# Streams, Salmon, and Orcas: The Conservational Relation of Riparian Zones and Marine Biodiversity

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## Abstract

Riparian zones are environments found along rivers, streams, wetlands, and other semi-aquatic environments, defined as the "transition between the aquatic area and adjacent upland areas" (US Department of the Interior, 2015). These transitional regions play a vital role for nearby terrestrial habitats through pollution prevention, nutrient supply, and erosion prevention. However, due to their importance for species of marine fish, these areas also have a strong link to the food chain and health of the broader marine environment. This paper argues that consideration of inter-ecosystem connections is important in regard to these aquatic environments, as riparian health is strongly linked to many important keystone species in the ocean. It focuses mainly on southern resident killer whales (*Orcinus orca*) and chinook salmon (*Oncorhynchus tshawytscha*) populations in the Puget Sound region, a "large inland estuary" (Puget Sound Estuarium, n.d.) in the Northwest corner of the State of Washington, as an example. This paper uses a secondary research method, with no laboratory work done. Sources consist of scientific articles, government websites, peer-reviewed journals, and educational websites.

## Introduction

Southern resident killer whales, found off the coasts of Washington, Oregon, and British Columbia, are apex predators in their ecosystems. Thus, they have a strong effect on the stability of their environments and food webs at large while also affecting them in turn. These orcas "feed exclusively on fish" (Orca Conservancy, n.d.), with salmon such as the chinook making up a majority of their diet. Southern resident killer whales have been federally recognized as endangered since 2005, "with declining chinook salmon one of the major threats" (Geiger, 2024) to their population. The survival of these salmon, in turn, is strongly influenced by watershed conditions and especially the health of riparian zones.

Chinook salmon spend multiple vital life stages in freshwater environments, meaning that these environmental conditions - especially riparian integrity - are crucial in ensuring safe and healthy populations.

Though a focus on ocean-based conservation efforts for orcas has been impactful, such as vessel noise reduction, pollution minimization (Washington Department of Fish and Wildlife, n.d.), and fishing regulation (NOAA, 2021), an inland focus is important as well due to the core resources generated there. This paper examines the impact of riparian zone degradation and restoration on marine biodiversity, highlighting the importance of inter-ecosystem considerations and approaches when tackling environmental issues.

## Structure and Roles of Riparian Zones

Riparian zones perform many ecological functions essential for salmonid survival. These functions include:

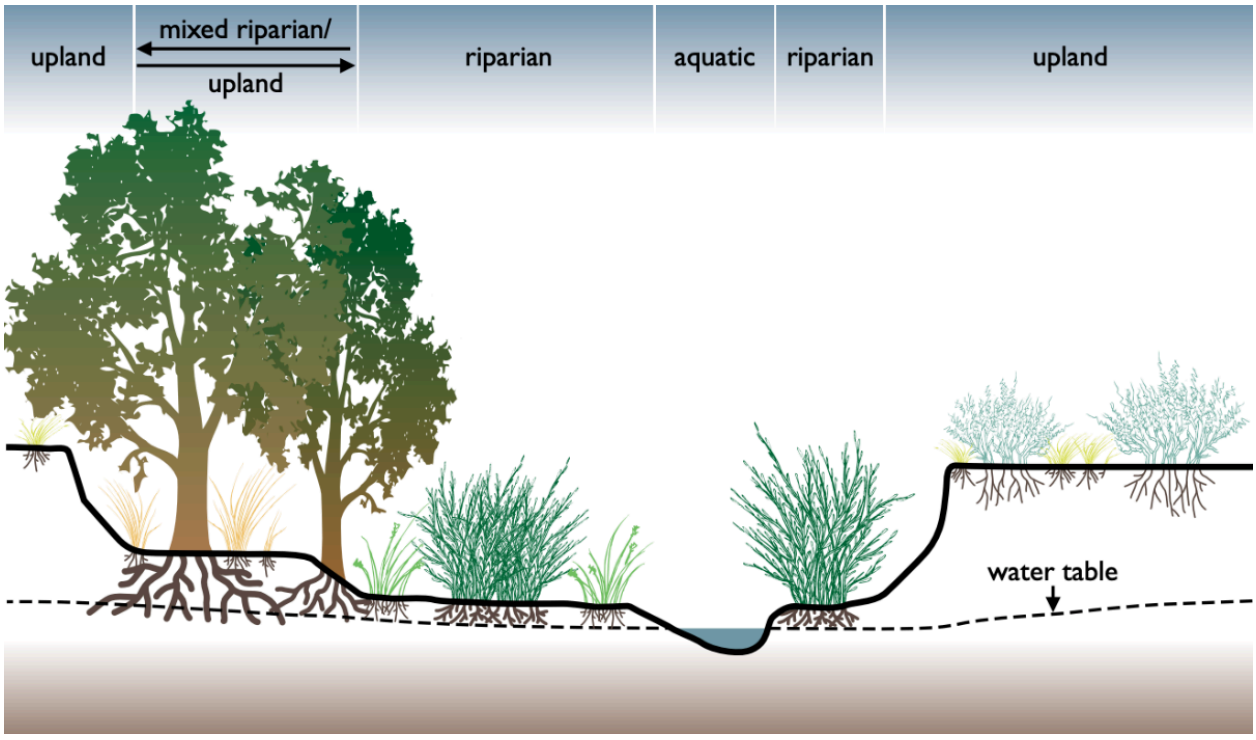


**Figure 1:** Visual model depicting the differences between riparian, aquatic, and upland areas (Washington Forest Protection Association, n.d.)

**1. Thermal Regulation**

Riparian canopy cover “plays a large role in regulating the transfer of thermal energy to stream ecosystems and is important in determining the thermal aspect of water quality in lotic environments” (Pusey & Arthington, 2003). Salmon require a water temperature range of 12.8 to 17.8 degrees Celsius, and a loss of canopy cover results in an increase in water temperature, which makes salmon “more susceptible to predators, parasites, and disease” (National Wildlife Federation, n.d.).

**2. Erosion Control and Substrate Stability**

Riparian trees armor stream banks against erosion (Pusey & Arthington, 2003), which reduces sediment runoff. Excess sediment is incredibly harmful for salmon populations as it can “settle on nests and block the flow of water through the gravel, depriving eggs and larvae of the oxygen they need” (Washington State Department of Ecology, 2019).

**3. Nutrient Filtration**

Inorganic contaminants from rain and snow runoff or groundwater are blocked and filtered out by riparian vegetation (Pusey & Arthington, 2003), ensuring that they do not contaminate the freshwater environment. Without this buffer, species like chinook salmon can become infected and contaminated with these pollutants, which is detrimental to their health.

**4. Food Web Support**

Due to high amounts of terrestrial material like plant debris, leaf litter, and roots, “riparian zones have been shown to support greater densities and diversity of invertebrates” (Pusey & Arthington, 2003). This is important for young chinook salmon living in these freshwater environments, which feed on invertebrate detritivores like amphipods (National Wildlife Federation, n.d.).

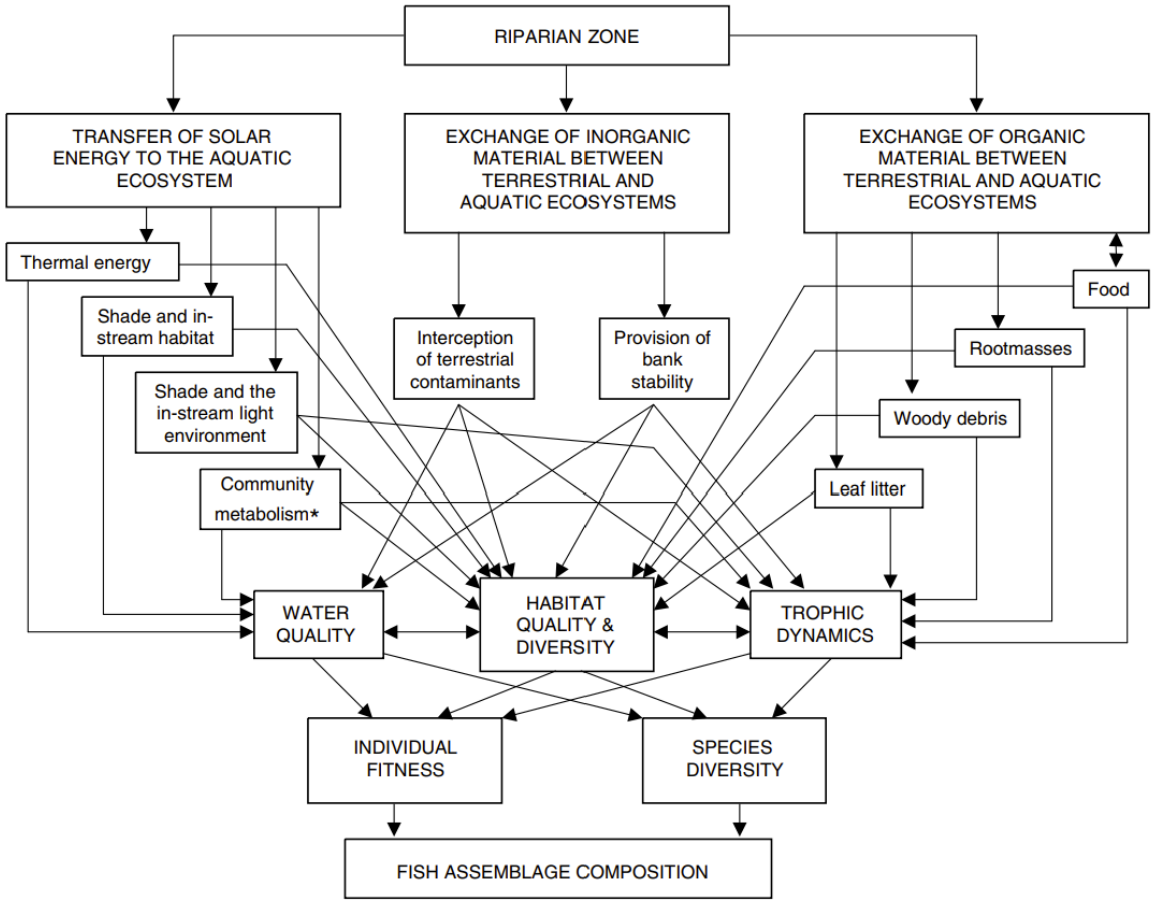


**Figure 2:** Conceptual model depicting the mechanisms by which riparian regulation of energy and material transfer to the riverine ecosystem impacts riverine fish communities (Pusey & Arthington, 2003)

## Southern Resident Orcas and Their Dependence on Chinook Salmon

Orca ecotypes are classified based on a population's unique diets and behaviors. Resident orcas in particular are exclusively fish-eaters, with southern residents preferring chinook salmon due to their higher fat content which makes them a more efficient food source compared to other fish species (Black et al., 2020). As mentioned previously, declining chinook populations have been one of the leading factors in southern resident endangerment (Geiger, 2024). Due to their high prey specialization compared to other orca ecotypes, southern resident orcas are "dependent on this single salmonid species to an extent that it is

a limiting factor in their population dynamics" (Ford et al., 2010), as decreases and increases in chinook salmon abundances end up correlating heavily with increases and decreases in orca birth and mortality rates.

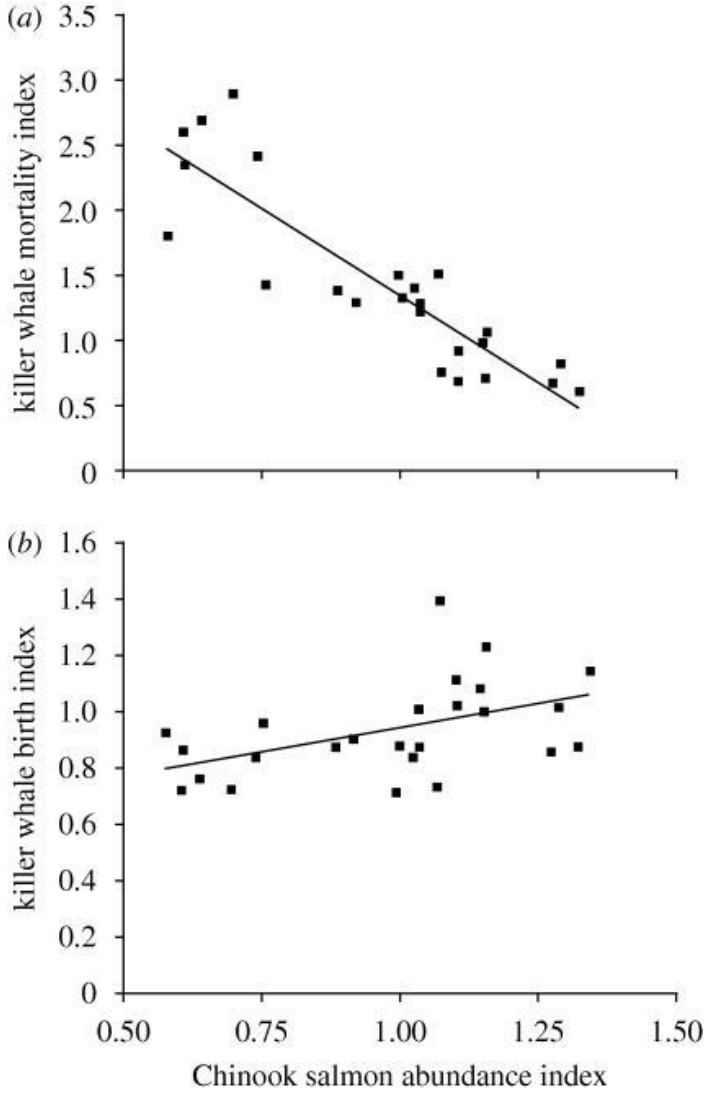


**Figure 3:** (a) Mortality and (b) birth rate indices of southern resident killer whales as a function of chinook salmon abundance indices (Ford et al., 2010)

This makes salmon decline incredibly detrimental for the orca population in the region, which has still been struggling in the past decades and itself has declined by over 10% from 2005 to 2020 (NOAA, n.d.). Recovery of prey populations is the best way to remedy this issue of food, as direct feeding "can

unintentionally reduce their chance of survival in the wild" (NOAA, n.d.) by making them more habituated to human interaction.

## Riparian Health and Orca Populations

Based on the relation between riparian zones and salmon populations, and salmon populations and orca populations, the overall link between riparian zone health and orca health becomes clear. The consequences of this link include:

### 1. Reduced Food Availability

Evidently, based on the necessity of rich riparian vegetation for salmonid survival, a lack of the former results in a decrease in the latter. This causes further decline in the populations of species like chinook salmon, which results in a decline of southern resident orcas due to an absence of their primary food source (Ford et. al., 2010).

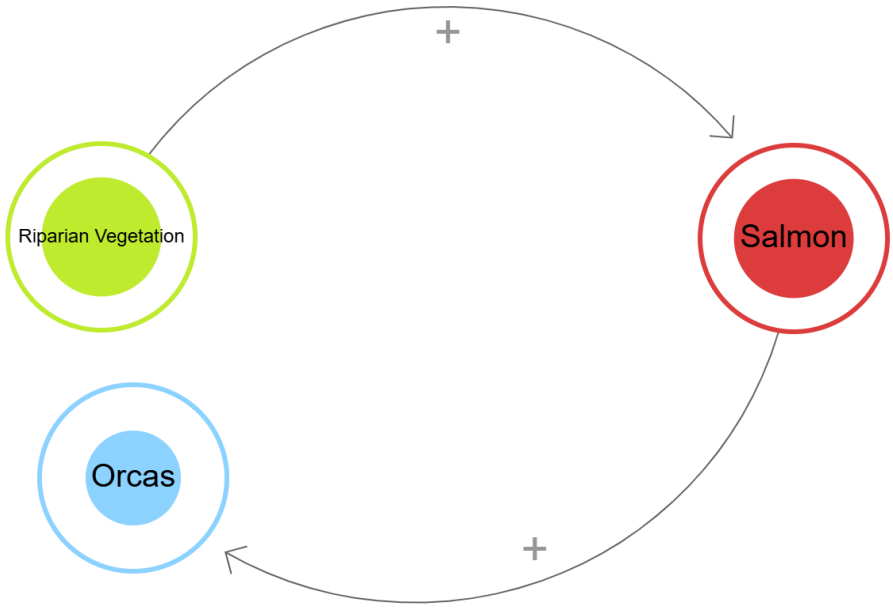


**Figure 4:** Visual model depicting system connection between riparian vegetation and orca population (Model by Author made using Loopy)

**2. Pollutant Biomagnification**

As mentioned earlier, a lack of riparian buffer results in further environmental pollutants entering streams. This also affects the southern resident orcas due to biomagnification, a process where absorbed or ingested pollutants become more concentrated as they move up the food web. Due to their high trophic level, orcas accumulate more of these chemicals, which can result in "endocrine disorders, reproductive dysfunction, a compromised immune system, neurological problems, unusual behavior, and cancer" (NOAA, 2016).

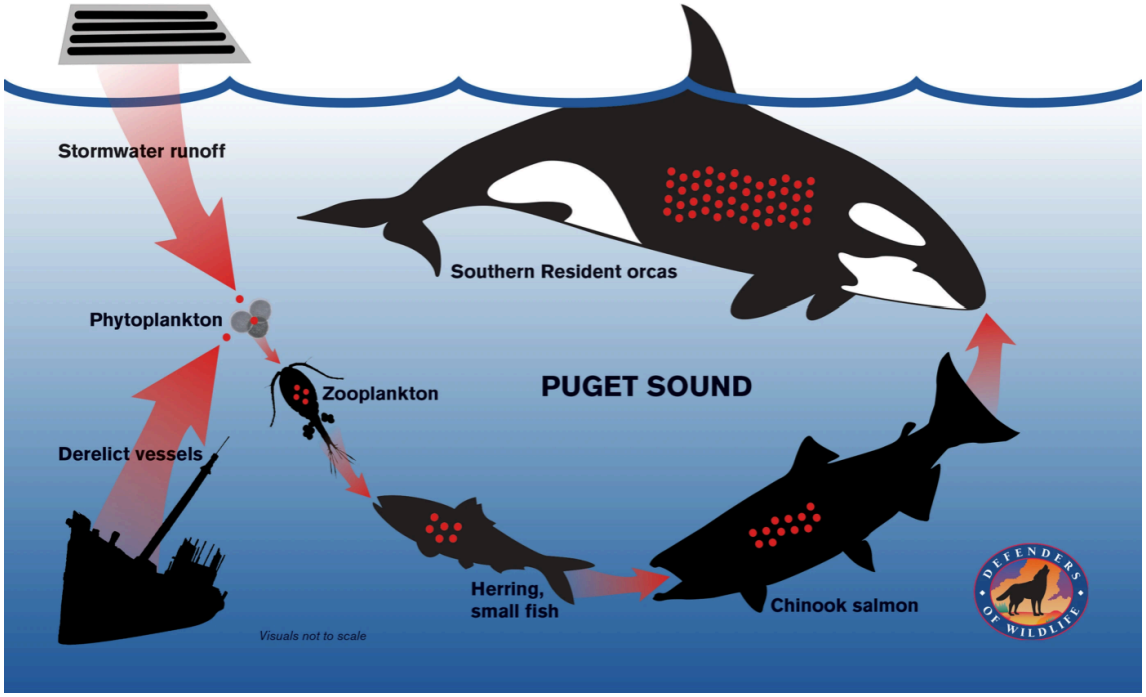


**Figure 5:** Visual model depicting the process of pollutant biomagnification in the Puget Sound ecosystem with regard to southern resident orcas (Orca Month, 2024)

## Application: Puget Sound Watersheds

Puget Sound riparian areas have been degraded "over decades of population growth and development" (Puget Sound Info, n.d.), correlating to a decline in chinook salmon populations as well

(NOAA, 2025). Restoration efforts have been put in place to combat this, such as in the 2007 Puget Sound Salmon Recovery Plan (Shared Strategy for Puget Sound) and its 2024 addendum (Puget Sound Partnership, 2024). These efforts have managed to make progress in improving salmon populations, such as in the Skagit River estuary and the Nisqually River Delta (Thom, 2020), which ends up helping orcas in the long-term by conserving their food sources.

## Riparian Conservation Strategies

The issue of riparian restoration requires a breadth of strategies to solve. These include:

### 1. Native Vegetation Planting

Increasing plant growth in riparian areas provides shade, food, and shelter to the environment there. Native plants in particular are important as they are better suited to the region and are more important to preserve than invasive species which harm the environment through crowding (Washington State Department of Ecology, 2008).

### 2. Pollution Reduction

Reducing polluted runoff protects chinook salmon from harmful toxins (Washington State Department of Ecology, n.d.). Wastewater runoff can also be reduced through regulation and improvement as contaminated wastewater is often “discharged directly into waterways” (Puget Soundkeeper, n.d.).

### 3. Indigenous Collaboration

Tribal nations “lead, maintain, and participate in forums that guide and inform salmon and Puget Sound recovery” (Puget Sound Partnership, 2024), and “lead many of the largest restoration and recovery efforts in the state” (State of Salmon in Watersheds, n.d.). Collaboration with Tribal nations and understanding of Indigenous ecological management would be helpful in Puget Sound conservation (Atlas et al., 2020).

**4. Monitoring and Research**

Establishing accurate spatial data layers and ranges for riparian habitats is essential in ensuring proper recovery programs and allowing for better trend monitoring of different regions and their circumstances. This data mapping should build off existing setups, “address regional data gaps” and be “readily accessible through online mapping applications to support restoration planning and evaluation” (Salish Sea Restoration, 2025)**.**

## Conclusion

The relation between riparian zone health, salmon populations, and orca conservation highlights the complexity and interconnectedness of environmental systems. Even though orca health might not seem to be closely related to inland regions, the decline of those habitats inevitably affects them. The protection of southern resident orcas is not a singular issue. Rather, it is a holistic responsibility engrained in the interconnectedness of Pacific Northwest biomes. The road towards recovery in this regard needs extended inland action in the form of riparian restoration and protection in the midst of growing population and production in the region. This paper seeks to illustrate the importance of this relation in this particular example of marine conservation, but also that this is just one of the numerous examples in which the vital inland riparian habitats influence the broader ecological health of the marine ecosystem.

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