Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

National Capital Region

Canadian Science Advisory Secretariat
Science Advisory Report 2020/040

GUIDANCE ON THE IDENTIFICATION OF CRITICAL HABITAT IN THE RIPARIAN ZONE FOR FRESHWATER SPECIES AT RISK

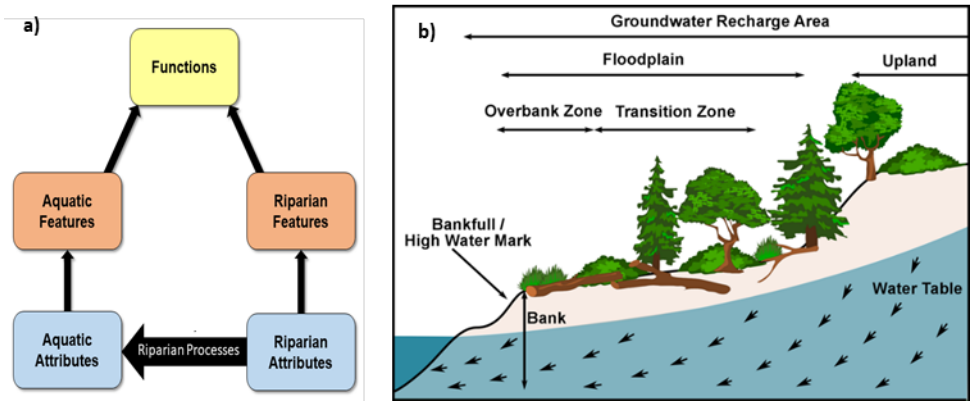

Figure 1. a) Riparian features can constitute Critical Habitat through their indirect effects of riparian processes on aquatic features considered Critical Habitat or through direct effects on a species' life cycle functions. b) Schematic of riparian features.

Context:

Fisheries and Oceans Canada (DFO) is responsible for identifying the Critical Habitat for aquatic species at risk listed under the Species at Risk Act (SARA). According to SARA, Critical Habitat is defined as "the habitat that is necessary for the survival or recovery of a listed wildlife species". For aquatic species, the Critical Habitat may include areas in the riparian zone that need to be protected under a Critical Habitat Order (Figure 1). In the 2015 DFO "Guidelines for the identification of Critical Habitat for aquatic species at risk", riparian zones are defined as features outside the aquatic ecosystem, which support the establishment and maintenance of deep and shallow pool features, supply food for migrating and juvenile fish of many species, and influence water temperature (e.g., tree shade). However, as the current riparian zone definition is based on the requirements of only a few fish species, it may not represent the features that support most freshwater fishes and mussels' life cycle process taking place in Critical Habitat (i.e., life cycle functions). Guidance is required that builds upon and complements the Department's existing approaches to identify riparian Critical Habitat, in order to make scientifically-defensible decisions about the identification of Critical Habitat in the freshwater riparian zone.

As specified in SARA (s. 41(1)(c) and 49(1)(a)), every Recovery Strategy and Action Plan developed for a species listed in Schedule 1 of the Act as Threatened, Endangered or Extirpated[1] must identify that species' Critical Habitat, to the extent possible. Currently, there is no national guidance on the identification of Critical Habitat in the riparian zone for aquatic species at risk. Consequently, DFO's

[1] Species listed as Extirpated under SARA may not require the identification of Critical Habitat unless a program of re-introduction is proposed.

Species at Risk Program has requested that DFO Science develop a national scientific guide for the identification of riparian Critical Habitat for listed freshwater species.

This Science Advisory Report summarizes the discussions of the Fisheries and Oceans Canada, Canadian Advisory Secretariat (CSAS) national science advisory meeting of March 3–4, 2020 entitled "Guidance on the identification of Critical Habitat in the riparian zone for freshwater species at risk". Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- A science-based guidance document on the identification of Critical Habitat in the riparian zone for listed freshwater fishes and mussels that builds upon and complements DFO's existing approach to identify Critical Habitat was reviewed.
- A review of Recovery Potential Assessments (RPA) and Recovery Strategies of currently listed freshwater fishes and mussels identified inconsistencies in the assessment of riparian habitat.
- A systematic approach to identify processes that affect listed freshwater fishes and mussels, such as the example in the Appendix 1, would provide a consistent way of identifying the role of riparian habitat on survival and recovery of these species.
- The proposed guidance suggests that riparian features should be considered as Critical Habitat when they 1) are necessary to maintain aquatic features and/or water quality attributes of aquatic features identified as Critical Habitat; and/or 2) support life cycle functions necessary for the survival or recovery of listed freshwater fishes and mussels species or their host species.
- For the purpose of the guidance, riparian zone was defined as the area located between a waterbody's high water mark and the upland area. However, other features such as groundwater recharge areas that may extend further than the riparian zone but still affect aquatic and/or riparian features may also be considered.
- The influence of riparian features on aquatic features and/or water quality can be represented by seven main processes: erosion, filtration, infiltration, isolation, meandering, shading, and subsidization. The importance of each process will be dependent on specific freshwater fish and mussel life history requirements.
- Literature regarding the widths of riparian habitat required for the processes was reviewed and showed that increasing width protected a greater number of processes. However, in this guidance specific widths of riparian zone for the different processes were not recommended due to species-specific habitat requirements and regional differences in underlying factors such as geomorphology, slopes, land use practices, and site potential vegetation height. When determining riparian Critical Habitat width, reference should be made to regional and species-specific guidance as appropriate.
- Riparian Critical Habitat may be located adjacent to aquatic Critical Habitat, but strong longitudinal connectivity in streams means that riparian Critical Habitat can also be identified upstream of the aquatic Critical Habitat if it is necessary for the survival and recovery of freshwater fishes and mussels.

- Processes that allow for the survival and recovery of an aquatic species have a range of natural variation. In the description of the extent of riparian Critical Habitat, the natural variation in the processes should be considered on a species- and site-specific basis, and be robust to environmental and climate change with the goal of maintaining or restoring the natural function of the riparian zone.
- There is a broad scientific consensus that riparian zones are essential habitat for natural aquatic ecosystem structure and biophysical functioning and are therefore important for all aquatic species.

BACKGROUND

Fisheries and Oceans Canada's (DFO) Species at Risk Program is responsible for carrying out the Department's mandate under the *Species at Risk Act* (SARA) to protect, recover, and conserve all listed aquatic species at risk in Canada. When a freshwater fish or mussel species is listed on Schedule 1 of SARA as threatened, endangered or extirpated, DFO is required to identify and protect the habitat that is necessary for the survival and recovery of the species (i.e., Critical Habitat), which is linked to the population and distribution objectives established in the Recovery Strategy.

The identification of a species' Critical Habitat is based on the best available scientific information. To determine Critical Habitat, a biophysical description is used. The biophysical elements of Critical Habitat are broken down into: life cycle functions, features, and attributes (Figure 2). Functions describe a species' life cycle processes, which are directly linked with feature(s) of the Critical Habitat. Features are defined by the attributes of an habitat that are key in supporting a species' life cycle function necessary to achieve the species' population and distribution objectives. Some features designated as Critical Habitat may support functions indirectly by supporting or reinforcing other features. These features may be outside of the aquatic ecosystem, i.e., in the riparian zones. Every feature is defined by a set of measurable attributes, which are the characteristics that enable the feature to support the species' functions. Attributes provide the greatest level of information about a feature, the quality of the feature, and the mechanism by which the feature is able to support particular life cycle requirements of a species and provide explicit targets for habitat management or restoration.

Although riparian habitat has been defined in the 2015 DFO "Guidelines for the identification of Critical Habitat for aquatic species at risk" as features outside the aquatic ecosystem, which support the establishment and maintenance of deep and shallow pool features, supply food for migrating and juvenile fish of many species, and influence water temperature, this definition was based on the requirements of only a few fish species, and it may thus not be representative of all of the features that support most freshwater fishes and mussels' life cycle process (i.e., functions) that take place in Critical Habitat. For aquatic species, Critical Habitat may include areas in the riparian zone. There is a desire that Critical Habitat identification guidelines be more representative of all features found in the riparian habitat that support freshwater fish and mussels' life cycle processes.

DFO's Species at Risk Program requested advice to ensure a more rigorous and systematic approach to identify Critical Habitat in the riparian zone. The purpose of this science advisory process is to provide guidance on the identification of Critical Habitat in the riparian zone for freshwater species at risk, while building on and complementing the Department's existing approaches to identify Critical Habitat. More specifically, the objectives of this process are to provide DFO's Species at Risk Program with guidance on: (1) How to determine when riparian

features constitute Critical Habitat; and (2) how to determine the extent of the riparian zone that is important for features that constitute Critical Habitat.

The riparian zone is defined as the area located between a waterbody's high water mark and the upland area. However, other factors such as groundwater recharge areas that may extend further than the riparian zone but still affect aquatic and/or riparian features may also be considered as Critical Habitat features.

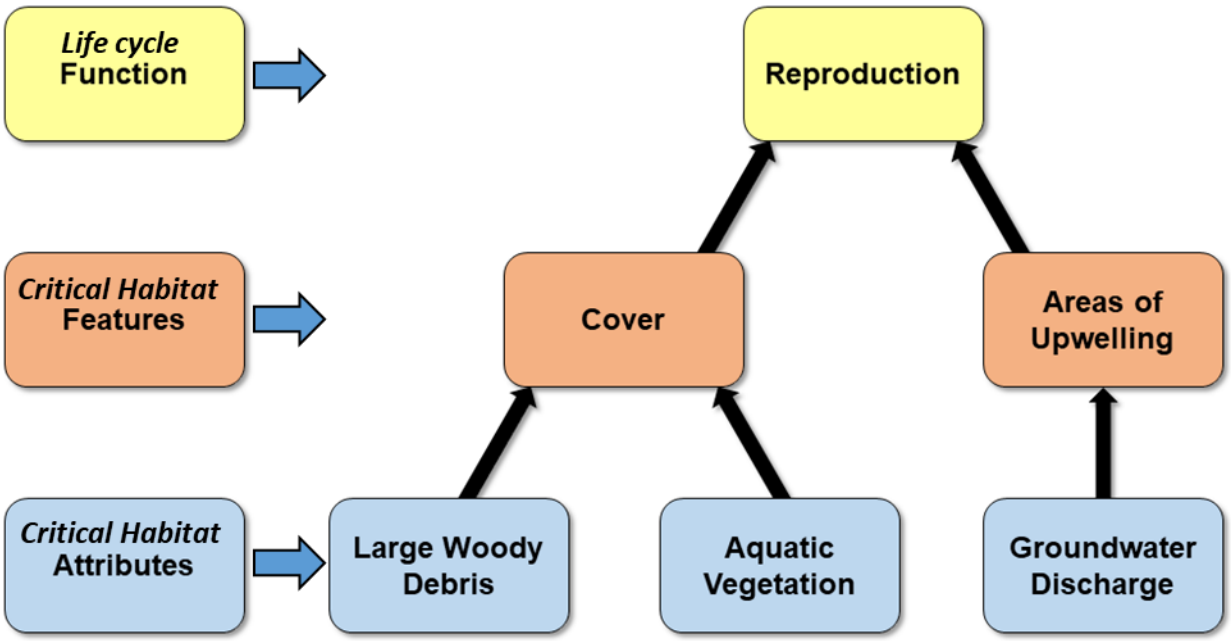

Figure 2. Flow chart representing examples of life cycle functions, Critical Habitat features, and Critical Habitat attributes.

ASSESSMENT

Identification of Riparian Critical Habitat

A review of the publicly available Recovery Potential Assessments (RPA) for freshwater fish and mussels showed a lack of inclusion of riparian zones as candidate Critical Habitat. As highlighted in several of the RPAs, this can be explained by a scarcity of data and/or a lack of understanding on how to define candidate Critical Habitat in the riparian zone for a given species.

Publicly available Recovery Strategies for freshwater fish and mussel species listed as Threatened or Endangered were also reviewed, and only a small proportion included riparian Critical Habitat as part of the species' Critical Habitat. Among those Recovery Strategies, there were inconsistencies in how the riparian Critical Habitat was described and its contributions to the aquatic habitat. Nevertheless, most of the Recovery Strategies reviewed, including the ones that did not include riparian zones as Critical Habitat, incorporated the loss, damage or reduction of riparian zones as a threat to the species, and included protection or recovery of riparian zones in the recovery planning sections. The inconsistencies that have been identified by this review underlines the need for guidance on how to determine when riparian features constitute Critical Habitat.

Richardson et al. (2010) suggested that riparian habitat should be considered as Critical Habitat if its impairment affects aquatic habitat or water quality in a way that negatively impacts the survival or recovery of a species at risk. Riparian habitat is considered impaired when the riparian features (Figure 1) are not able to support the life cycle functions of fishes and mussels. Therefore, riparian features should be considered as Critical Habitat if they are necessary to maintain aquatic habitat or water quality attributes required for the survival or recovery of freshwater fishes and mussels (Figure 1a). If a riparian feature affects aquatic habitat features identified as Critical Habitat, that is a clear path forward for identifying the riparian feature as Critical Habitat (Richardson et al. 2010).

Current SARA guidelines on determining Critical Habitat do not provide guidance on how to include water quality as Critical Habitat (DFO 2015) since water quality is not listed a feature in the current guidelines but rather a set of attributes common to most aquatic features. In this sense, any riparian feature that affects water quality in turn affects any aquatic features that would be impaired by poor water quality. However, riparian features located upstream of aquatic Critical Habitat features may influence water flow and quality attributes of aquatic Critical Habitat, and should also be considered when defining riparian Critical Habitat.

The boundary between terrestrial and aquatic habitats is not necessarily a barrier for freshwater fishes and mussels. Due to changes in water level (i.e., flooding), the ability to tolerate desiccation or life cycle process requirements, riparian features may also directly support functions of some freshwater fishes or mussels. Riparian features that directly support functions required for the survival or recovery of freshwater fishes and mussels should also be included as Critical Habitat (Figure 3b).

Consequently, riparian features should be considered as Critical Habitat when they:

1. are necessary to maintain aquatic features identified as Critical Habitat,
2. are necessary to maintain water flow and water quality upstream of Critical Habitat, and/or
3. support functions necessary for the survival or recovery of a listed wildlife species.

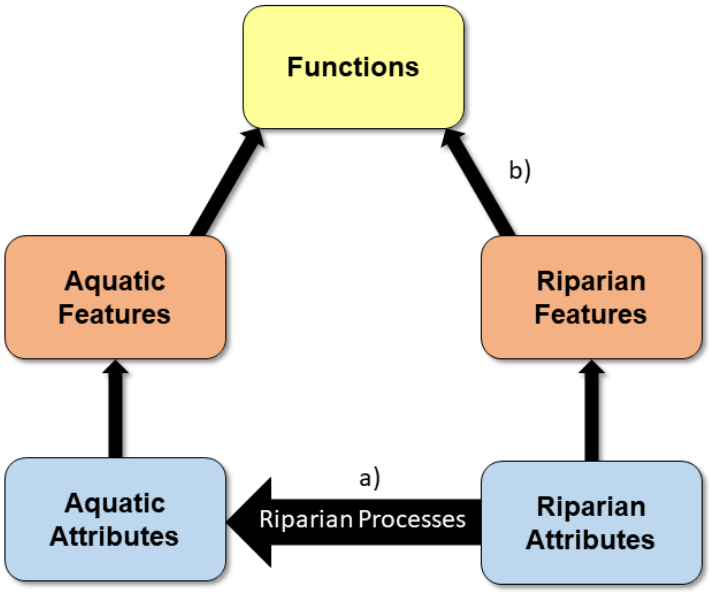

Figure 3. Riparian features can constitute Critical Habitat through a) their indirect effects of riparian processes on aquatic features considered critical habitat or b) through direct effects on a species' functions.

Riparian features that affect aquatic habitat features and water quality attributes

The riparian zone is defined as the area located between a waterbody's high water mark and the upland area. The ecosystem in the riparian zone has unique physical, geomorphological, and chemical properties. The riparian zone acts as an interface between aquatic and terrestrial habitats, and is sensitive to environmental change. Activities that occur in the riparian zone may have direct implications for the aquatic habitat due to the strong connections between aquatic and riparian features.

A literature review was undertaken to identify current scientific evidence regarding the effect of riparian features on aquatic habitat features. Seven main processes that occur in the riparian zone that help maintain aquatic features were identified (Table 1; Figure 4).

Table 1: Main processes occurring in the riparian zone that support aquatic features and their description. These processes are dynamic and occur within a range of natural of variation that needs to be considered when defining riparian areas as Critical Habitat.

Process	Description
Erosion	The wearing of soil from terrestrial sources by wind, water or gravity. When erosion is occurring within a natural range of variation, it controls sedimentation and siltation; supporting aquatic attributes such as aquatic vegetation and interstitial spaces.
Filtration	Removal of matter, light or sound from air or water. Filtration prevents contaminants and excess nutrients in surface and subsurface water in the riparian zone from entering a waterbody.
Infiltration	Entry of surface water into soil. Riparian vegetation provides shading and structure that prevents evaporation, runoff, and allows surface water in the riparian zone to infiltrate into the water table.

Process	Description
Isolation	Spatial distancing of a place or thing from a disturbance. The intensity of noise and light decreases the farther away from the source. Therefore, the riparian zone isolates the water body from noise and light pollution that can affect the acoustic and photic environment, as well as other forms of human disturbance.
Meandering	Back and forth movement of a stream or river, changing shape as it flows across a floodplain or valley eroding and depositing sediments on alternating banks. Natural levels of meandering by a river or stream creates habitat features such as cover, backwater, and shoals.
Shading	Regulation of the amount of light admitted onto a surface. Shading in the aquatic habitat by vegetation, large woody debris (LWD), and undercut banks provides cover and maintains the photic environment. Shading by riparian vegetation maintains natural variation in temperature of water in the aquatic habitat.
Subsidization	Transfer of energy, food, and structural components from the terrestrial zone to the aquatic habitat. Riparian features provide food for mussels (e.g., organic matter) and fishes (e.g., terrestrial insects, nutrients and organic matter that support aquatic invertebrates). Coarse sediment, such as gravel and boulders from banks and beaches, in the riparian zone is transferred into waterbodies as a result of erosion processes and meandering. The subsidization of wood, also termed wood recruitment, is the addition of wood into waterbodies from the associated riparian trees as a result of the mortality of individual trees, disturbances affecting multiple trees or meandering of a river or stream.

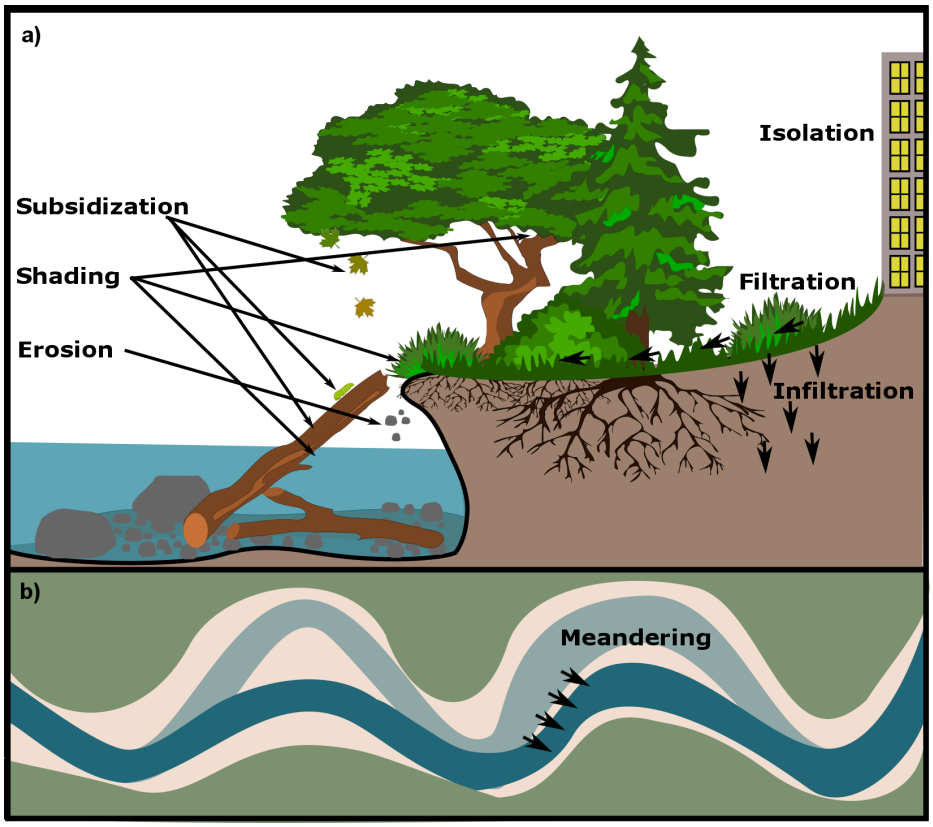

Figure 4. The seven main processes by which features in the riparian zone maintain aquatic features from two different perspectives, cross-sectional (a) and aerial (b).

To determine which riparian features may be considered Critical Habitat through their impact on aquatic Critical Habitat features (Figure 3), their associated processes were outlined for each aquatic feature (Table 2).These processes are dynamic and occur within a range of natural variation. In the description of the extent of riparian Critical Habitat, the natural variation in the processes should be considered on a species- and site-specific basis. The natural state of the riparian habitat will have a considerable impact on its capability to provide the functional processes. For example, an altered riparian vegetation community, such as a lawn or cultivated field, may not provide key functional processes like provision of large woody debris (LWD) inputs or solar shading. It is therefore implicit in the description of riparian Critical Habitat that a native vegetation community be present or if absent, that it be actively or passively restored to a native vegetation community. Riparian Critical Habitat identification should also be robust to environmental change with the goal of maintaining or restoring the natural function of the riparian zone.

*Table 2: The features in the riparian zone that have an effect on aquatic features, and the processes by which these riparian features impact them. The details pertaining to water quality attributes (marked with an *) are found in a separate table (Table 3) to reduce redundancies.*

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Acoustic environment	sound intensity	filtration, isolation	Riparian features filter out and isolate waterbodies from anthropogenic noise (e.g., road/bridge traffic, urbanization) that can interfere with acoustic signal-to-noise ratios, mask signals or alter organismal behavior.	beach, floodplain	(Mickle and Higgs 2018; Reid et al. 2019)
Areas of upwelling	groundwater discharge	infiltration	Upwelling in the freshwater habitat is caused by groundwater discharge that is recharged in the groundwater recharge area.	floodplain, groundwater recharge area	(Ouellet et al. 2017)
Areas of upwelling	water quality*	-	-	-	-
Backwater	aquatic vegetation	erosion, filtration, subsidization	Aquatic vegetation can reduce flow to create backwater and is supported by the floodplain through control of sedimentation, siltation, water clarity, light, and nutrient inputs.	bank, beach, floodplain	(Cheng and Yong-ming 2008; Jones et al. 2012)
Backwater	-	meandering	Channel migration in the meander belt creates backwater.	meander belt	(Biron et al. 2018)
Backwater	-	erosion	Riparian vegetation maintain banks from eroding and separating backwater from the waterbody.	bank, beach, floodplain	(Mondal and Patel 2018)
Backwater	large woody debris (LWD)	subsidization	Backwater is created by LWD being recruited from the floodplain.	floodplain	(Lehane et al. 2002; Seo et al. 2010)
Backwater	water quality*	-	-	-	-
Cover	groundwater discharge	infiltration	Upwelling groundwater is recharged in the groundwater recharge area.	floodplain, groundwater recharge area	(Malcolm et al. 2005)

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Cover	interstitial spaces	erosion	Vegetation in the floodplain controls erosion, which prevents sedimentation that fills interstitial spaces.	bank, beach, floodplain	(Wohl 2015)
Cover	-	shading, erosion, meandering	Undercut banks are maintained through erosion control in the floodplain and created by meandering in the meander belt.	bank, beach, floodplain, meander belt	(Florsheim et al. 2008; Vargas-Luna et al. 2018)
Cover	LWD	subsidization, shading	LWD in the floodplain provides shading. LWD that falls into the aquatic habitat from the floodplain creates complex habitat and cover.	floodplain	(Crook and Robertson 1999)
Cover	small woody debris	subsidization	Small woody debris that falls into the aquatic habitat from the floodplain creates shelter for juveniles and small-bodied fishes.	floodplain	(Enefalk and Bergman 2016)
Cover	-	shading	Overhanging riparian vegetation in the overbank zone provides cover.	bank, floodplain	(Raines and Miranda 2016)
Cover	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects the availability of refugia and cover.	floodplain, meander belt	(National Research Council 2002; Logez et al. 2016)
Cover	aquatic vegetation	erosion, filtration, subsidization	Aquatic vegetation provides cover and is supported by the floodplain through control of sedimentation, siltation, water clarity, light, and nutrient inputs.	bank, beach, floodplain	(Jones et al. 2012; Massicotte et al. 2015)
Eddies	aquatic vegetation	erosion, filtration, subsidization	Aquatic vegetation causes swirling and is supported by the floodplain through control of sedimentation, siltation, water clarity, light, and nutrient inputs.	bank, beach, floodplain	(Nepf 2012; Jones et al. 2012)

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Eddies	LWD	subsidization	LWD that falls into the aquatic habitat from the terrestrial habitat creates obstacles that create eddies.	floodplain	(Lehane et al. 2002)
Eddies	flow	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects the flow regimes of eddies.	floodplain, meander belt	(National Research Council 2002)
Eddies	water quality*	-	-	-	-
Food supply	terrestrial and amphibious prey	subsidization	Terrestrial and amphibious prey species in the floodplain supply food in the aquatic habitat due to incidental use or their life-history requirements.	floodplain	(Albertson et al. 2018)
Food supply	terrestrial organic matter	subsidization	Transfer of organic matter from the floodplain to the aquatic habitat supplies food for freshwater fishes and mussels.	floodplain	(Brett et al. 2017)
Food supply	aquatic insects	subsidization	Some life-history stages of aquatic insects (e.g., adult stage) require use of the floodplain, aquatic insects also need terrestrially sourced nutrients and organic matter.	bank, beach, floodplain	(Harabis 2017)
Food supply	aquatic vegetation	erosion, filtration, subsidization	Aquatic vegetation is supported by the floodplain through control of sedimentation, siltation, water clarity, light, and nutrient inputs.	bank, beach, floodplain	(Jones et al. 2012)
Glides	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects the flow regimes of glides.	floodplain, meander belt	(National Research Council 2002)

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Glides	water quality*	-	-	-	-
Host species (availability of)	water quality	filtration	Terrestrial sources of nitrates filtered by the floodplain affect the ability of mussels to attach to host.	floodplain	(Moore and Bringolf 2018)
Host species (availability of)	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects host attachment by mussels.	floodplain, meander belt	(National Research Council 2002; Modesto et al. 2018)
Upstream habitat	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects upstream habitat.	floodplain, meander belt	(National Research Council 2002)
Upstream habitat	water quality*	-	-	-	-
Lake benthic habitat	sediment	filtration, erosion	Erosion and filtration of contaminants in the floodplain affects sediment quality and quantity in benthic habitat.	bank, beach, floodplain	(Crane 2017)
Lake benthic habitat	water quality*	-	-	-	-
Lake littoral habitat	aquatic vegetation	erosion, filtration, subsidization	Filtration and erosion in the floodplain, and littoral habitat alteration affects the presence of aquatic vegetation in lake littoral habitats.	bank, beach, floodplain	(Doi et al. 2010)
Lake littoral habitat	water quality*	-	-	-	-
Lake pelagic habitat	water quality*	-	-	-	-
Migration/Movement corridors	sensory cues	subsidization, filtration	Sensory cues that support homing or initiate migration may come from or be disrupted by contaminants from the floodplain.	floodplain	(Scholz et al. 1976)

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Migration/Movement corridors	flow and level	infiltration	Infiltration in the floodplain affects flow rates and water level which affects hydrological connections between critical habitats.	floodplain	(Crook et al. 2015)
Migration/Movement corridors	water quality*	-	-	-	-
Photic environment	artificial light	filtration, isolation	Filtration in the floodplain of, and isolation from, light pollution (street lights, houses, etc.) affects parental care behaviour of a fish, timing of migration, and dial movements of prey.	floodplain	(Foster et al. 2016; Reid et al. 2019)
Photic environment	shade	shading	Shading from riparian vegetation, overhanging banks, and LWD in the overbank zone affect the quantity and quality of light in the aquatic habitat.	bank, floodplain	(Pusey and Arthington 2003)
Photic environment	turbidity	erosion, filtration	Riparian vegetation in the floodplain affects sediment load in the waterbody by control of erosion and filtration of surface water that would otherwise increase turbidity.	bank, beach, floodplain	(Vargas-Luna et al. 2018)
Photic environment	water colour	subsidization, filtration	Lack of browning or greening of water due to filtration of terrestrial nutrient or organic matter in the floodplain affects the photic environment.	floodplain	(Karlsson et al. 2009)
Pools	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects the connectivity of pools in the waterbody.	floodplain, meander belt	(National Research Council 2002)

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Pools	LWD	subsidization	The addition of LWD from the floodplain increases the presence of pools in rivers and streams.	floodplain	(Davidson and Eaton 2013)
Pools	water quality*	-	-	-	-
Riffles	exposed coarse sediment	erosion, meandering, subsidization	Erosion control in the floodplain reduces sediment load in the waterbody which maintains exposed coarse sediment. Meandering and erosion of beaches and banks subsidizes coarse sediment.	bank, beach, floodplain	(National Research Council 2002)
Riffles	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects the production of riffles as they require appropriate flow regimes.	floodplain, meander belt	(National Research Council 2002)
Riffles	LWD	subsidization	The addition of LWD from the floodplain increases the presence of riffles in rivers and streams.	floodplain	(Davidson and Eaton 2013)
Riffles	water quality*	-	-	-	-
Runs	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects the production of runs as they require appropriate flow regimes.	floodplain, meander belt	(National Research Council 2002)
Runs	water quality*	-	-	-	-
Shoals	flow and level	infiltration, meandering	Infiltration in the floodplain and meandering in the meander belt affects flow rates and water level which affects whether the shoal is submerged.	floodplain, meander belt	(National Research Council 2002)

Aquatic features	Aquatic attributes	Process	Details	Riparian features	Source(s)
Shoals	sediment	meandering, erosion	Erosion of banks and beaches, and meandering in the meander belt affects sedimentation in the riparian zone, which can add or remove shoals.	bank, beach, floodplain, meander belt	(National Research Council 2002)
Shoals	water quality*	-	-	-	-
Sympatric species	-	meandering, subsidization	Hierarchical, dendritic, spatially fragmented systems may exhibit high genetic diversity. Allowing natural processes to create dendritic channels and oxbow lakes could support sympatric speciation.	floodplain, meander belt	(Ruzzante et al. 2019)
Wetlands	aquatic vegetation	erosion, filtration, subsidization	Aquatic vegetation is supported by the floodplain through control of sedimentation, siltation, water clarity, light, and nutrient inputs.	bank, beach, floodplain	(National Research Council 2002)
Wetlands	flow and level	infiltration, groundwater discharge	Wetlands are maintained through flow from rivers and streams, groundwater inputs, and run-off from floodplain.	floodplain, groundwater recharge area, meander belt	(National Research Council 2002)
Wetlands	water quality*	-	-	-	-

A second literature review was undertaken to determine the most current scientific evidence to provide guidance on riparian features that affect water quality. Riparian features affect water quality attributes with a subset of the same processes by which they affect aquatic habitat features (Table 3).

The review showed that water quality attributes are usually affected by sets of riparian features through a combination of processes. The level of contaminants in the aquatic habitat, for example, is influenced by several riparian features (bank, beach and floodplain) which, through a combination of four processes (erosion, filtration, infiltration, isolation), filter water and sediments and thus prevent contaminants from entering the aquatic habitat.

Table 3: Riparian features and processes that impact water quality attributes (see Caskenette et al. (2020) for source information).

Aquatic Attributes	Process	Details	Riparian Features	Source(s)
Contaminants	erosion, filtration, infiltration, isolation	Contaminants in surface water and sediments are filtered by riparian vegetation and sediments (through infiltration) in the floodplain and are prevented from entering the aquatic habitat through erosion control and isolation.	bank, beach, floodplain	(Yu et al. 2019; Reid et al. 2019)
Dissolved oxygen	erosion, filtration	Natural levels of dissolved oxygen available to fishes and mussels in a waterbody can be maintained through filtration of nutrient and through control of sedimentation that would otherwise fill interstitial spaces.	bank, beach, floodplain	(Wood and Armitage 1997; Crossman et al. 2019)
Nutrients (P, N, C, Ca)	erosion, filtration, infiltration, subsidization	Erosion, filtration, infiltration, and subsidization in a properly functioning floodplain maintains natural levels of nutrients in waterbodies.	bank, beach, floodplain	(Stutter et al. 2019)
pH	erosion, filtration, infiltration, subsidization	pH buffering capacities of soils affects pH of surface and subsurface water, erosion inputs acidified soils into water, and leaf litter affects aquatic pH.	Bank, beach, floodplain	(Hruška et al. 2001)

Aquatic Attributes	Process	Details	Riparian Features	Source(s)
Temperature	shading, infiltration	Shading of surface and subsurface water by undercut banks and riparian vegetation in the floodplain, and infiltration that recharges in the groundwater recharge area contributes to maintaining natural water temperature ranges.	bank, beach, floodplain, groundwater recharge area	(Chu et al. 2008; Albertson et al. 2018)

Riparian features that support the functions of freshwater fishes and mussels

Riparian features can directly provide for functions of freshwater fishes and mussels. A literature review was conducted to identify the most current scientific evidence in regards to how riparian features directly affect the functions of freshwater fishes and mussels. However, there was a sparsity of available literature and information explicit to Canada. In addition, most examples will be species specific. Some examples are: fish that deposit eggs on beaches or floodplains, which directly supports dispersal, reproduction, and rearing during intermittent flooding events, and foraging for terrestrial food sources outside of the aquatic habitat (e.g., capturing insects on riparian vegetation, feeding in flooded riparian zones).

Delineating protected area in the riparian zone

The review of existing RPAs and Recovery Strategies showed a large range in recommended widths of riparian protection (0–30 m) underlining the importance of considering the species specific requirements and landscape features when recommending Critical Habitat protection in the riparian zone. The inconsistencies between species, and absence of recommendations for many species, may also signify both the variation and uncertainty about the extent to which riparian zones need to be protected to maintain species' functions. When defining Critical Habitat in the Recovery Strategy, a clear description of the geographic area to be protected is provided (DFO 2015). This should include the geographic area representing riparian features that are considered Critical Habitat. The extent of riparian Critical Habitat protected should be grounded in an empirical understanding of the processes that impact the ability of the riparian zone to support freshwater fishes and mussels' functions (Figure 5).

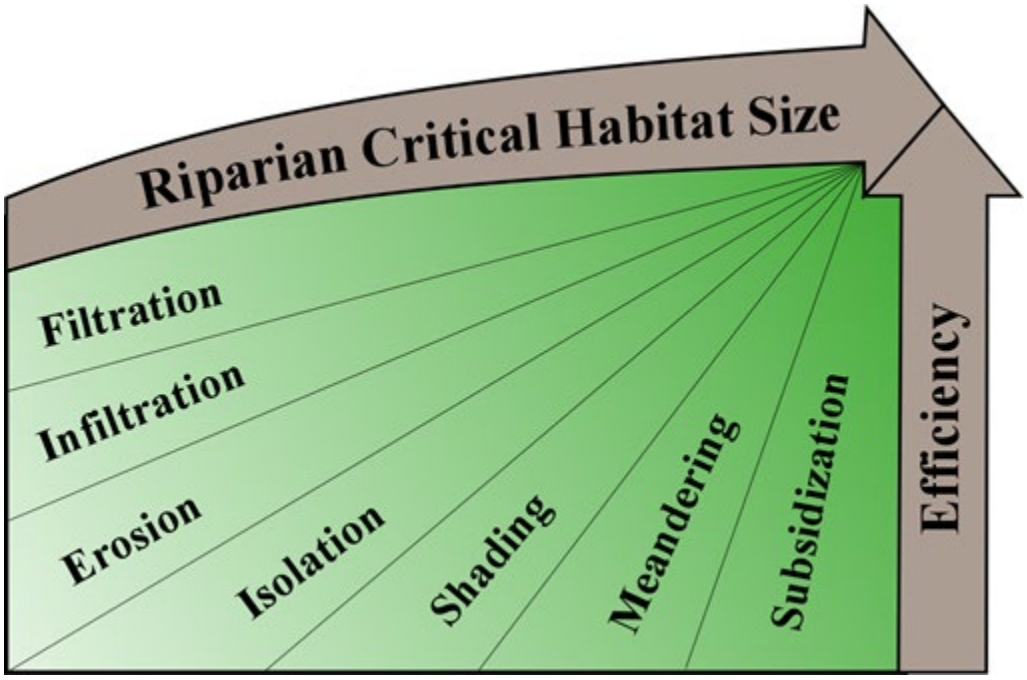

Figure 5. The size of Critical Habitat protected determines which riparian processes are supported by the riparian habitat and the efficiency of the riparian processes. The greater the size of riparian critical habitat that is protected, the greater the number and efficiency of processes supported. For simplicity, the efficiency of the processes are shown here to increase linearly with riparian Critical Habitat size, however, it is important to note that the shape of the response curve for individual processes will depend on the riparian attributes.

Current literature and appropriate guidance on regional riparian processes and species specific needs should be taken into account to determine the relationship between the amount of riparian habitat protected and its influence on the quality of the aquatic habitat feature of interest. It is also important to consider the shape of the response curve and any dependencies of the attributes of the riparian zone (e.g., slope, land use, soil type). Consequently, a single value for the extent of riparian Critical Habitat to be protected will likely not be representative of all species or landscapes. This provides a challenge when developing a national standard.

A formal meta-analysis that was beyond the scope of this CSAS meeting is required to inform further guidance on threshold values per region for delineating protected riparian zone in perspective of each of the identified process (i.e., erosion, filtration, infiltration, isolation, meandering, shading, and subsidization).

Sources of uncertainty

There are inherent uncertainties in the advice outlined above. One source of uncertainty is linked with the identification of the aquatic habitat features important for the freshwater fishes and mussel species in the Recovery Documents. Since riparian Critical Habitat delineation is based on aquatic features identification found in the recovery documents, if their identification was to be inaccurate or missing, the suite of riparian features needed to support the functions of a given species as well as its riparian Critical Habitat would also be inaccurate.

Meta-analyses may provide more precise width recommendations than individual studies, and an examination of heterogeneity that many individual studies are not able to provide. However, even meta-analyses are not able to capture the range of climates encountered across Canada,

since they may be limited in scope to a narrow range of land uses (e.g., agriculture) and shorter-term studies. Many of the reviews and meta-analyses included were performed in agricultural areas and because of this, there was more information regarding erosion, filtration, and infiltration than there was for isolation, meandering, shading or subsidization. Although the scientific basis for the development of guidance on the extent of the riparian zone that is important for features that constitute Critical Habitat is sound, the data available for the literature review was heavily skewed towards agricultural systems and warmer months. Hence, there is uncertainty about how the riparian features are impacting aquatic features through the different processes in the full range of northern climates. In particular, there is uncertainty regarding the impact of frazil and anchor ice formation induced by colder temperatures due to a lack of insulating vegetation after riparian removal. When determining riparian Critical Habitat widths for Species at Risk, biologists should consult regional process-based guidelines for riparian buffers and appropriate species-specific requirements when available

Uncertainty linked to the natural state of the riparian habitat was also identified, as it has a considerable impact on its capability to provide the functional processes. For example, an altered riparian vegetation community, such as a lawn or cultivated field, may not provide key functional processes like provision of large woody debris or solar shading. Although riparian habitat is key in the survival and recovery of freshwater fishes and mussels, further studies are needed to assess the effectiveness of riparian Critical Habitat to fully mitigate identified threats to the species. Future studies, evaluations, effectiveness assessments or new information may eventually provide a more specific riparian habitat width range to be protected for freshwater fishes and mussels.

As in all peer-review processes, the science advice developed depends on which experts were present at the meeting. Best attempts were made to include the full range of expertise needed to assess the importance of Critical Habitat in the riparian zone for freshwater species at risk, but subject matter experts for Fluvial Geomorphology were unable to attend the meeting. The process would have benefitted from participation of fluvial geomorphological knowledge holders, and this may have impacted the science advice.

CONCLUSIONS AND ADVICE

Riparian features are not consistently included as Critical Habitat for listed freshwater fishes and mussels. An evidence-based approach was developed to guide the identification of features (e.g., bank, beach, floodplain, groundwater recharge area) in the riparian zone as Critical Habitat. Riparian Critical Habitat are riparian features that: maintain the quality of aquatic features and water quality attributes identified as Critical Habitat, and are directly used by fishes and mussels. Riparian features should be considered as Critical Habitat when they 1) are necessary to maintain aquatic features identified as Critical Habitat; 2) are necessary to maintain water flow and water quality upstream of Critical Habitat, and/or 3) support functions necessary for the survival or recovery of listed freshwater fishes and mussels species or their host species.

The relevant riparian features and the processes by which they affect aquatic features and water quality attributes were identified. These seven main processes by which riparian features affect aquatic features and water quality attributes are: erosion, filtration, infiltration, isolation, meandering, shading, and subsidization.

The guidance on how to determine when riparian features constitute Critical Habitat and the extent of the riparian zone required for features that constitute Critical Habitat is based on the current best available information. Given that many factors may influence the riparian Critical

Habitat delineation among sites and species, the quantitative aspect of the guidance is limited. Further meta-analyses are required to provide guidance on the extent of riparian habitat that is needed to support these seven processes in specific landscapes (e.g., forested vs grasslands, high vs low topography). Not all species will be equally affected by the riparian zone. For example, species that are not sensitive to water quality, prefer turbid, warm waters, or live in the pelagic zone of a large lake, probably require less riparian Critical Habitat.

As habitat requirements differ between species and ecosystems, the delineation of riparian Critical Habitat should be species- and site-specific and is best evaluated by species experts based on the biology of individual species using knowledge of the local landscape and regional riparian processes. Using a case study it is demonstrated how practitioners may apply the guidance provided to determine riparian Critical Habitat for a listed species (Appendix 1). To facilitate riparian Critical Habitat designation, the guidance suggests to gather important species- and site-specific information by identifying:

- the aquatic habitat features that support the life cycle functions necessary for the survival of the species and their underlying Critical Habitat attributes;
- the processes needed in order to maintain the aquatic Critical Habitat features identified previously, as well as the species water quality attributes requirements and the process(es) needed to maintain them;
- any additional process(es) specific to the type of ecosystem in which the species is found;
- the riparian Habitat features that support freshwater fishes and mussels' life cycle functions (i.e., riparian Critical Habitat) through their impact on the identified processes.

OTHER CONSIDERATIONS

Resilience to natural variation and extreme events

The goal of protecting riparian habitat is to ensure that there is sufficient area to provide the ecosystem services (i.e., processes) that the aquatic habitat requires; which also means maintaining a large enough riparian zone to allow for proper function and resilience of riparian features to natural variation and to extreme events. Long term studies may be required to capture any loss of utility of Critical Habitat in the riparian zone due to limited protection.

Native (site potential) vegetation

Provision of essential processes by riparian Critical Habitat is contingent on the presence of a native vegetation community typical of the local biogeoclimatic zone. Naturalness refers to how much a system has already been changed, directly or indirectly by human activities. An altered riparian vegetation community, such as a lawn or cultivated field, may not provide key functional processes like provision of LWD inputs or solar shading. For instance, source distances for riparian wood inputs and therefore buffer widths will be contingent on the natural site potential vegetation (tree) height. It is therefore implicit in the designation of riparian Critical Habitat that a native vegetation community be present or if absent, that it be actively or passively restored to an appropriate vegetation community.

Scale

The magnitude of the influence of the riparian habitat on the aquatic habitat depends on the size of the waterbody. Smaller waterbodies (e.g., small streams) may have stronger connections with the riparian habitat than larger waterbodies (e.g., large lakes). However, regulations often

scale with waterbody size (e.g., a multiple of channel width), resulting in less protection – in terms of distance from high water mark for smaller waterbodies. This is due to the fact that riparian habitat, in terms of the extent of the terrestrial habitat that interacts directly with the aquatic habitat, scales with waterbody size.

Connectivity

Riparian Critical Habitat will generally need to be located on both sides of a river or stream, adjacent to the aquatic Critical Habitat features that riparian processes support. However, riparian habitat upstream of the identified aquatic Critical Habitat (including non-fish-bearing reaches) may also be identified if the features of upstream riparian habitat are necessary to maintain features of downstream aquatic habitat. This may occur, for example, when lack of upstream riparian habitat results in diminished bank stability and excessive sediment or nutrient inputs that adversely affect downstream aquatic Critical Habitat or when lack of shading affects downstream water quality (temperature, dissolved oxygen) or contributes to a water quality barrier (e.g., to fish movement) between aquatic Critical Habitat features.

Upland areas

Performance of the riparian zone is often dependent on the state and use of the upland areas. Although the science advice in this document pertains to Critical Habitat associated with the riparian zone, it is important to note that identifying riparian Critical Habitat will not mitigate threats to upland areas. Some upland areas may also be disproportionately important in maintaining attributes of aquatic Critical Habitat features, and therefore may warrant protection as Critical Habitat. Furthermore, identifying Critical Habitat in the riparian zone or even upland areas, is not a substitute for adequately managing land use at the broader scale.

Host species

Under the current SARA guidelines, the availability of a host species is considered a Critical Habitat feature when necessary for the survival, recovery, and resilience of a SARA listed species. Current SARA policy does not, however, consider the habitat that supports the host as Critical Habitat. However, activities occurring outside the identified critical habitat that reduce the availability of hosts inside the Critical Habitat may be considered an activity likely to destroy Critical Habitat. This may be an oversight; we feel that the inclusion of the habitat of the host species as Critical Habitat should be considered on a case-by case basis. If availability of a host species is limiting the survival or recovery of a listed species, then the habitat of the host species may also need to be considered Critical Habitat for extreme events and/or effects of climate change.

LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Boyko, Amy	DFO SARA – C&A
Bradford, Mike	DFO Science – PAC
Breau, Cindy	DFO Science – Gulf
Caskenette, Amanda	DFO Science – C&A
Clarke, Keith	DFO Science – NFLD
Cormier, Roland	DFO SARA – Gulf
Depaiva, Alex	DFO FFHPP – NCR
Drake, Andrew	DFO Science – C&A

Name	Organization/Affiliation
Durhack, Travis (Rapporteur)	DFO Science – C&A
Ellefsen, Hans-Frederic	DFO Science – QC
Enders, Eva (Co-Chair)	DFO Science – C&A
Fitch, Lorne	Alberta Riparian Habitat Management Society (Cows and Fish)
Lacho, Christine	DFO SARA – C&A
Makkay, Kristina	DFO SARA – NCR
Mannion, Justine (Co-chair)	DFO Science – NCR
Reader, Jeff	DFO Science – MAR
Robert, Karine (Rapporteur)	DFO Science – NCR
Rosenfeld, Jordan	BC Environment
Winegardner, Amanda	DFO Science – NCR

SOURCES OF INFORMATION

This Science Advisory Report is from the CSAS national science advisory meeting of March 3–4, 2020 entitled “Guidance on the identification of Critical Habitat in the riparian zone for freshwater species at risk”. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Caskenette, A.L., T.C. Durhack, E.C. Enders. 2020. Review of information to guide the identification of Critical Habitat in the riparian zone for listed freshwater fishes and mussels. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/049.

DFO 2015. Guidelines for the Identification of Critical Habitat for Aquatic Species at Risk. Unpubl. Report, Ecosystem Management Branch, Ottawa, Canada, 43 p.

Fisheries and Oceans Canada 2019. Recovery Strategy for the Salish Sucker (*Catostomus* sp. cf. *catostomus*) in Canada [Proposed]. 1st amendment. Fisheries and Oceans Canada, Ottawa.

Richardson, J.S., E. Taylor, D. Schluter, M. Pearson, T. Hatfield 2010. Do riparian zones qualify as critical habitat for endangered freshwater fishes? Can. J. Fish. Aquat. Sci. **67**(7): 1197–1204. doi:10.1139/F10-063.

APPENDIX 1. SALISH SUCKER CASE STUDY

The Salish Sucker (*Catostomus* sp. cf. *catostomus*) is a small bodied freshwater fish that is found in low elevation, meandering headwater streams, sloughs, marshes and beaver ponds in eleven watersheds in the Fraser Valley between Surrey and Chilliwack in southern British Columbia (Fisheries and Oceans Canada 2019). Salish Sucker require a mixture of shallow and deep pools, riffles, and glides as habitat to support all of their life stages. Connectivity of these aquatic habitats is important, as different life stages make use of different habitat types. Riffle habitat with water depths of more than 70 cm is used for spawning, and populations that do not have riffle habitat near their marsh or pond have been known to travel long distances in order to find suitable riffle habitat for spawning. Shallow pools and glides are used as nursery and rearing habitat by young-of-the-year Salish Sucker, while juvenile and adults are most often found in the deep pool habitat (pools deeper than 70 cm). Adequate dissolved oxygen levels (≥ 4 $mg \cdot l^{-1}$), water temperatures between 6 and 23 °C and low levels of sediment, nutrients and toxins are required in all aquatic Critical Habitat to support survival of Salish Sucker.

Riparian habitat has been identified as Critical Habitat for Salish Sucker in the Recovery Strategy (Fisheries and Oceans Canada 2019), specifically a continuous strip of native vegetation along the entire length of aquatic Critical Habitat. All seven of the processes provided by riparian habitat are required by Salish Sucker, with erosion, infiltration, filtration, and isolation providing protection to water quality attributes from agricultural runoff and sedimentation from residential land development, subsidization providing LWD for the formation of pools and is a source of terrestrial insects, a major food source of adult, juvenile, and young-of-the-year fish, shading providing cover and temperature control, and meandering causing additions of LWD and the formation of cover and pools (Table A1).

Table A1: Guidance for riparian Critical Habitat designation for Salish Sucker.

Aquatic Features	Aquatic Attributes	Processes	Riparian Features
Pool	flow and level, LWD, water quality*	infiltration, meandering, subsidization	floodplain, meander belt
Riffle	exposed coarse sediment, flow and level, LWD, water quality*	erosion, infiltration, meandering, subsidization	bank, beach, floodplain, meander belt
Glide	flow, water quality*	infiltration, meandering	floodplain, meander belt
Cover	aquatic vegetation, interstitial spaces, flow and level, LWD, small woody debris, water quality*	erosion, filtration, infiltration, meandering, recruitment, shading, subsidization	floodplain, bank, meander belt, beach,
Food supply	terrestrial prey, aquatic insects	subsidization	bank, beach, floodplain
Migration /movement corridors	sensory cues, flow and level, water quality*	filtration, infiltration, subsidization,	floodplain
Photic environment	turbidity, shade	erosion, filtration, shading	bank, beach, floodplain
Water Quality Attributes*			
	contaminants, dissolved oxygen, nutrients, temperature	erosion, filtration, infiltration, isolation, shading, subsidization	bank, beach, floodplain, groundwater recharge area

THIS REPORT IS AVAILABLE FROM THE:

Canadian Science Advisory Secretariat (CSAS)
National Capital Region
Fisheries and Oceans Canada
200 Kent Street, Ottawa, ON K1A 0E6
Telephone: 613-990-0293
E-Mail: csas-sccs@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087

Correct Citation for this Publication:

DFO. 2020. Guidance on the identification of Critical Habitat in the riparian zone for freshwater species at risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/040.

Aussi disponible en français :

MPO. 2020. Lignes directrices sur la désignation de l'habitat essentiel dans la zone riveraine des espèces d'eau douce en péril. Secr. can. de consult. sci. du MPO, Avis sci. 2020/040.