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Research article

Ecological risk based assessment used to restore riparian physical functions to a fresh water Creek

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ABSTRACT

The purpose of this study was to determine if an interdisciplinary team using a qualitative proper functioning condition (PFC) assessment protocol could identify and reverse significant detrimental ecological alterations which occurred within Gertie's Creek watershed, Ontario, Canada. At potential, Gertie's Creek supported a woody debris glacial outwash fine gravel substrate fish spawning habitat. The anthropogenic activities on Georgina Island caused a denuded anadromous fish population since the early-to mid-1990's in the Gertie's Creek watershed. The PFC assessment indicated that anthropogenic activities on Georgina Island negatively impacted stream flows in Gertie's Creek. Reduced stream flow resulted in the natural stream (lotic) riparian habitat not advancing out of an early seral silver maple and eastern hemlock vegetated swamp (forested wetland) habitat. The Gertie's Creek interdisciplinary team PFC assessment indicated that the entire watershed is not in balance with the water and sediment being supplied along with a lack of diverse riparian vegetation. Sediment was not being transported to the wetland and lake coastal areas because of chronic reduced flows. Further qualitative assessments by the authors of other smaller lentic and lotic ecosystems on Georgina Island indicate that reduced hydrologic flow is an issue for the entire island. Ecosystem function management planning works with the ecosystem to continually respond as the ecology changes in ways that enhance remarkable natural recovery.

1. Introduction

Ecosystems are dynamically affected by bio-geoclimatic setting and anthropogenic modification of natural conditions (Tamario et al., 2018). Centering the focus on ecosystem physical processes prioritizes actions for maintaining and restoring the foundation needed for resilience and restoration (Rollan et al., 2018; Hall et al., 2014; Kondolf, 2006; Kondolf et al., 2006; Kondolf, 2011). To determine impacts from environmental stressors, it is important to understand ecosystem functions and recognize their role in the capture, storage and safe release of water, sediment, nutrients, and organic materials (Swanson et al., 2017; Kozlowski et al., 2013, 2016; Hall et al., 2009, 2014). The degree to which stream and wetland riparian areas function properly, regarding their potential/altered potential, makes the connection between form, function, management and monitoring to address the underlying causative factors behind the restoration of biological values and ecosystems (Aron et al., 2013; Pander et al., 2018; Swanson et al., 2015). This study determined the restoration potential of Gertie's Creek back to a functional lotic ecosystem. The determination of other Georgina Island upland areas to their potential natural condition (PNC) and restoring these areas to a white pine and sugar maple ecosystem is also included. Stream and wetland riparian proper functioning condition (PFC) assessments are an appropriate starting point for determining, prioritizing and inventorying riparian resources (Ward et al., 2003; Winward, 2000), and developing monitoring needs (Swanson et al., 2017). More important, PFC provides context for quantitative data. Therefore, monitoring focused on the drivers (vegetation, hydrology, soil and landform) of ecosystem functions is fundamental to maintaining water quality and the rich values of

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riparian ecosystems (Aron et al., 2013; Swanson et al., 2015, 2017; Winward, 2000).

Restoring an ecosystem to its potential is dependent on the development of a riparian and upland management strategy, which considers and adapts to certain basic ecological and economic relationships (Kozlowski et al., 2013, 2016; Swanson, 1996, 2015; Wyman et al., 2006). Ecosystems are defined as an interconnected community of vegetation, soils, landforms, hydrology, and micro-organisms, linked by physical and chemical interactions (Dickard et al., 2015; Kondolf, 2006; Nakano and Murakami, 2001; Nakano et al., 1999; Prichard et al., 1998a,b). An appropriate management strategy incorporates ecosystem patterns, attributes (vegetation, soils, landforms) and processes (hydrology) to attain sustainable ecosystem functions that support biological diversity (Garcia et al., 2017; Barbour et al., 2000; Angermeier and Karr, 1994). Understanding the ecosystem function physical processes allows sustainable management of many ecological goods and services (Aron et al., 2013) including water quality through assimilation, water stability (aquifer recharge), fish and wildlife habitat, and enhancement of focal niches (Kozlowski et al., 2016; Swanson et al., 2015; Hall et al., 2014). Managing for restoration efforts requires focus on the drivers of ecosystem function. These drivers are the leading indicators used to augment and manage the physical process through adaptive management based on monitoring (Swanson et al., 2012, 2017). Linking the leading indicators of ecological functions to time yields an ecosystem condition status and then ecological risk can be determined. For example, what would be the consequences of success/failure if an ecosystem is left unattended? How fast would the ecosystem improve/degrade? What is the importance to users in maintaining and/or increasing long-term sustainability?

Evaluating and managing ecosystems proactively provides the largest return for the investment in time and resources for the benefit of the users. This research outlines the essential goods and services of an ecosystem by focusing on the drivers of stream and wetland riparian functions, which often determine if resource goals and objectives are being met. This study identifies and analyzes areas of ecological modification (hydrology, vegetation, erosion/deposition) to improve best management practices (BMP) implementation, and what parameters need to be monitored (Swanson et al., 2017).

2. Method – riparian proper functioning condition (PFC)

Stream and wetland riparian proper functioning condition (PFC) is an assessment protocol focusing on physical structure and functioning in relation to on-site potential (Dickard et al., 2015). Although qualitative, it is based upon quantitative science (Dickard et al., 2015; Prichard et al., 1998a; Leonard et al., 1992). PFC incorporates the important attributes numerically-based (CWMW, 2013) and other qualitative surveys commonly address (Ward et al., 2003). The PFC assessment method refers to a consistent quantitative science-based approach for considering stream and wetland hydrologic, vegetative, and geomorphic attributes and processes (Schumm, 1977; Schumm et al., 1984) at a point in time (Dickard et al., 2015). An interdisciplinary (ID) team conducting a PFC assessment in the field uses all relevant science and life experience to inform understanding of local potential to determine what is locally possible, and what is needed for the ecosystem to maintain functions during large flow events. Potential is defined by Dickard et al. (2015), as “the highest ecological status an ecosystem can attain given no social, political or economic constraint.” An altered potential is the highest ecological status an ecosystem can attain given these constraints are present (Dickard et al., 2015).

The ID team analyzes the “yes's” and “no's,” in relation to the reaches potential/altered potential and determines a functional rating and trend. To be properly functioning, a riparian system will: “Dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve floodwater retention and groundwater recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses, and; support greater biodiversity” (Prichard et al., 1998a).

The term proper functioning condition (PFC) also is used to describe both an assessment process, and a defined, on-the-ground, condition of a riparian-wetland area. Therefore, PFC refers to how well the physical processes within a stream and wetland riparian area can sustain a state of resiliency (Wyman et al., 2006; Prichard et al., 1998a,b; Prichard et al., 1996; Dickard et al., 2015). This resiliency allows an area to provide and produce desired and valued ecosystem services (e.g., fish habitat, livestock and/or wildlife forage, water purification, carbon storage and nutrient cycling) over time (Wyman et al., 2006). To determine how well a lotic riparian area functions to achieve these criteria, an interdisciplinary team of experienced professionals uses a checklist of seventeen attributes for lotic ecosystems (Dickard et al., 2015) and twenty for lentic (Prichard et al., 1998b) in three categories: hydrology, vegetation, and geomorphology. The functional attributes in the PFC assessment form provide important foci for this study's research. The rationale for the PFC assessment are summarized in technical references (Prichard et al., 1998a; Dickard et al., 2015).

Stream and wetland riparian PFC assessments connect to water quality and aquatic habitat by assessing the degree of functionality and the risk of losing those functions (Swanson et al., 2017). By focusing on physical functioning, the PFC protocol is designed to yield information about the biology of the plants and animals dependent on the riparian-wetland area (Prichard et al., 1998a; b; Prichard et al., 1996; Dickard et al., 2015). When the stream and riparian ecosystem functions properly, it is stable and resilient to major hydrologic events (Prichard et al., 1998a). Stream stability requires that a stream be self-sustaining, retain the same general geometry over time (decades), and balance the import and export of sediment (Ward and Trimble, 2004).

Functional at Risk, refers to riparian areas functioning, but with an existing soil, water, or vegetation attribute making them susceptible to degradation. Apparent trend is an assessment of direction of change (e.g., upward or downward) in conditions either toward or away from the potential or functionality (Prichard et al., 1998a; b; Prichard et al., 1996; Dickard et al., 2015). Trend is determined by comparing the present condition with previous photos, trend studies, inventories, other documentation, or personal knowledge. The lack of historical information on the condition of a site may lead to a “trend not apparent” assessment unless other clues are well understood such as the population growth of young woody species (e.g., willows). Nonfunctional indicates the stream and wetland riparian is in a degraded state.

3. Results - Gerties Creek PFC assessment

Georgina Island is located approximately 3 km north of the southeast shoreline of Lake Simcoe, Ontario, Canada. Lake Simcoe is located approximately 80 km north-northeast of Toronto, Ontario, Canada (Fig. 1). Stream and wetland riparian PFC assessments were completed for Gertie's Creek, which is located on the west side of Georgina Island (Fig. 2).

A multidisciplinary team completed PFC assessments for 4 lotic