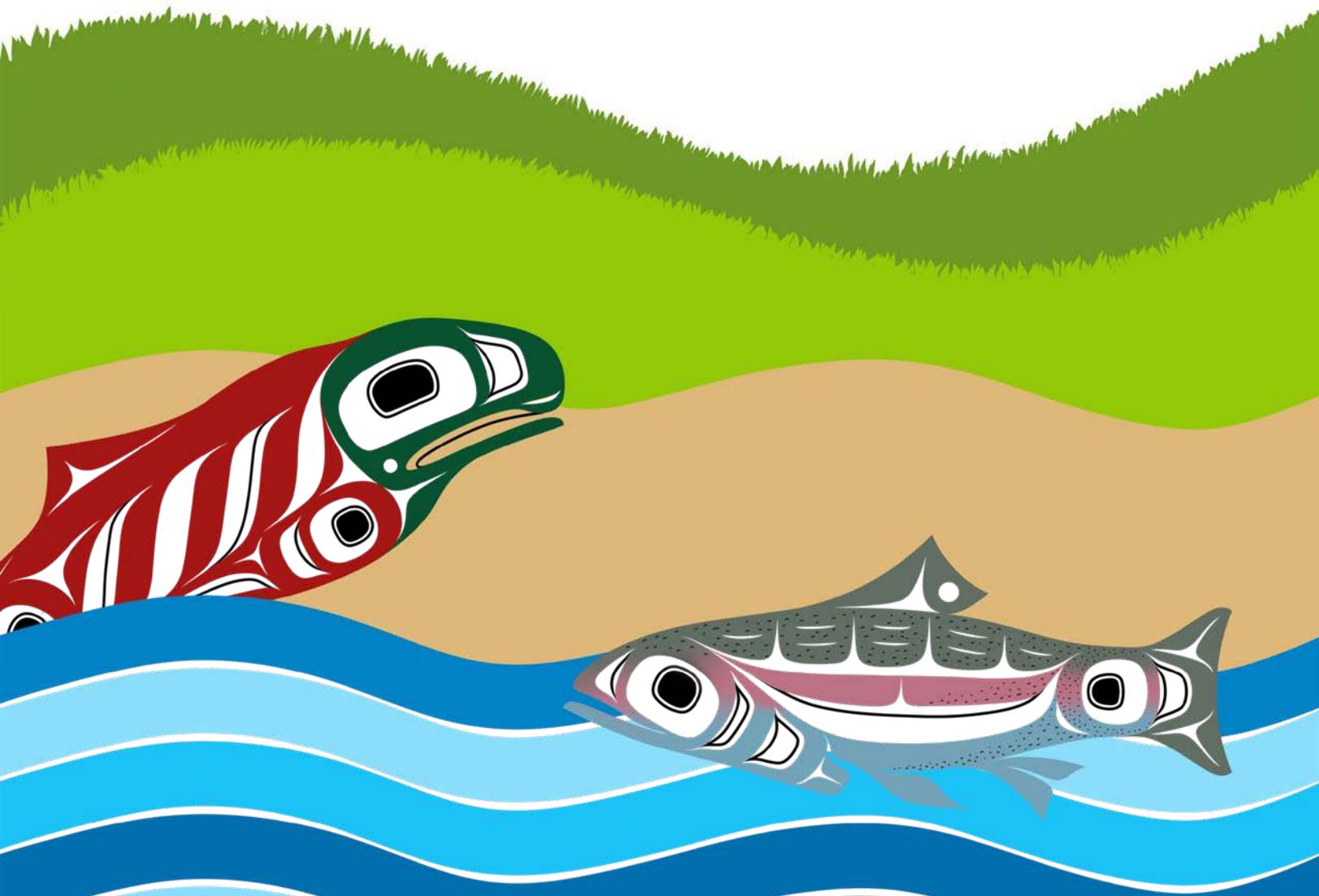
lucius), Yellow perch (*Perca flavescens*), Eurasian watermilfoil (*Myriophyllum spicatum*), and Blueweed (*Echium vulgare*) have impacted five at-risk species and a plethora of key food species. Ongoing collaboration between Indigenous communities, western scientists, governments, and policy makers is needed to increase the understanding of the many different impacts of invasive species. The inclusion of Indigenous traditional ecological knowledge of native and invasive species, ecological stewardship, and invasive species management planning will help ensure that culturally important and at-risk species remain healthy and bountiful for future generations.

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Appendix

ISCBC has compiled an extensive literature review, **Culturally Important At-Risk Species and Invasive Species**, which summarizes the impacts of invasive species on 35 culturally significant endangered and at-risk species in British Columbia. This literature review is attached for your convenience.





Culturally Important At-Risk Species and Invasive Species

Literature Review prepared by the Invasive Species Council of BC
March 31, 2022

1. Executive Summary

Invasive species can have considerable negative influence on the ecosystems they invade, and particularly devastating impacts on endangered and at-risk species. Many species currently listed on Canadian and Provincial endangered species lists are culturally significant species to Indigenous groups in British Columbia (BC).

This literature review summarizes invasive species impacts on 35 culturally significant endangered and at-risk species in BC and was compiled as an appendix to **In Their Own Words: The Impact of Invasive Species on Indigenous Communities and Species at Risk**. The full report can be found at bcinvasives.ca/indigenous-connections

2. Introduction

2.1 Problem statement

Invasive species can cause significant impacts on species at risk. Many species at risk are culturally significant species to Indigenous groups and cultures. Reviews have identified invasive species impact species at risk in Canada (e.g. (McCune et al., 2013; Tamburello & Litt, 2021; Woo-Durand et al., 2020), but there are limited reviews on the impacts of invasive species on culturally important species at risk. Invasive species are a leading cause of threatened species declines (Dueñas et al., 2018). Culturally important species are defined as species that

are significant for Indigenous communities, with roles in food, materials, medicine, identity, and/or spiritual values (Freitas et al., 2020; Garibaldi & Turner, 2004). Invasive species can impact species at risk through monopolizing resources, competition, predation, herbivory, behavioural disruption, altering food webs, ecosystem modification, allelopathy, hybridization, parasitism and by introducing new diseases/pathogens (Dueñas et al., 2018). BC has the highest biodiversity in Canada, and also the most endangered species (Westwood et al., 2019). There is no provincial endangered species legislation to protect the over 1800 species listed Provincially. There are 278 Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed species present in BC, and 214 of those are listed federally under the *Species at Risk Act* (SARA). Many of these species have worsened or failed to improve, even with recovery efforts (Westwood et al., 2019). This indicates the need for more research and further knowledge on invasive species and species at risk, especially with regard to Indigenous communities, which can lead effective actions in the future.

2.2 Purpose

The purpose of this literature review is to summarize invasive species impacts from scientific literature on culturally important species at risk in British Columbia. The goal is to identify recorded impacts, and to identify gaps in literature. The objective of this document is

to help inform and provide support for much needed funding, research and action on invasive species impacting species at risk.

The use of this document is intended to be for the Indigenous Invasive Species Network (IISN), to facilitate funding applications for action, research, and outreach on invasive species. The IISN facilitates meetings between Indigenous communities and organizations across BC.

2.3 Scope

The scope of this literature review was limited by species that have documented use by BC Indigenous groups, are species at risk, and have known invasive species impacts in scientific literature. Species at risk are defined as any species that is listed by COSEWIC, SARA, or is on the BC Blue or Red list. The species also must have distribution in BC.

- COSEWIC is an independent committee that classifies species that are at risk of extinction and makes recommendations to the federal government.
- The federal government is responsible for providing legal ranking and protection to species at risk of extinction under SARA.
- Species on the BC Red list are defined as any species that are at risk of being extirpated, endangered or threatened.
- Species on the BC Blue list are defined as any species that are of special concern.

*Species on the BC Red and Blue lists do not have specific legal protections.

3. Methods

3.1 Compiling the species

A list of species that are culturally significant to BC Indigenous groups from published sources was compiled. The species were gathered from

the following resources: (Bird, 2017; Bouchard & Kennedy, 2004; Charlie, 2021; Kuhnlein, 2017; Kuhnlein et al., 1996, 2013; Kuhnlein & Humphries, 2020; Kuhnlein & Receveur, 1996; Kuhnlein & Turner, 1991; Lemke & Delormier, 2017; MacKinnon, 2016, 2016; Markey & Ross, 2005; McAllister, 1980; Moss, 2007; Oloriz & Parlee, 2020; Receveur et al., 1997; Turner, 2006, 2014, 2019; Turner & Turner, 2007). Additionally, species identified by Tamburello & Litt (2021) as culturally significant to BC Indigenous groups were added to the list for literature review. All BC Blue and Red listed species were downloaded from the [BC Species & Ecosystems Explorer](#), and were cross referenced with the list of culturally significant species. Any species overlaps between the two lists were included in this literature review.

3.2 Literature review

A review of the scientific literature was conducted on the species identified as being culturally significant to BC Indigenous groups, and at risk. Literature linked to on the BC Species and Ecosystems Explorer, [NatureServe Explorer](#), and in COSEWIC and SARA reports (if available) was reviewed. Additionally, a literature review was conducted using the following search terms on Google Scholar:

“Common name” OR “Scientific name” AND “invasive species” OR “invasive species impacts” OR “naturalized species” OR “non-native species” OR “alien species” OR “introduced species” OR “invasive alien species” OR “exotic species” OR “non-indigenous species” OR “impacts” OR “SAR” OR “species at risk” OR “BC red list” OR “BC blue list”

Any documented impacts of invasive species on the particular species at risk were summarized. Invasive species needed to be present in BC, in a neighboring jurisdiction, or identified as a priority species for their impacts to be noted.

4. Results

FEDERALLY LISTED SPECIES

Ancient murrelet (*Synthliboramphus antiquus*)

Ancient murrelet is a BC Blue-listed (S2S3B, S4N) species, is Special Concern (SC) under COSEWIC, and is Special Concern (1-SC) under SARA.

Ancient murrelet is a seabird species in the auk family distributed throughout the North Pacific from Alaska to California. Its breeding range includes the North Coast of British Columbia, including Haida Gwaii (COSEWIC, 2009b). These birds breed and burrow in soft soil, under tree roots or logs (Bird, 2017) and are impacted by invasive and introduced mammals (COSEWIC, 2009b). Brown rats (*Rattus norvegicus*) and Black rats (*Rattus rattus*) are introduced rat species that prey on Ancient murrelet nests, and Sitka black tailed deer (*Odocoileus hemionus sitkensis*) are changing forest understory composition rapidly on Haida Gwaii, altering nesting habitat (Stockton, 2004).

Bull trout (*Salvelinus confluentus*)

Bull trout is a char of the family Salmonidae. It's a mostly fresh, cold-water fish that lives throughout North America along the West Coast from Alaska to Oregon, including interior areas like Alberta, Idaho and Montana. Several populations have been identified including the South Coast British Columbia population which is anadromous. This population of Bull trout is BC Blue-listed, is Special Concern (SC) under COSEWIC, and is Special Concern (1-SC) under SARA (COSEWIC, 2013). Native bull trout are threatened and impacted by invasive aquatic species such as Large and Smallmouth bass (*Micropterus* spp.), Yellow perch (*Perca flavescens*), Northern pike (*Esox lucius*) and Brook trout (*Salvelinus fontinalis*) who can outcompete Bull trout (COSEWIC, 2013; Tamburello & Litt, 2021).

Cassin's auklet (*Ptychoramphus aleuticus*)

Cassin's auklet is a BC Red-listed (S2B, S3N) species, is Special Concern (SC) under COSEWIC, and Special Concern (1-SC) under SARA.

There are an estimated 62 colonies in BC of this small seabird, primarily off the West and North Coast of Vancouver Island, the central mainland coast and Haida Gwaii. Cassin's auklet breeds on cliffs, grassy plains or slopes on coastal islands usually nesting in an underground burrow (COSEWIC, 2014). On breeding islands, introduced predators may decrease numbers of Cassin's auklet (Bailey & Kaiser, 1993; COSEWIC, 2014; Harfenist et al., 2002). Black rat (*R. rattus*) and Norway rat (*R. norvegicus*) have caused extirpation of three colonies on Haida Gwaii and decline of other colonies. Rats prey on adults, nestlings, and eggs. Raccoons (*Procyon lotor*) are found on nine colony islands and impact Cassin's auklet by excavating burrows and predated on adults, chicks and eggs (Bailey & Kaiser, 1993; Gaston & Masselink, 1997). Mink (*Noegale vison*) present on breeding islands predate on nesting birds (Hipfner et al., 2010; Rodway & Lemon, 1990). Outside of BC, Cassin's auklet has been predated on by introduced Red foxes (*Vulpes vulpes*) and Arctic foxes (*Vulpes lagopus*, formerly *Alopex lagopus*) and cats (*Felis catus*) (Bailey & Kaiser, 1993; Wolf et al., 2006). Introduced herbivores European rabbits (*Oryctolagus cuniculus*) and Sitka black-tailed deer (*O. hemionus sitkensis*) may impact Cassin's auklet in BC, as introduced herbivores in other parts of the range impact the birds (Aguirre-Muñoz et al., 2011; McChesney & Tershy, 1998). Eradication of predators have been shown to be successful (COSEWIC, 2014; Golumbia, 2000; Regehr et al., 2007).

Coast manroot (*Marah oreganus*)

Coast manroot is a BC Red-listed (S1) species and is Endangered (E) under COSEWIC.

It is a climbing perennial species of the cucumber family (Cucurbitaceae) with a distribution limited to Southern Vancouver Island and the Gulf Islands (COSEWIC, 2010). Coast manroot is impacted by interspecific competition for root space, nutrients and water from Scotch broom (*Cytisus scoparius*), Himalayan blackberry (*Rubus armenicus*) and Hedge bindweed (*Calystegia sepium*) (COSEWIC, 2010).

Cutthroat trout (*Oncorhynchus clarkii clarkii*)

Coastal cutthroat trout is a BC Blue-listed species (S3S4) species.

Coastal cutthroat trout are subspecies of the Cutthroat trout (*Oncorhynchus clarkii*). There is documented hybridization between *O. clarkii* and Rainbow trout (*O. mykiss*) (Buehrens, 2011; Moore et al., 2010). Migratory disorientation of hybrids may be a limiting factor in the wild (Moore et al., 2010). One study found that *O. clarkii clarkii* prey heavily on the introduced Longfin smelt (*Spirinchus thaleichthys*) (Coastal Cutthroat Trout Symposium et al., 2008). Adult *O. clarkii clarkii* may be subject to predation and other negative interactions with introduced salmonids. One-third of *O. clarkii clarkii* populations in Washington and Oregon are expected to contain hybrids. One study suggests that the hybrid rate could be as high as 20% in the Georgia Basin, with rates declining northward towards BC. *O. clarkii clarkii* may be subjected to extreme declines where there are introduced fish species and degraded habitats.

Cutthroat trout (*Oncorhynchus clarkii lewisi*)

Westslope cutthroat trout is a BC Blue-listed (S2S3) species, is Special Concern (SC) under COSEWIC, and is Special Concern (1-SC) under SARA.

Westslope cutthroat trout are subspecies of the Cutthroat trout (*Oncorhynchus clarkii*). Non-native brook trout (*Salvelinus fontinalis*) lead to range constriction or elimination of Cutthroat trout (COSEWIC, 2016; Donald, 1987). *O. clarkii lewisi* have been documented hybridizing with Rainbow trout (*O. mykiss*) (Rubidge, 2003). Rainbow trout are considered invasive in some BC waters (BC Ministry of Fisheries, n.d.). Introgression has occurred between *O. clarkii lewisi* and *O. mykiss* across the entire range, and the upper Kootenay River has been the most recent to have hybrids between the two species (Bennett, 2007; Rubidge, 2003). It has been documented that hybridization is more likely to occur in streams with warmer water, increased land use disturbance, and proximity to main source of hybridization (Muhlfield et al., 2009). Whirling disease is a threat to BC populations of *O. clarkii lewisi*, there have been several instances of it in Alberta (COSEWIC, 2016).

Ermine (*Mustela erminea haidarum*)

Ermine is a BC Red-listed (S2) species, is Threatened (T) under COSEWIC and is Threatened (1-T) under SARA.

The Haida Ermine subspecies is a mustelid and is impacted by several invasive species such as the Sitka black tailed deer (*Odocoileus hemionus sitkensis*) drastically altering forest understory vegetation composition (Stockton, 2004). Introduced rats (*Rattus* spp.) also may be increasing the prey base for the Pacific martin (*Martes caurina*) leading to a higher population of Martins, a natural predator of the Haida ermine (Breault et al., 2021).

Great basin spadefoot (*Spea intermontana*)

Great basin spadefoot is a BC Blue-listed (S3) species, is Threatened (T) under COSEWIC, and Threatened (1-T) under SARA.

Great basin spadefoot is a toad species typical of dry grasslands throughout interior Western North America with BC representing the most Northern extension of its range (COSEWIC, 2009a). Great basin spadefoots are vulnerable to direct predation of introduced sport fish as well as habitat modification or increased resource competition. Introduced amphibians such as the American Bullfrog (*Rana catesbeiana*) can also contribute to this increased pressure on the Great basin spadefoot (COSEWIC, 2009a).

Great blue heron (*Ardea herodias fannini*)

Great blue heron is a BC Blue listed (S3) species, a species of Special Concern (SC) under COSEWIC and Special Concern (1-SC) under SARA.

Great blue heron *fannini* is a subspecies of heron distributed along the coast of BC. The introduced Raccoon (*Procyon lotor*) impacts Great blue herons on Haida Gwaii (Voller & McNay, 2007).



Green sturgeon (*Acipenser medirostris*)

Green sturgeon is a BC Blue listed (G3) species, a species of Special Concern (SC) under COSEWIC and a Special Concern (1-SC) under SARA.

Green sturgeon is a large anadromous fish in the Acipenseridae Family that occur in marine and freshwater rivers along the Pacific coast. Populations in BC have likely been impacted as invasive Amur river clam (*Potamocorbula amurensis*, formerly *Corbula amurensis*) have replaced native mollusks and shrimps in the Sacramento river estuary, where they are known to spawn (Israel & Klimley, 2008). This dietary shift may result in dietary dilution, bioaccumulation of contaminants, and reduced growth of green sturgeon life (Israel & Klimley, 2008). Invasive plant species have likely impacted the quantity of shallow habitat available to coastal migrant and adult Green sturgeon (Israel & Klimley, 2008).

Grizzly bear (*Ursus arctos*)

Grizzly bear is a BC Blue-listed (S3?) species, Special Concern (SC) under COSEWIC and Special Concern (1-SC) under SARA.

Grizzly bears in Yellowstone National Park have been affected negatively by the invasive Common dandelion (*Taraxacum officinale*) and clovers (*Trifolium* spp.), which provide little energy compared with high-quality native plants (Reinhart et al., 2001). Bovine brucellosis (*Brucella abortus*) negatively affects Bison (*Bison bison*) and Elk (*Cervus elaphus*), which are both prey species for Grizzly bears (Reinhart et al., 2001). White pine blister rust (*Cronartium ribicola*) has the potential to destroy White pine forests in Yellowstone Park that Grizzly bears depend on (Reinhart et al., 2001).

Lake chub (*Couesius plumbeus*) – Atlin Warm Springs and Liard Hot Springs populations

Lake chub is a BC Red-listed (S1S2) species and is Threatened (T) under COSEWIC.

Lake chub is freshwater cyprinid fish. The Atlin Warm Springs population occurs in the Atlin Warm Springs in an area of 4 km². The Liard Hot Springs population occurs in the Liard and Deer River hot springs in an area of 12 km². The Liard Hot Springs Lake chub population may be impacted by invasive fish if they were introduced, including Mosquitofish (*Gambusia affinis*), Goldfish (*Carassius auratus*), Common carp (*Cyprinus carpio*), Bluegill sunfish (*Lepomis macrochirus*), Black crappie (*Pomoxis nigromaculatus*), Yellow perch (*Perca flavascens*), Smallmouth bass (*M. dolomieu*), Largemouth bass (*M. salmoides*) (COSEWIC, 2019; Stasiak, 2006). The Atlin Warm Springs Lake chub population is impacted by the invasive Cherry shrimp (*Neocaridina davidi*) that was detected in 2015 and has become a food source for Lake chub (COSEWIC, 2019). It may be impacted by other aquarium species, like Goldfish (*Carassius auratus*), turtles, or other warm water fish species if introduced (COSEWIC, 2019). In Alberta, the invasive Prussian carp (*Carassius gibelio*) was found to decrease Lake chub populations (Docherty, 2016; Ruppert et al., 2017).

Lewis's woodpecker (*Melanerpes lewis*)

Lewis's Woodpecker is a BC Blue-listed (S2S3B) species, is Threatened (T) under COSEWIC and Threatened (1-T) under SARA.

Lewis's woodpecker is a large and social bird species found in the interior of BC, primarily associated with the Ponderosa Pine (PP)

biogeoclimatic (BEC) zone. Lewis's woodpecker is thought to be directly impacted by the invasive European starling (*Sturnus vulgaris*) in competition for nesting cavities. There is evidence Lewis's woodpecker frequently outcompetes European starlings for these cavities, however the full extent of the energetic cost is not fully understood (COSEWIC, 2010a).

Mountain sucker (*Catostomus platyrhynchus*)

Mountain sucker is a BC Blue-listed (S3?) species, is Special Concern (SC) under COSEWIC, and Special Concern (1-SC) under SARA.

Mountain sucker is a small, torpedo-shaped fish that is threatened by many non-native species like Brown bullhead (*Ameiurus nebulosus*), American Bullfrogs (*Rana catesbeiana*), Brown trout (*Salmo trutta*), Largemouth bass (*Micropterus salmoides*), and Smallmouth bass (*M. dolomieu*). These species would likely opportunistically prey on the Mountain sucker. Mountain sucker may be impacted by Russian olive (*Elaeagnus angustifolia*), which is present in riparian habitats of the Southern Interior including the Okanagan and Lower Mainland (Collette & Pither, 2015). Russian olive increases benthic organic matter which may affect Mountain sucker habitat quality (Collette & Pither, 2015). Yellow perch are present in 70 waterbodies in BC, many of which are also inhabited by Mountain sucker (Runciman & Leaf, 2009). Yellow perch competes with native fish species for planktonic food and preys on juveniles of other fish species (Government of Canada, 2018), though a knowledge gap exists on specific impacts to Mountain sucker populations in these waterbodies.

Northern fur seal (*Callorhinus ursinus*)

Northern fur seal is a BC Red-listed (S2M) species and is Threatened (T) under COSEWIC.

Northern fur seals are eared seal species in Canadian waters that breed at four islands — St. Paul and St. George in the Pribilof Islands and Bogoslof in Alaska and San Miguel island in California (COSEWIC, 2010a). In the Pribilof Islands, non-native Arctic fox (*Alopex lagopus*) has been identified as spreading *Salmonella enteritidis* in seals (Poland et al., 2021).

Northern saw-whet owl (*Aegolius acadicus brooksi*)

The Northern saw-whet owl is a BC Blue-listed (S2S3) species, is Threatened (T) under COSEWIC and is listed under Schedule 1 Threatened (1-T) under SARA.

The entire *brooksi* subspecies is restricted to Haida Gwaii and the population is non-migratory (COSEWIC, 2006). Saw-whet owls are vulnerable to nest predation by mammals introduced to Haida Gwaii, including Red squirrels (*Tamiasciurus hudsonicus*), Common raccoons (*Procyon lotor*), Black rats (*Rattus rattus*) and Norway rats (*Rattus norvegicus*). Although Sealy (1999), reported a juvenile saw-whet owl killed by a domestic cat on Haida Gwaii, this is likely to be a negligible threat as cats are not widespread in the archipelago. Barred owls (*Strix varia*) are not present on Haida Gwaii, but a range expansion may have negative effects as they are known to prey on small owl species (Elliott, 2006). European starling (*Sturnus vulgaris*) may compete for nest cavities and harass owls causing nest abandonment. The establishment of Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) have caused over-browsing, potentially limiting available food for Saw-whet owls (COSEWIC, 2006).

Olympia oyster (*Ostrea lurida*)

Olympia oyster is a BC Blue-listed (S3) species, Special Concern (SC) under COSEWIC, and Special Concern (1-SC) under SARA.

Olympia oyster is a small bivalve and only native oyster to BC's west coast. European green crab (*Carcinus maenas*) threatens Olympia oyster on the west coast of Vancouver Island (COSEWIC, 2011b; Yamada et al., 2008). Lab studies show that European green crabs prefer Olympia oysters over other species (COSEWIC, 2011b; Palacios & Ferraro, 2003). Invasive fouling organisms, ascidians, sponges and hydrozoans (including *Styela clava*, *Ciona intestinalis*, *Botryllus schlosseri*, *Botrylloides violaceus* and *Didemnum* sp.) may compete with Olympia oysters for space (COSEWIC, 2011b; DFO, 2010). Predatory gastropods Japanese oyster drill (*Ocenebrellus inornatus*) and Eastern drill (*Urosalpinx cinerea*) may negatively impact Olympia oysters and prevent recovery (Buhle & Ruesink, 2009; COSEWIC, 2011b; Padilla et al., 2011). A parasitic copepod, *Mytilicola orientalis*, may negatively impact Olympia oysters (Padilla et al., 2011). The non-native Pacific oyster (*Magallana gigas*) has escaped cultivation in BC and it has been recorded that Pacific oyster has increased populations while Olympia oyster has decreased populations (Kornbluth et al., 2022).



Rocky Mountain ridged mussel (*Gonidea angulate*)

Rocky Mountain ridged mussel is a BC Red-listed (S2) species, is Endangered (E) under COSEWIC, and Special Concern (1-SC) under SARA.

The biggest invasive species threat to this bivalve species is invasive Zebra and Quagga mussels (*Dreissena polymorpha* and *Dreissena rostriformis bugensis*). Neither species have been introduced to BC yet. It is also threatened by Eurasian watermilfoil (*Myriophyllum spicatum*) which can outcompete *G. angulate*, or drastically degrade freshwater habitats and nutrient profiles to make it unsuitable habitat. A host fish is necessary to complete its lifecycle and currently the host fish in Canada is unknown (COSEWIC, 2011).

Short-tailed albatross (*Phoebastria albatrus*)

Short-tailed albatross is a BC Red-listed (S1N) species, is Threatened (T) under COSEWIC, and Threatened (1-T) under SARA.

Short-tailed albatross is a seabird species that has a range over most of the Pacific Ocean and is a non-breeding species off the coast of BC. They were a once abundant seabird along the coast of BC and Vancouver Island but have seen a population decrease to near extinction levels due to a volcanic eruption on their main breeding island (COSEWIC, 2009c). Short-tailed albatrosses are affected by the invasive Black rat (*R. rattus*) on their breeding islands (COSEWIC, 2009c).

Silky beach pea (*Lathyrus littoralis*)

Silky beach pea is a BC Red-listed (S2) species and is Threatened (T) under COSEWIC.

It is a perennial rhizomatous species in the pea family (Fabaceae), primarily found in dune habitats and is threatened by invasive species stabilization of dunes. Invasive beach grass species such as European beachgrass (*Ammophila arenaria*) and American beachgrass (*A. breviligulata*) outcompete and alter dune ecosystem services to the detriment of the Silky beach pea. Those species were originally introduced to stabilize beach dunes. They are also affected by invasive deer species like the Sitka black tailed deer (*Odocoileus hemionus sitkensis*) on Haida Gwaii and Farrow deer (*Dama dama*) on Sidney Island which both heavily graze the Silky beach pea (Tamburello & Litt, 2021).

Western grebe (*Aechmophorus occidentalis*)

Western grebe is a BC Red-listed (S1B, S2N) bird species, listed as Special Concern (SC) under COSEWIC and Special Concern (1-SC) under SARA.

Western grebe is a migratory waterbird that is restricted to three breeding sites in BC: Salmon Arm, the north arm of Okanagan Lake, and Duck Lake. Common carp (*Cyprinus carpio*) is often present in lakes where Western grebe nests are. Common carp may uproot vegetation where nests are, causing nest failure (Blouin, 2001; LaPorte, 2012). The presence of Hybrid cattail (*Typha x glauca*) and Flowering rush (*Butomus umbellatus*) may cause shoreline modification that no longer support Western grebe nests (Alberta Environment and Parks, 2021; COSEWIC, 2014; LaPorte, 2012). Hybrid cattail creates dense stands of vegetation, forcing Western grebes to nest closer to water, where nests are more vulnerable to wave action (LaPorte, 2012; LaPorte et al., 2020).



White bark pine (*Pinus albicaulis*)

White bark pine is a BC Blue-listed (S2S3) species, is Endangered (E) under COSEWIC, and Endangered (1-E) under SARA.

White bark pine is a subalpine evergreen tree. The main invasive species impacting White bark pine is White pine blister rust, which can cause 50% mortality in a stand of trees (COSEWIC, 2010b). The spread of White pine blister rust also depends on the presence of alternative hosts — typically native currant and gooseberry shrubs (COSEWIC, 2010b). White pine blister rust may also kill upper portions of the tree, limiting cone production (COSEWIC, 2010b). White pine blister rust infected trees may be more susceptible to Mountain pine beetle attacks (McKinney & Tomback, 2007).

White sturgeon (*Acipenser transmontanus*)

White sturgeon Upper Columbia River population is a BC Red-listed (S1) species, is Endangered (E) under COSEWIC and Endangered (1-E) under SARA. The Lower Fraser River Population is BC Red-listed (S1S2) and is Threatened (T) under COSEWIC.

White sturgeon is a large anadromous fish in the Acipenseridae Family. These two populations are the only ones with noted invasive species impacts. White sturgeon is a freshwater fish in the Columbia and Fraser River basins in BC (COSEWIC, 2012). The main source of predation is on larval and juvenile White sturgeon. Invasive Walleye in the Columbia River prey on yearling sturgeon in a different way than co-evolved predators (COSEWIC, 2012). They may or may not have a significant effect on the Upper Columbia River Sturgeon population. Large and Smallmouth bass (*Micropterus* spp), are present in the Lower Fraser River Sturgeon population, and they may or may not have a significant negative effect (COSEWIC, 2012). Northern pikeminnow (*Ptychocheilus oregonensis*) (invasive in southern BC) was observed in the lab preying on White sturgeon between 121-134 mm (Gadomski & Parsley, 2011). Juvenile Walleyes ate White sturgeon up to 59 mm long, and adult Walleye (*Sander vitreus*) ate almost no sturgeon. Channel catfish (*Ictalurus punctatus*) ate White sturgeon from 121-145 mm total length (Gadomski & Parsley, 2011).

BC RED-LISTED SPECIES

American white pelican (*Pelecanus erythrorhynchos*)

American white pelican is a BC Red-listed (S1B) species and is Not At Risk (NAR) under COSEWIC.

American white pelican is a large aquatic soaring bird. The only breeding population in BC occurs at Stum Lake on the Chilcotin Plateau, and Pelicans forage on other lakes in the area (Vanspall et al., 2005). Stocked fish in foraging lakes could reduce prey species populations by competition for food and stocked fish may prey on Pelican prey fish species (Government of BC, 2004; Voller & McNay, 2007).

Chocolate-tips (*Lomatium dissectum*)

Chocolate-tips is a BC Red-listed (S2) plant species with all known mapped locations on Vancouver Island in the CDFmm BEC zone.

Chocolate-tips is a perennial herb in the carrot family. Research on effects of invasive species on Chocolate-tips is limited. One study found that after various disturbance events, Chocolate-tips had a lower survivorship rate than other *Lomatium* species (Marsico & Hellmann, 2009). A study in Idaho found that the plant community containing Chocolate-tips had relatively few invasive species, but did include Russian thistle (*Salsola kali*) and Desert alyssum (*Alyssum desertorum*) (Blew et al., 2005).

Common murre (*Uria aalge*)

Common murre is a BC Red-listed (S2B, S3S4) species.

It is a large auk which breeds in four locations in BC: Sartine Island, Triangle Island, and the Kerouard Islands. 95% of the breeding population is found on Triangle Island. One study found that the introduction of two red foxes to Shaiak Island (where Common murre

breed in Alaska) caused near-complete breeding failure of 25,000 Common murre (Townsend et al., 2011). A study on Tatoosh Island, Washington state found that increasing numbers of Bald eagles (*Haliaeetus leucocephalus*) flushed adult Common murre off nests, which facilitated crow predation on eggs (Parrish et al., 2001; Russell, 2011).

Snowshoe hare (*Lepus americanus washingtonii*)

Snowshoe hare is a BC Red-listed (S1) hare species.

Snowshoe hare is a subspecies of hare in family Leporidae. Coyote (*Canis latrans*) range expansion has been found to negatively impact the Snowshoe hare (Voller & McNay, 2007). Feral dogs (*Canis familiaris*) and cats (*F. catus*) also prey on the snowshoe hare (Voller & McNay, 2007). Competition for habitat with the invasive Eastern cottontail (*Sylvilagus floridanus*) may cause declines in Snowshoe hare populations (Voller & McNay, 2007).

Swainson's hawk (*Buteo swainsoni*)

Swainson's hawk is a BC Red-listed (S2B) bird species.

Swainson's hawk breeds in the Thompson-Okanagan Plateau. Some introduced species across North America that threaten Swainson's hawk are Eucalyptus (*Eucalyptus viminalis*), Siberian elm (*Ulmus pumila*), pines (*Pinus* spp.) and Cypress (*Cupressus* spp.) (Speziale & Lambertucci, 2013). One study found that Swainson's hawks preferred to nest in native prairie, but if native prairie is not available trees may work as a secondary site (Dechant et al., 2001).

BC BLUE-LISTED SPECIES

American bittern (*Botaurus lentiginosus*)

American bittern is a BC Blue-listed (S3B, SNRN) species.

American bittern is a medium-sized wading bird in heron family which breed in south and central interior BC and the lower Fraser Valley. Wetlands are key habitat features for American bittern to nest in, and they will not nest in habitats with Purple loosestrife (*Lythrum salicaria*) (Anderson et al., 2019; Butler et al., 2014; Catling, 2005; Gherardi et al., 2009; Swain et al., 2011). Direct impacts of Purple loosestrife on American bittern have not been studied (Butler et al., 2014). Invasion of Reed canary grass (*Phalaris arundinacea*) into wetland environments deterred American bittern from utilizing those sites (McKown et al., 2021). In Common reed (*Phragmites australis*) dominated wetlands in the Great Lakes region, American bittern were not observed utilizing those wetlands (Robichaud & Rooney, 2021). Another study found that control of *P. australis* caused American bittern to respond positively (although this was not statistically significant) (Tozer & Mackenzie, 2019).

Arctic grayling (*Thymallus arcticus* — Nahanni lineage)

Arctic grayling is a BC Blue-listed (S3?) species.

Arctic grayling is a freshwater fish in the Salmonidae family. The Nahanni lineage is only found in the Nahanni and Lower Liard rivers in BC. Invasive species impacts in BC have not been documented on the BC Nahanni population, however in Mississippi, invasive Brown trout (*Salmo trutta*) have negatively impacted recovery of Arctic grayling (Peterson & Ardren, 2009; Stamford et al., 2017).

Brant (*Branta bernicla*)

Brant is a BC Blue-listed (S3M) species.

Brant are a small goose found on Vancouver Island, Haida Gwaii and the Fraser River delta. There are limited academic research ties to Brant and invasive species. One study found that Japanese eelgrass (*Zostera japonica*) present in Boundary Bay in BC had a positive influence on Brant (Baldwin & Lovvorn, 1994). *Z. japonica* was found to be the largest fraction of the diet for Brant (Baldwin & Lovvorn, 1994). Brant consumed more *Z. japonica* than the native *Z. marina* (Baldwin & Lovvorn, 1994).

Double-crested cormorant (*Nannopterum auritum*)

Double-crested cormorant is a BC Blue-listed (S3S4) species.

Double-crested cormorants are a waterbird species with breeding populations in the Strait of Georgia and may be found in non-breeding times in the Juan de Fuca strait. Invasive round goby (*Apollonia melanostoma*) is the main diet component of Double-crested cormorant colonies in eastern Lake Ontario (Johnson et al., 2010). Alewife (*Alosa pseudoharengus*), Round goby (*Neogobius melanostomus*), *Lepomis* spp., White perch (*Morone americana*) and yellow perch (*Perca flavescens*) are the most commonly found Double-crested cormorant food sources in the north basin of Lake Michigan, making up 80% and 90% of the diet of cormorants by biomass and number, respectively (Madura & Jones, 2016). Higher levels of nutrients in soil resulted in proliferation of invasive and non-native species Garlic mustard (*Alliaria petiolata*), White goosefoot (*C. album*), and Purple deadnettle (*Lamium purpureum*) (Boutin et al., 2011). Damage to trees caused by cormorants caused the decrease of native species in favour of exotics (Boutin et al., 2011).

Long-tailed duck (*Clangula hyemalis*)

Long-tailed duck is a BC Blue-listed (S2S3B, S4N) species.

Long-tailed duck is a medium-sized sea duck with limited breeding records in BC (MacLeod et al., 2007). Studies on invasive species effects in BC are limited, but there are some examples from around the world that are relevant. In Lake Ontario, it was found that the presence of invasive *Dreissenid* spp. mussels increased populations of overwintering Long-tailed ducks (Schummer et al., 2010). However, *Dreissenid* spp. can transfer selenium (Se) to waterfowl. It was found that 19% of Long-tailed ducks surveyed in Lake Ontario had elevated concentrations of Se (MacLeod et al., 2007). In the Baltic Sea, the introduction of the Round goby (*Neogobius melanostomus*) reduced the main prey of Long-tailed ducks, primarily impacting hard-bottom habitats (Forni et al., 2022; Samson et al., 2017).

Sharp-tailed grouse (*Tympanuchus phasianellus columbianus*)

Columbian Sharp-tailed grouse is a BC Blue-listed (S2S3) species.

It is a subspecies of Sharp-tailed grouse (*Tympanuchus phasianellus*) in BC that is threatened by invasive Wild turkeys (*Meleagris gallopavo*), which may lay eggs in grouse nests, which may negatively contribute to re-introduction efforts of Sharp-tailed grouse (Voller & McNay, 2007). Removal of conifers from sagebrush habitat can improve nest success (McNew et al., 2017). Spotted knapweed (*Centaurea stoebe*) reduces diversity of key grassland habitat (Key & Tyser, 1988). A study in Colorado found that Sharp-tailed grouse mortality was 11 times higher for Sharp-tailed grouse that chose to live in non-native sod forming grasslands (Boisvert et al., 2005). In Washington, non-native bunchgrass habitat (E.g. Crested wheatgrass *Agropyron cristatum*)

resulted in only 18% nesting success for females (McDonald & Reese, 1998). A study in Idaho found that Sharp-tailed grouse in Crested wheatgrass, Intermediate wheatgrass (*Thinopyrum intermedium*), and Smooth brome (*Bromus inermis*) had poor reproductive success, which resulted in declining populations (Gillette, 2014).

Tufted puffin (*Fratercula cirrhata*)

Tufted puffin is a BC Blue-listed (S2S3B, S4N) species.

Tufted puffin are a medium-sized pelagic seabird in the auk family. Most breeding colonies in BC are found on the Scott Islands, Solander Island, and Haida Gwaii. It is threatened by invasive Norway rats (*R. norvegicus*) and Black rats (*R. rattus*) that prey on nests in Haida Gwaii (Martin et al., 2007; Sjodin et al., 2020; Voller & McNay, 2007). Removal of invasive rats from an island in Alaska was found to increase nesting Tufted puffin populations (CAFF, 2017; Croll et al., 2016; Kurle et al., 2021). In Washington state, it is thought that European rabbit (*O. cuniculus*), Cheatgrass (*Bromus tectorum*) and Scotch broom (*Cytisus scoparius*) may negatively impact puffins or availability of nesting habitat (Hanson et al., 2019).



5. Discussion

5.1 Synthesis of Current Knowledge

Many species reviewed were not found to have documented invasive species impacts. This may reflect a limited opportunity to conduct research on invasive species impacts on endangered species, as most land managers will remove the invasive species that threaten the endangered species, rather than leaving it to allow for rigorous scientific study of impacts (Dueñas et al., 2018). Additionally, there may be ethical issues of conducting impact studies of invasive species on rare or endangered species, as some experimental blocks may reduce the population of the rare or endangered species (Dueñas et al., 2018). One literature review evaluating impacts of invasive species found that only 6.5% of endangered species in the USA have noted impacts from invasive species (Dueñas et al., 2018). However, the impacts noted were strongly negative.

A lack of quantitative data on the impacts of invasive species highlights the need for further research. Ideally, field-based studies should include quantifying interspecific differences among native and introduced species in a region, and intraspecific differences between populations in native and introduced ranges (Colautti et al., 2014). Traits of invasive species are often similar to widespread native species, but it is difficult to quantify these traits over large scales. Measures of abundance, survival, reproductive rates would be helpful to identify voracious invaders (Colautti et al., 2014).

The invasive species and species at risk relationships should be correlated with field observations before taking action — it is important in the field of invasive species management to prioritize limited funding to the most problematic invasive species. Some important things to measure might include biomass of invasive species, time since invasion, anthropogenic stressors, functional or phylogenetic novelty, impact history of the invader, abundance of invader, and diversity of habitats that invader can occupy (Kumschick et al., 2015).

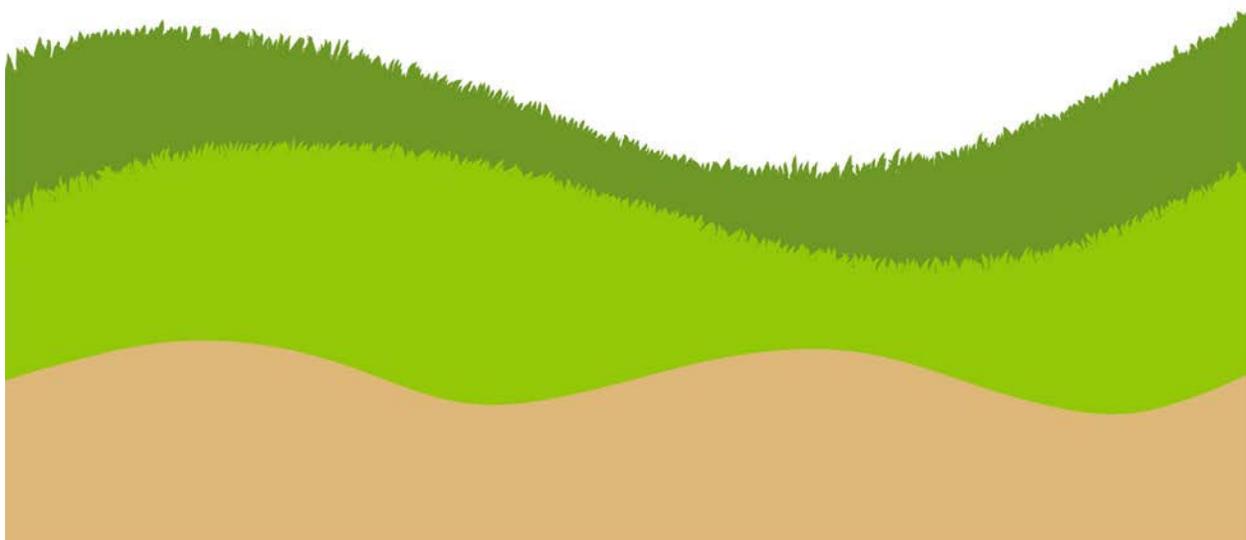
A review article on COSEWIC listed species in Canada found that habitat loss was the most prevalent risk facing endangered species, followed by overexploitation, native species interactions, pollution, and finally, introduced species (Venter et al., 2006). A review of aquatic endangered species in Canada found that invasive species were the second most prevalent threat against endangered fish, affecting 26 of 41 species. Brown bullhead (*Ameiurus nebulosus*) and Pumpkinseed sunfish (*Lepomis gibbosus*) were the widest ranging invasive species (Dextrase & Mandrak, 2006). In the USA, Wild pigs (*Sus scrofa*) co-occur with 87.2% of endangered species, putting them at risk (McClure et al., 2018). Although Wild pigs are not specifically identified in most literature reviewed, the rapid expansion of Wild pigs across western Canada in the last two decades should be monitored closely in regards to species at risk (Aschim & Brook, 2019).

5.2 Knowledge Gaps and Opportunities for Future Research

The ability to identify what species are culturally significant to BC Indigenous groups is a significant gap. The culturally important species identified in this report are all from published literature; there may be culturally important species that have not been identified in scientific literature. The list of culturally important species at risk with documented invasive species impacts could be expanded with Elder and knowledge keeper consultations.

Many species at risk (especially plants) in BC have extremely limited ranges, known locations or poorly understood distributions. This limits the amount of scientific research that has been done on these species, and often, potential invasive species impacts have not been quantified. Many of these species are in ecosystems that have experienced landscape-level changes (including new invasive species), but these landscape level pressures are not necessarily recorded in literature as an impact on an individual species.

Indigenous peoples of Canada currently occupy less than 1% of their traditional lands (Usher, 2003). Laws and policies around SARA and COSEWIC dictate a necessity to include Indigenous people in recovery plans (Hill, 2018). However, when a review of all recovery documents was done, it was found that 52% suggested no Indigenous involvement, and species that are from less iconic and economically valuable taxa (e.g. mosses) tended to have less Indigenous involvement (Hill, 2018). Lack of Indigenous involvement in federal recovery plans may indicate that certain relationships between species may not be included, or invasive species impacts that have been observed may not be included. This literature review presents a base for what scientific literature currently exists. Many invasive species impacts that have been observed by practitioners in the field may not necessarily be recorded and may be considered anecdotal by scientific papers. This presents an opportunity to record these observations in the future and share with other practitioners.



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