Riparian Lands in Alberta

Current state, conservation tools, and management approaches

FINAL REPORT

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Executive Summary

As the Latin root of the word “riparian” (*ripa* = bank) suggests, riparian lands are found along the edges of water bodies. These lands are under the influence of both terrestrial and aquatic processes and are thus considered to be “transitional” habitats, i.e., representing a transition from wet (open water) to dry (uplands). Hydrology - both groundwater and surface water - is the driving force behind the physical, chemical, and biological processes on these lands, and environmental processes show steep gradients from the water’s edge to the adjacent uplands. These characteristics result in riparian lands having relatively higher biological diversity and productivity than other habitats of comparable size, especially in dry climates.

Given the importance of riparian lands to the overall ecological health of watersheds, the Alberta Water Council struck the Riparian Land Conservation and Management Project Team in 2011 in an effort to better understand the current state of riparian lands in the province. To that end, the objective of this report is to help inform the work of the Alberta Water Council by summarizing existing information on the “current state” of riparian lands in Alberta, including information on riparian extent, health, and approaches to management of riparian lands.

Current State of Riparian Land Extent
To date, there has been no systematic measurement of the aerial extent of riparian lands in the province of Alberta. The most commonly used method for delineating riparian lands is an expert-based approach using aerial photos, topographic maps, and field-based mapping that is typically conducted as part of a site-specific riparian health assessment. While there are a host of other methods currently under development that could be used to estimate riparian land extent at larger spatial scales, to date there has been no systematic, comprehensive, or coordinated quantification of riparian land extent at either the regional (watershed) or provincial scale.

Progress toward the completion of province-wide mapping of riparian lands would be greatly aided by the availability of fine spatial resolution and up-to-date geospatial data. At a minimum, an up-to-date and more accurate province-wide hydrography dataset, along with high-resolution digital terrain information, would allow for the estimation of riparian land extent based on hydro-geomorphic setback models. This could subsequently be refined through dedicated riparian land mapping exercises based on hydrology, vegetation, land use, soils, and geomorphology.

As a first step in trying to better understand riparian land extent in the province of Alberta, we used existing hydrographic data for the province to roughly estimate the shoreline length of lotic water bodies (as categorized by small streams [Strahler order 1-5] and large rivers [Strahler order 6 and up]), as well as lentic water body perimeter length for water bodies greater than 0.5 ha within each of the seven major watersheds in the province. This dataset allowed us to estimate the density of riparian health assessments (# of sites/total shoreline length) in each of the seven watersheds.

Current State of Riparian Land Health
Since the 1990s, there have been two different tools used to assess riparian health in Alberta: one field-based and the other remotely sensed. Of these methods, the field-based Riparian Health Assessment, originally developed by Hansen et al. (2000) and modified for use in Alberta by the Alberta Riparian Habitat Management Society, has been used most widely, comprising approximately 96% of provincial assessments conducted to date. The systematic collection of

riparian health information using this method (hereafter referred to as *ARHMS-Riparian Health Assessment*) began in 1997, and since that time, just over 5100 sites have been assessed across the province by both government and non-government agencies. The second most frequently used method is low-level videography, with approximately 100 sites being surveyed to-date; however, each videography site covers much a much longer (≈100 km) stretch of shoreline than an *ARHMS-Riparian Health Assessment* site (≈1 km).

Of the riparian lands that have been assessed using the *ARHMS-Riparian Health Assessment* method, the majority of sites have been located in the White Zone, and in particular, in the South Saskatchewan River watershed, where over 58% of assessments have been conducted to date. A much smaller proportion of riparian health assessments have been completed in the Green Zone, with the majority of those assessments being conducted by Alberta Sustainable Resource Development on public grazing leases. Based on a summary of available riparian health data collected in Alberta between 1997 and 2011 using the *ARHMS-Riparian Health Assessment* method, approximately 75% of the sites surveyed were considered "Healthy", although over half of them with problems, while the remaining 25% of sites were reported to be "Unhealthy" (n=2520).

This estimate of provincial riparian health is crude at best, and should not be taken as a definitive statement on the condition of riparian lands in the province. It is very difficult to get a comprehensive picture of riparian health in Alberta, primarily due to a lack of commonly applied assessment methods and a lack of data. For example, the South Saskatchewan River watershed with the highest density of assessments has less than 3% of its rivers and lakes assessed. Even in areas where a larger number of assessments have been conducted, the sampling has not been systematic, which means that results cannot be generalized to give an overall picture of riparian health at either the watershed- or provincial-scale. The increasing use of low-level videography offers some promise of rounding out riparian health assessments in areas where fewer assessments have been conducted; however, there is currently no systematic information regarding how closely field-based and aerial videography-based assessments correlate to one another. As a result, it is currently unknown whether the data collected using these two methods is directly comparable.

Current State of Riparian Management

The responsibility for managing riparian land in Alberta is shared amongst jurisdictions, from local municipalities through to the provincial and federal governments. While there are no existing laws or policies that *explicitly* apply to the management of riparian lands, there are a number of laws, regulations, standards, guidelines, policies, and voluntary programs administered by both government and non-government agencies that can be used to direct riparian land management in the province. However, the question of whether these existing laws, policies, and programs effectively consider riparian land conservation goals in the province has never been closely examined, and the barriers that prevent improved outcomes have never been systematically identified.

To that end, a key objective of this project was to survey a broad range of stakeholders to gain insights into their perspectives as to whether they feel existing riparian land management programs and policies are effective on both private and public land. This survey also asked participants to identify key barriers or challenges that limit the success of riparian stewardship and conservation in Alberta, and to provide suggestions for how these barriers could be overcome.

When survey respondents were asked to rate the overall effectiveness of existing riparian land management programs and policies, the majority felt that outcomes have been "Somewhat Effective", with this percentage being slightly higher on public (69%) *versus* private (66%) land. As many as 25% of respondents felt that existing management programs and policies have been "Not at all Effective" on public land, with this proportion increasing to 36% for private land.

When respondents were asked to identify the top three barriers that currently limit the success of riparian land management in Alberta, a number of common themes and concepts emerged, including (in no particular order):

a) Jurisdictional fragmentation
b) Insufficient public, scientific, & technical knowledge
c) Insufficient or ambiguous regulation
d) Economic constraints & lack of incentives
e) Lack of financial & human resources
f) Misplaced government priorities
g) Agency capture & lack of government legitimacy
h) Inappropriate or unrealistic planning and management scales
i) Insufficient compliance & enforcement

The strategies put forward by respondents for improving riparian land management in Alberta were a corollary to the barriers presented above, and included the following (in no particular order):

a) Improve coordination of governments, information, & programs
b) Increase public awareness & scientific knowledge
c) Provide clear guidelines, rules, & direction
d) Encourage conservation through incentives
e) Increase the capacity of government & other agencies
f) Update existing legislation, regulation, & policy
g) Increase government accountability & empower front-line decision makers to say 'no'
h) Utilize watershed scale planning & cumulative effects management
i) Improve compliance & enforcement of existing laws and regulations

When participants were asked whether they thought there was a need for a new provincial policy to direct riparian land management in the province, the overwhelming majority of respondents were in favor of adopting a new policy. However, many of those who supported the idea of a new riparian policy also acknowledged that improved riparian management outcomes could likely be achieved through better enforcement and implementation of existing law and policy. Several respondents also noted that changes to existing laws and policies could result in improved outcomes without the need for a new riparian policy. Still others pointed out that the development of a new riparian policy would be effective only if accompanied by adequate human and financial resources for proper and effective policy implementation.

Conclusions

It is our view that the building blocks for successful management of riparian lands in Alberta are largely in place, be they science-based assessment tools, stewardship programs and incentives, or policy and regulation. The challenge lies in bringing these disparate pieces together in a coordinated and cohesive manner under a common and collective goal. In

addition, it is important to identify those areas were significant gaps in knowledge, process, or practice exist, and begin to constructively move forward to address these crucial issues. **Finding ways to remove institutional barriers that currently limit the success of existing management tools and creating new tools that enhance the effectiveness of those that already exist should be a focus of management efforts moving forward.**

What follows are some of what we perceive as being the key considerations for advancing the agenda of improving riparian lands management in the province of Alberta. These considerations are informed by what we perceive to be the major gaps in existing knowledge and practice, as well as by the recommendations provided by survey respondents. While these recommendations are not presented in any particular order, it is important to note that several are interdependent, and as such, their effectiveness may depend upon the adoption of other complementary recommendations.

Key Considerations:

1. Riparian land management should be set within an integrated ecosystem management framework that considers riparian lands as components of a larger ecosystem (i.e., the watershed).
    - Within this larger watershed context, riparian lands should be managed together with other ecosystem components including wetlands, groundwater aquifers, rivers and lakes, forests, and human systems (agricultural, urban, industrial).
    - Concepts of natural range of variability and resilience should inform and be integrated into these management plans.
2. A province-wide framework for riparian assessment should be created that addresses the scaling of information from the local to the regional scale. This framework should consider the geographic and hydrological differences across the province in order to give managers and planners the appropriate data to evaluate and drive their management plans.
    - This framework should outline consistent standards and/or methods that should be used by all agencies engaged in collecting information on the extent and health of riparian lands in the province. This should include standards and/or methods for collecting information for both field-based and remotely sensed assessments. This standardized information will ensure comparability of data, which in turn will create reliable and consistent information that can be used to monitor and manage riparian lands across the province.
3. Establish a publically accessible repository for riparian land data that includes information related to both riparian extent and health. This repository should also include hydrological data that delineates and classifies all water bodies in the province, including all classes of wetlands, seeps, and springs.
    - This data should be freely available to the public so that it may be used to help inform land use planning at the local, municipal, and regional scales.
4. Calibrate field-based riparian health assessment methods that are currently in use against remotely sensed techniques to test the efficacy of adopting a remote sensing riparian health assessment approach, such that remote sensing information can be used to assist with planning at larger spatial scales (e.g., regional and provincial scales).

- This calibration should be done using a number of remote sensing techniques and across different locations (i.e., natural regions) in the province, with sufficient sample size to make valid inferences.

5. Establish clear, consistent, and enforceable standards for determining riparian setback widths across the province based on the best existing science.
    - The majority of survey respondents raised concerns over the inconsistencies in how development setbacks are being determined, with particular concern expressed by land managers in municipalities. Creating clear standards or guidance for determining riparian setback widths would be beneficial.
    - Adopting an approach for determining riparian setback widths would effectively create a functional definition for riparian lands in the province, which could then be applied to riparian land management under a variety of different land uses.
6. Create more incentives for adopting behaviours that create desired environmental outcomes.
    - Many survey respondents suggested that these incentives should be economic, and consideration should be given to pilot testing a range of possible instruments for use in riparian land management. These economic instruments should be carefully designed with a clear objective, and should be sensitive to the local and regional context within which they are being used to ensure they do not produce unintended social or economic outcomes.
    - Respondents also recognized the importance of the work that is currently being done by a number of different stewardship groups and not-for-profit organizations, and expressed their desire for continued financial support of these organizations to maintain or expand existing programs.
7. Consider developing and implementing a new provincial policy dedicated to riparian land management. As an alternative to developing a new riparian land policy, consider improving the implementation of existing legislative and policy tools that are currently in place for riparian land management. Specifically, survey respondents suggested the following:
    - Improve coordination within and between jurisdictions responsible for managing riparian lands in the province, including increased transparency in government decision-making.
    - Provide sufficient human and financial resources to government departments responsible for riparian land management.
8. Regularly evaluate the success of scientific, policy, economic, and social management actions to help improve and adapt existing management strategies to deal with new realities.
    - This kind of evaluation is not possible without reliable program monitoring data; thus, consideration should be given to developing transparent monitoring programs that are designed with the intent of providing information that can be used to evaluate policy or program success.

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1. Introduction

1.1. Project Context & Objectives

In June of 2011, the Alberta Water Council struck the Riparian Land Conservation and Management Project Team (hereafter "the Project Team") to complete three main tasks related to questions and priorities around the conservation and management of riparian lands in Alberta, including:

1. The development of a provincial definition for riparian lands;
2. Documentation of the current states of riparian lands, management and stewardship in Alberta, as well as the riparian management and stewardship "best practices" of other jurisdictions;
3. Evaluation of the current state of riparian lands, management and stewardship against the needs of all relevant sectors and propose recommendations for improving riparian land conservation and management in Alberta.

As part of this work, the Project Team retained Fiera Biological to provide information that can be used by the Project Team to meet the goals stated above. Specifically, the objectives of this project included the following:

1. Summarize the existing information on the "current state" of riparian health by major watershed;
2. Elucidate challenges and/or barriers associated with riparian management in Alberta, as articulated by key riparian land managers and decision makers in the province;
3. Draw on information from across Alberta and other jurisdictions (with a focus on North America) to summarize existing and emerging scientific, social, and economic approaches to riparian area assessment and management.

This report addresses these main questions in six chapters. What follows in Chapter 2 is an overview of the various legislation, policies, and voluntary programs that are currently employed in Alberta to manage riparian lands. Chapter 3 describes the current tools that are being used in the province to quantify the extent of riparian lands, while Chapter 4 summarizes the state of knowledge with respect to riparian health assessments that have been conducted throughout Alberta. Perceptions of key actors regarding the existing barriers and challenges to achieving improved riparian conservation outcomes are summarized in Chapter 5, along with a summary of strategies put forward by survey respondents that could be employed to improve outcomes. Finally, Chapter 6 presents alternative approaches for managing riparian lands, including examples from other jurisdictions where riparian land management has been successful, and considerations for how to improve management in Alberta. Conclusions and key considerations of our report are listed in Chapter 7.

1.2. Riparian Lands: What are they and why are they important?

As the Latin root of the word "riparian" (*ripa* = bank) suggests, riparian lands are found along the edge of water bodies including rivers, streams, lakes, wetlands, springs, and ponds. Given the inherently complex and dynamic of nature of these lands, there is no universally agreed upon definition for riparian lands; however, a sample of definitions from various governmental and

non-governmental organizations as well as the academic literature, reveal a number of critical elements that are common to most of these definitions (Table 1.1).

Table 1.1. Common definitions of riparian lands from governmental and non-governmental organizations, as well as the academic literature.

Source	Definition of Riparian
Government	
Town of Cochrane Land Use Bylaw (2004)	Lands adjacent to lakes, rivers, streams and other bodies of water, where the vegetation and soils show evidence of being influenced by the presence of water. Riparian lands are the green zones around lakes, rivers, streams and other bodies of water. They are the transitional zone between surface water and the drier uplands and play a vital role in the healthy functioning of both.
Alberta Environment (2003)	The area along streams, lakes and wetlands where water and land interact. These areas support plants and animals, and protect aquatic ecosystems by filtering out sediments and nutrients originating from upland areas.
Government of Canada (2008)	Riparian areas are the vegetated areas adjacent to a watercourse or water body that directly contribute to fish habitat by providing shade, cover and food production areas. Riparian areas are important because they stabilize stream banks and shorelines.
Non-government	
Alberta Riparian Habitat Management Society (recent reports)	Riparian areas are the portions of the landscape strongly influenced by water and are recognized by water-loving vegetation along rivers, streams, lakes, springs, ponds and seeps. Riparian areas can be described as the "green zones" around lakes and wetlands and bordering rivers and streams.
Alberta Riparian Habitat Management Society (website)	Riparian areas are the lands adjacent to streams, rivers, lakes and wetlands, where the vegetation and soils are strongly influenced by the presence of water. Although they make up only a small fraction of the land, they are among the most productive and valuable of all landscape types and have been the focus of conflicts between resource users.
Petry & Palechek (Oldman River State of Watershed Report) (2010)	The transitional zone between upland and aquatic habitat. Riparian areas perform important ecological functions, contain a diverse assemblage of plant and animal species, provide essential habitat for wildlife and are influenced by seasonal water levels.
Academic	
Naiman & Decamps (1997)	Riparian zones are an unusually diverse mosaic of landforms, communities, and environments within the larger landscape, and they serve as a framework for understanding the organization, diversity, and dynamics of communities associated with fluvial ecosystems.
NRC (2002)	Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e. a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines.
Fitch & Ambrose (2003)	Riparian areas are the green zones around lakes and wetlands, the emerald threads of vegetation that border rivers and streams and the lush fringe in valleys. Riparian areas are transitional; they exist between the surface water of a river, wetland or lake and the surrounding drier upland.
Lee & Smyth (2003)	Areas closer to the water's edge are more likely to be riparian.

Perhaps the most important concept that is common to the riparian definitions presented above is that hydrology (both groundwater and surface water) is the driving force behind physical, chemical, and biological processes occurring on these lands. Given that these lands are "transitional" habitats, i.e., representing a transition from wet (open water) to dry (uplands), environmental processes also show steep gradients from the water's edge to the adjacent uplands.

A second key concept is that of "connectivity", whereby riparian lands facilitate connections that allow the transfer of energy and materials between terrestrial and aquatic ecosystems. Riparian lands themselves are under the influence of both terrestrial processes and aquatic processes (e.g. nutrient and sediment transfer) (Figure 1.1). In drier regions such as Alberta, riparian zones can be a source of water and nutrients to underlying aquifers and adjacent uplands (Figure 1.2), whereas in more humid climates, riparian lands are more often recipients of groundwater discharge.

A final important concept that is emphasized by many definitions is that riparian lands have a disproportionately greater influence on aquatic ecosystems than other terrestrial lands, and in many landscapes riparian lands are much more biologically productive and with much higher biodiversity than other habitats that are of comparable size.

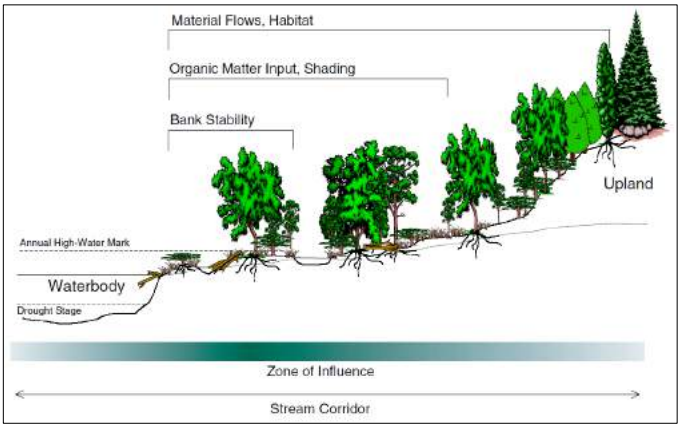

Figure 1.1. Schematic of a generic riparian area showing a zone of influence relative to aquatic and upland areas. The intensity of riparian influence is depicted with shading. "Material flows" refers to energy, organic matter, water, sediment, and nutrient flow (from NRC 2002).

While these common elements provide useful description of riparian lands conceptually, arriving at operational definitions to be used in management and regulatory frameworks can be very difficult due in part to a lack of a universally accepted functional definition, as well as the lack of clear ecosystem boundaries. In practice, definitions for what constitute riparian areas vary according to its intended use in research, management, or policy.

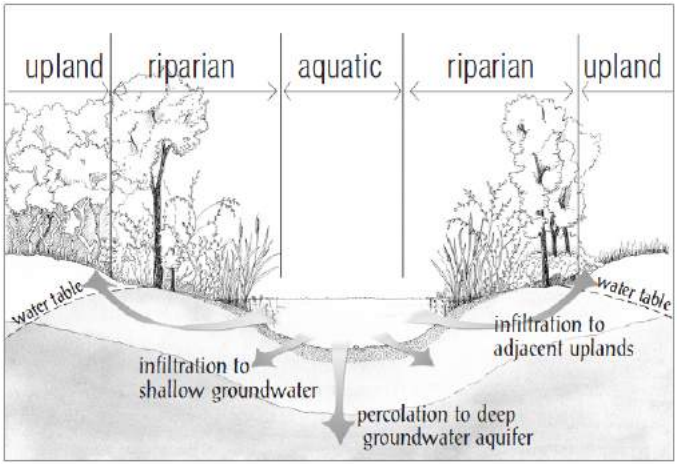

Figure 1.2. Diagrammatic representation of a lentic riparian area showing dominant direction of water across riparian lands (from Ambrose et al. 2004).

1.3. Defining Riparian Lands in Alberta

In order to create more clarity for the management of riparian lands in Alberta, the Alberta Water Council Riparian Land Conservation and Management Project Team has developed a draft definition for Riparian Lands in Alberta. This definition was developed with the intent of creating a common understanding across sectors as to

what constitutes 'riparian land' in the province.

The draft definition developed by the Project Team pulled together a variety of sources and subsequently constitutes what the Team considers to be the core ecological elements of what defines riparian land from the scientific literature (*Note: the definition is considered to be a "draft" because it has not yet been adopted by the Alberta Water Council Board*).

1.3.1. Riparian Lands: A Draft Provincial Definition

The draft definition of riparian lands developed by the Alberta Water Council Riparian Land Conservation and Management Project team is as follows:

"Riparian lands are transitional areas between upland[1] and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated water bodies[2], which includes alluvial aquifers[3] and floodplains[4], when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes."

The information contained within this report has been informed by this draft definition of riparian lands, and the considerations provided in Chapter 7 are given being mindful of this definition.

[1] For the purpose of this definition, "upland" is considered to be the land that is at a higher elevation than the alluvial plain or stream terrace or similar areas next to still water bodies, which are considered to be "lowlands."
[2] A water body is any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood, and includes but is not limited to wetlands and aquifers (generally excludes irrigation works). Source: Water Act.
[3] For the purpose of this definition, alluvial aquifers are defined as groundwater under the direct influence of surface water (GUDI).
[4] For the purpose of this definition, floodplain is synonymous with flood risk area. The flood risk area is the area that would be affected by a 100-year flood. This event has a one percent chance of being equaled or exceeded in any year.

2. Overview of Riparian Management in Alberta

Riparian land management in Alberta falls under the jurisdiction of the federal, provincial, and municipal governments. While Alberta does not have legislation or policy that explicitly manages riparian lands, there are a number of laws, regulations, standards, policies, and voluntary programs that can be used to direct the management of riparian lands, or land that directly adjoins riparian lands. The following section highlights the key legislation, policies, and programs that are currently in place for riparian land management in the province of Alberta. Note that this is not intended to be an exhaustive list; rather, it is intended to highlight legislation, policy, and programs that are considered to be the most relevant and commonly employed to achieve riparian land conservation in the province.

2.1. Riparian Legislation, Regulation, and Standards

2.1.1. Federal

The responsibility for managing natural resources primarily falls under provincial jurisdiction, and as a consequence, federal jurisdiction over riparian lands in Alberta is somewhat limited in scope. Exceptions to this include federal authority to manage riparian habitat on federal land (e.g., First Nation Reserves, National Parks), as well as the authority to manage riparian land as it relates to the regulation of fish and fish habitat, migratory birds, and species at risk. While the federal government currently has a number of laws and regulations that directly or indirectly relate to riparian land management (Table 2.1), it is important to note that many of the existing environmental laws and regulations are currently undergoing review and modification as per the adoption of Bill C-38. Thus, changes to federal environmental laws and regulations may have implications for how riparian lands are managed by the federal government in the near future, and in particular, how riparian habitat may be managed under the Fisheries Act.

Table 2.1. Federal legislation, regulation, or standards that directly or indirectly relate to the management of riparian lands in Alberta.

Legislation, Regulation, or Standard	Description
Fisheries Act	Includes provisions for the protection of fish and fish habitat, and requires an authorization for activities that cause harmful alteration, disruption and destruction of fish habitat. In many cases, riparian lands may contribute to, or constitute, fish habitat.
Migratory Birds Convention Act	Prohibits the harming or killing of migratory birds listed under the Act, which includes riparian obligate or dependent bird species.
Species At Risk Act	Protects listed wildlife species and their critical habitats on federal lands, but does not apply to lands held by the Province of Alberta or its private citizens unless “the laws of Alberta do not effectively protect the species or the residences of its individuals”. In this case, the Minister may issue an order in council to protect federally listed species that occur on provincial or private lands.
Navigable Waters Protection Act	Prohibits the placement of any work in, on, over, under, through, or across any navigable water unless the work, the site, and the plans have been approved and the work is built and maintained according to approved plans. This includes construction of structures on the shore of a water body (e.g., docks) that may impact riparian habitat.

2.1.2. Provincial

At the provincial level, there a number of statutory laws, regulations, and standards that directly or indirectly relate to the management of riparian habitat on both private and public land (Table 2.2). The responsibility for managing riparian land falls to a number of provincial ministries and departments, and the mechanisms through which riparian lands are managed varies with respect to whether these habitats are located on private land (White Zone) or public land (Green Zone). In addition, the nature of the disposition and the activities associated with the land use(s) (e.g., forestry, oil and gas, agriculture, or urban development) greatly influences how riparian lands are managed on both private and public land.

In instances of overlapping land use or activities (e.g., forest harvest operating together with oil and gas exploration), the manner in which riparian lands are managed is directed by the laws, regulations, and standards that are specific to that particular land use or activity. In these situations, coordination between the various government ministries responsible for enacting those laws, regulations, or standards is an important aspect of successful riparian management outcomes. Regardless of where the riparian land is located, or what the land use and associated activities may be, the provincial government has jurisdiction over the management of all water in the province under the *Water Act*, as well as all lands that are defined as "public" (regulated under the *Public Lands Act*), which includes the bed and shore of all permanent water bodies, regardless of whether these water bodies are located on private land.

While the provincial government holds the authority to regulate water and public land throughout the province, municipalities are also given authority to manage riparian lands under the *Municipal Government Act (MGA).* The MGA gives municipalities the power to enact land use bylaws, as well as the authority to designate land as Environmental Reserve at the time of subdivision. Environmental Reserves are defined in Section 664 of the MGA as water bodies or watercourses, lands that are unstable or subject to flooding, and lands "not less than 6 metres in width abutting the bed and shore" of a water body or watercourse. While the MGA allows municipalities to take a 6 metre (or more) setback on Environmental Reserve lands, the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution or provide public access to the bed and shore of the water body or watercourse. In addition to the limited opportunities that are available for conserving riparian land as Environmental Reserve, Section 640(4)(l) of the MGA allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any water body.

Table 2.2. Provincial legislation, regulation, or standards that directly or indirectly relate to the management of riparian lands in Alberta.

Legislation, Regulation, or Standard	Description
Water Act • Water (Ministerial) Regulation • Codes of Practice	The stated purpose of this Act is to support and promote water conservation and management. Under the Act, any activity that causes or has the potential to cause an effect on the aquatic environment requires an approval. • Regulations and Codes of Practice under this Act apply to water and water use management, the aquatic environment, fish habitat protection practices, in-stream construction practices, and storm water management.
Alberta Land Stewardship Act	Creates authority of regional plans and enables the development of conservation and stewardship tools that can be used to manage riparian lands (e.g., conservation easement).
Public Lands Act • Public Lands Administration Regulation	Regulates and enforces activities that affect the Crown-owned bed and shore of water bodies, as well as Crown-owned riparian and upland habitats (e.g., forest and grazing leases).
Surveys Act	Definitions for the “legal bank” of a water body, upon which the Crown-owned “bed and shore” is defined. The legal boundary between the bed and shore and the adjacent lands is the naturally occurring high water mark, and may not extend to include the full extent of riparian lands adjacent to a water body.
Environmental Protection & Enhancement Act • Pesticide Ministerial Regulation	Management of contaminated sites, storage tanks, landfill management practices, hazardous waste management practices and enforcement.
Municipal Government Act • Subdivision & Development Regulation • Land Use Bylaw • Intermunicipal Development Plan • Municipal Development Plan • Area Structure Plan • Area Redevelopment Plan	Provides municipalities with the authority to regulate water on municipal lands, manage private land to control non-point source pollution, and regulates land use practices such that they are compatible with the protection of aquatic environment.
Agricultural Operation Practices Act	Regulates and enforces confined livestock feeding operations planning for siting, manure handling/storage, and environment standards.
Soil Conservation Act & Regulations	Regulates activities that may cause erosion and sedimentation of a water body.
Safety Codes Act	Regulates and enforces septic system management practices, including installation of septic field and other subsurface disposal systems.
Wildlife Act	Regulates and enforces protection of wildlife species and their habitats, which may include riparian dependent species.

Table 2.2 continued. Provincial legislation, regulation, or standards that directly or indirectly relate to the management of riparian lands in Alberta.

Legislation, Regulation, or Standard	Description
Forests Act • Timber Management Regulation • Alberta Timber Harvest Planning & Operating Ground Rules	Provides the legal framework for the management of forests on public land, including rules for tenure, policies and regulations for acceptable logging methods, standards for wood utilization, and the management of non-timber values • The Timber Management Regulation and Timber Harvest Planning & Operating Ground Rules set forth standards and guidelines for timber harvest planning and specifically stipulate setbacks for timber harvest adjacent to any water body. See Table 2.3 for more detailed information about timber harvest riparian setback operating ground rules.
Provincial Parks Act & Wilderness Areas, Ecological Reserve and Natural Areas Act	Both Acts can be used to minimize the harmful effects of land use activities on water quality and aquatic resources in and adjacent to parks and other protected areas.
Oil & Gas Conservation Act • Oil & Gas Conservation Regulation	Section 8.060 and 8.070 stipulate that when a well or facility is located closer than 100 m to the normal high water mark of a water body or permanent stream, the application must be reviewed to assess the risks and minimize direct disturbance to the water body.
Memorandum of Understanding Between the Energy Resources Conservation Board, Alberta Environment, Alberta Sustainable Resource Development, and the Special Areas Board on the Identification and Delineation of Water Bodies (DRAFT)	This *draft* document provides direction on how to delineate and identify the ecological boundaries of water bodies that may be impacted by oil and gas activity. Setback for oil and gas developments are based on the ecological boundary of the water body, and depending upon the setback distance, riparian areas may be included in the development setback.
ERCB Directive 056: Appendix 14 – Oil & Gas Development In or Within 100m of Water Bodies (DRAFT)	While there is a stated preference for avoiding development within 100m of a water body, this *draft* directive sets out the information and procedural requirements for locating a facility within 100m of a water body where “no other viable option exists”. In these cases, riparian areas may be impacted if the development setback is not inclusive of the riparian area.
Approval Standards: Enhanced Approval Process	This document outlines standards for upstream oil and gas activity, Mineral Surface Leases, Licenses of Occupation, Pipeline Installation Leases, and Pipeline Agreement as it relates to setbacks on watercourses and water bodies. Required setback distances range from 45 to 100m, which may include associated riparian lands (or a portion thereof).

Table 2.3. Timber harvest setback requirements for water bodies and watercourses as specified under the Alberta Timber Harvest Planning and Operating Ground Rules (1994).

Watercourse Classification	Watercourse Protective Buffer
Large Permanent	• No disturbance or removal of merchantable timber within 60m of the high-water mark except where specifically approved in the Annual Operating Plan.
Small Permanent	• No disturbance or removal of merchantable timber within 30 m of the high-water mark except where specifically approved in the Annual Operating Plan.
Intermittent	• Buffer of brush and lesser vegetation to be left undisturbed along the channel. • Width of buffer will vary according to soils, topography, water-source areas and fisheries values. • Treed buffer is not required unless specifically requested by a Forest Officer.
Ephemeral	• Buffer of lesser vegetation in wet gullies to be left undisturbed.
Lakes (little or no recreation, waterfowl or sport fishing potential)	• On lakes exceeding 16ha in area, there will be no disturbance of timber within 100m of the high-water mark except where specifically approved in the Annual Operating Plan.
Lakes (with recreational, waterfowl or sport fishing potential)	• On lakes exceeding 4 ha in area, there will be no disturbance or removal of timber within 100 m of the high-water mark except where specifically approved in the Annual Operating Plan.
Water-source Areas and Areas Subject to Normal Seasonal Flooding.	• Treed buffers of at least 20 m on all streams. • No harvest of merchantable trees or disturbance of lesser vegetation unless approved in the Annual Operating Plan. • Buffer width may be altered according to its potential to produce surface water, provided it is approved in the Annual Operating Plan.

2.1.3. Municipal

The Municipal Government Act requires each municipality to develop statutory planning documents that provide a framework and vision for development and land use within their jurisdictions. Within many of these statutory documents, municipalities provide specific direction for development requirements in or near riparian lands, or set forth minimum development setback widths on Environmental Reserve (ER), environmentally sensitive land, or water bodies and watercourses. Statutory planning documents required under the MGA include:

- Municipal Development Plans
- Intermunicipal Development Plans
- Area Structure Plans
- Area Redevelopment Plans

Within these planning documents, municipalities can provide specific direction for development requirements that may impact riparian lands. In addition to statutory planning documents, municipalities can influence the management of riparian lands by enacting Land Use Bylaws that set forth requirements for development setbacks on environmentally sensitive lands. Table 2.4 provides some examples for how a selected number of municipalities in Alberta have provided guidance for riparian land management within their various statutory planning documents.

Table 2.4. Examples of riparian land management that is required by various municipalities as outlined in statutory planning documents.

Municipality	Description
City of Brooks	• **Municipal Development Plan**: Use Municipal Reserve and Environmental Reserve dedication to protect sensitive water bodies with setbacks on permanent water bodies ranging from 6 to 40m.
City of Calgary	• **Municipal Development Plan**: Development setback zones of 18m from the top of an escarpment in any new development or redevelopment area.
City of Edmonton	• **North Saskatchewan River Valley Area Redevelopment Plan**: a comprehensive management plan that envisions a significant portion of the river valley and ravines be assembled, protected, and maintained by the City as a major urban and natural park.
City of Grande Prairie	• **Municipal Development Plan:** 30m Environmental Reserve setback on any future subdivision and development of lands adjacent to Crystal Lake. A minimum of 15m setback is required on all other crown owned lakes and wetlands, unless a reserve greater than 15m is prescribed based on a biophysical assessment.
City of Spruce Grove	• **Municipal Development Plan**: Restricts development in wetlands, riparian zones and flood-prone areas.
City of St. Albert	• **Municipal Development Plan & Intermunicipal Development Plan**: 50m setback on Carrot Creek and 50% Municipal Reserve Credits for protection of lands between 1:25 and 1:100 yr. flood line.
Lac La Biche County	• **Land Use Bylaw**: Development is not allowed within a development setback as calculated by the Riparian Setback Matrix Model, and this land is dedicated to the county as Environmental Reserve.
Lacombe County	• **Municipal Development Plan**: 30m Environmental Reserve or Environmental Reserve Easement from the top of the high water mark for all water bodies or from the top of bank of watercourses to the lot line, as a condition of subdivision approval.
Leduc County	• **Pigeon Lake & Wizard Lake Area Structure Plan**: Development setbacks calculated using the Riparian Matrix Setback Model to protect water quality.
MD of Bighorn	• **Municipal Development Plan**: 30m setbacks on water bodies and watercourses; however, an application for relaxation of setbacks can be made.
MD of Foothills	• **Municipal Development Plan:** Sets out goals for protecting natural capital, with an emphasis on surface water features. Objectives include minimizing development impacts on seasonal water bodies and surface and sub-surface water resources through land use designation as Environmental Reserve Easement of Conservation Easement. Development within the 1:100 flood fringe is also discouraged.
Strathcona County	• **Municipal Development Plan**: 50m setback from top of bank on the North Saskatchewan River; 36m setback from top of bank on Old Man Creek and its tributaries; 30m setback from top of bank for all other water bodies and watercourses.
Town of Cochrane	• **Land Use Bylaws:** Section 11.12.4 stipulates no new development in riparian lands and no net loss of riparian lands for developments that are exceptions.

2.2. Riparian Policy, Guidelines, and Strategies

In addition to the statutory obligations for the management of riparian lands in Alberta, there are a number of federal, provincial, and municipal government policies, guidelines, and strategies that provide direction for managing riparian habitat on both private and public land. While policies, guidelines, and strategies are typically considered non-obligatory, the goals stated in many of the policies outlined in this section are enforced through one or more of the statutory laws, regulations, or standards outlined in Section 2.1 above.

2.2.1. Federal

The most relevant federal policy related to riparian land management in the province of Alberta is the "*Policy for the Management of Fish Habitat"*. While this policy is not technically statutory in nature, the goals of the policy are enforced through the Federal Fisheries Act, which applies to the management of fish and fish habitat in both the Green and White Zones of the province. Other federal policies, such as the wetland conservation policy, apply only to the management of wetlands on federal lands (Table 2.5)

Table 2.5. Examples of Federal policy, guidelines, and strategies directing riparian land management in Alberta.

Policy	Description
Policy for the Management of Fish Habitat	This policy sets forth the goal of increasing the "natural productive capacity of habitats for the nation's fisheries resources" through the achievement of an overall net gain of productive fish habitat capacity. The goal of this policy is directly enforced through the Federal *Fisheries Act*.
Federal Policy on Wetland Conservation	Adopted in 1991, the goal of this policy is to sustain the ecological and socio-economic functions of wetlands through no net loss of wetland functions on all federal lands and waters.
Federal Policy on Wetland Conservation: Implementation Guide for Federal Land Managers	Guidelines to provide federal land managers with direction on how to interpret the Federal Wetland Policy to ensure that decision-making is consistent with the environmental commitments made in the policy.
Field Manual on Buffer Design for the Canadian Prairies	This field manual is intended for use by agricultural practitioners to help locate and design riparian vegetated buffers adjacent to cropland in Prairie landscapes to improve and protect water quality by reducing the runoff of nutrients and other substances from fields into water bodies.

2.2.2. Provincial

While there are several provincial policies, guidelines, or strategies that relate directly to riparian land management, most of the applicable policies and guidelines relate to the management of water or wetlands (Table 2.6). Most notable of these is the "*Water For Life Strategy*", which sets out high-level direction for the management and maintenance of healthy aquatic ecosystems and safe drinking water. In addition, the "*Grazing Lease Stewardship Code of Practice"* identifies the roles and responsibilities that public land grazing leaseholders have and consolidates Sustainable Resource Development (SRD) requirements, including responsibilities and associated costs for land and riparian management on publically owned grazing leases. Further, the new best management practices that have recently been released by the government ("*Stepping Back from the Water*") sets out expectations for how riparian lands should be managed in the White Zone in relation to new developments near water bodies.

Table 2.6. Examples of Provincial policy, guidelines, and strategies directing riparian land management Alberta.

Policy, Guideline, or Strategy	Description
Stepping Back from the Water: A Beneficial Management Practices Guide for New Developments Near Water Bodies	Released in March 2012, this document provides discretionary guidance to local authorities and watershed management groups to assist with "decision making and watershed management relative to structural development near water bodies" primarily within the White zone.
Interim Wetland Policy for the Settled Region of the Province	Policy goal is to conserve wetlands in a natural state, mitigate the degradation or loss as close to the site as possible, and enhance, restore, or create wetlands in areas where they have been depleted or degraded. While this policy does not explicitly manage riparian land, there is opportunity within the stated goals and intent of this policy to extend the policy to include riparian lands.
Wetland Restoration/Compensation Guide	Provides direction for the type and location of compensatory wetlands, as well as guidelines for calculating replacement ratios. While not explicitly stated, these guidelines could be extended to include provisions for the restoration or compensation of riparian lands associated with wetland impacts.
Water For Life Strategy	Two of the three stated goals for this strategy include: 1) the maintenance of safe drinking water and 2) the maintenance of healthy aquatic ecosystems. The appropriate management of riparian lands is central to achieving desired outcomes as stated under this government water strategy.
Guidelines for Recommended Minimum Reserve Widths Adjacent to Water Features	Suggested minimum reserve widths to minimize impact to water bodies and maintain public access to land resources located on public lands.
Municipal Land Use Policies	Section 5 encourages municipalities to identify significant water bodies and watercourses in their jurisdiction, and to minimize habitat loss and other negative impacts of development through appropriate land use planning and practices. In addition, Section 6 encourages municipalities to incorporate measures into planning and land use practice that minimizes negative impacts on water resources, including surface and groundwater quality & quantity, water flow, soil erosion, sensitive fisheries habitat, and other aquatic resources.
Grazing Lease Stewardship Code of Practice	These guidelines set out requirements for rangeland management practices and monitoring of rangeland and riparian health on Crown-owned grazing leases. Renewal of a grazing lease is subject to Riparian Health Assessments to ensure responsible grazing and stable riparian health and function.

2.2.3. Municipal

Under the direction set out by the *Municipal Government Act* and the municipal Land Use Policies, many municipalities throughout the province have taken the initiative to enact policies that provide guidance on how riparian lands should be managed within their jurisdictional boundaries (Table 2.7). In many cases, these policies provide specific guidance on acceptable development setback widths and conditions for the application of those setbacks. While many municipalities rely on minimum setback width standards, there are others who have taken the initiative to develop field-based models to determine variable width setbacks based on physical land characteristics. A short description of some of the most popular approaches for determining riparian setback width is presented below.

a. Minimum Development Setbacks

In lieu of determining site-specific riparian setback widths, many municipalities specify a static development setback for lands adjacent to a water body or steep slope. These minimum setbacks may be specific to water body type or class, or they may be specific to a particular water body or circumstance. These setbacks typically extend from the “high water mark” or the “top of bank”, and in many cases, may not be sufficiently large enough to include the full extent of riparian lands.

b. Riparian Setback Matrix Model

The Riparian Matrix Setback Model (RSMM) is a site-specific ground-based assessment tool that is used to determine variable riparian setbacks widths with the intent of minimizing water pollution (Aquality 2010). The RSMM has been adopted and applied in numerous municipalities throughout Alberta, including the counties of Lac La Biche, Leduc, Sturgeon, Rocky View, and the Municipal District of Foothills. This model requires one or more survey points to calculate riparian setback widths based upon the following physical site characteristics (Aquality 2010):

i. Slope
ii. Bank height
iii. Level of the groundwater table
iv. Soil type and texture
v. Vegetation and/or ground cover

The scores for each of the physical characteristics are combined to determine the riparian setback width within a required minimum and maximum setback distance. Both the minimum and maximum riparian setback widths specified in the model are determined through consultation with each municipal government, and are thus somewhat arbitrary and vary by municipality (Jay White, Personal Communication). For example, in the Municipal District of Foothills, the required riparian setback width ranges between 15m and 75m, while in the County of Lac La Biche the minimum and maximum setback distance ranges from 6m to 30m.

Given that this model includes site-specific physical characteristics, the calculated widths should more accurately reflect the actual extent of riparian lands adjacent to each water body; however, the model is still constrained by subjectivity in determining the minimum and maximum setback distances. Further, the application of the RSMM is discretionary in some municipalities, and may be required to determine setbacks for large watercourses, but may not be required for calculating setbacks on smaller, seasonal watercourses or wetlands. In other cases, the setback calculated by the model has been deemed insufficient, and has been overruled by the municipality upon subdivision application (Heather Hemingway, Personal Communication).

Table 2.7. Examples of municipal policy, guidelines, and strategies directing riparian land management Alberta.

Municipality	Description
City of Calgary	• **Environmental Reserve Policy**: Outlines setback distances based on stream order ranging from 6m (1st order) to 50m (4th order), with Class III to VI wetlands requiring a 30m setback. Setbacks can be further modified based upon site-specific characteristics including slope, cover type, and hydraulic connectivity. • **Wetland Conservation Plan & Policy**: Key policy goal includes no net loss of wetlands through the application of the mitigation hierarchy (avoid, minimize, compensate). This policy prioritizes the conservation of wetlands that have been identified as environmentally significant and/or that contribute to water quality and quantity, while at the same time can be integrated into urban development in such a way as to maintain "ecosystem survivability and sustainability".
City of Edmonton	• **Guidelines for Determining Environmental Reserve Dedication for Wetlands and Other Water Bodies**: development setbacks on wetlands and other water bodies determined as the greatest extent of lands required to achieve flood protection, bank stability, public access, or pollution control (specified as 30m). • **Top of Bank Policy**: Guides development within and adjacent to the river valley and ravine system and promotes the retention of riparian areas by way of municipal takings such as Environmental Reserve, top-of-bank restrictive covenants, top-of-bank roadways, top-of-bank walkways and public and emergency access through servicing agreements and conditions of subdivision approval.
MD of Foothills	• **Developer's Guide to the Riparian Setback Matrix Model for the MD of Foothills**: As per the direction set out in the MD of Foothills Municipal Development Plan, riparian setbacks must be calculated on lands designated for subdivision using the Riparian Matrix Setback Model developed for the MD.
Rocky View County	• **Riparian Land Conservation and Management Policy**: Stipulates the use of "science-based standards" to develop setback requirements for riparian lands, and states that the County may require the dedication of riparian lands as Environmental Reserve or Environmental Reserve Easement at the time of subdivision. • **Wetland Conservation and Management Policy**: Similar in intent as the Riparian Land Conservation and Management Policy, the wetland policy relies on "science-based standards" to develop setback requirements for wetlands, and states that the County may require the dedication of wetlands as Environmental Reserve or Environmental Reserve Easement at the time of subdivision.
Strathcona County	• **Wetland Conservation Policy**: 50m setback from top of bank on the North Saskatchewan River; 36m setback from top of bank on Old Man Creek and its tributaries; 30m setback from top of bank for all other water bodies and watercourses
Town of Cochrane	• **Wetlands and Riparian Areas Conservation and Management Plan**: Policy related to the inventory and protection of wetlands and their associated riparian lands within the town boundaries.
Town of Strathmore	• **Wetland Conservation Policy and Plan**: In 2005, the Town of Strathmore inventoried, mapped, and classified all wetlands located within the town boundaries, and "environmentally significant" wetlands were identified as part of their Wetland Conservation Plan. A wetland policy followed in 2007 that stipulated that the Town would conserve and/or restore wetlands, wetland area and riparian lands wherever feasible by employing a 30 m development setback on Class IV and V wetlands, and a 6m setback on Class II and III wetlands.

2.3. Voluntary Riparian Management and Conservation Programs

There are many government and non-government organizations that are directly or indirectly involved in promoting riparian stewardship and conservation through the development and delivery of voluntary programs (Table 2.8). Many of these programs are partially or wholly funded by government, but are administered by not-for-profit organizations whose mandate may include the protection or conservation of riparian lands. Examples of programs that are funded through partnerships between the federal and provincial governments include the Growing Forward Stewardship Plan, which is jointly managed by Alberta Agriculture and Rural Development and Agriculture and Agri-Food Canada, as well as the Watershed Stewardship Grant program that receives funding through Alberta Environment and Water. Given that many of these programs receive funding from government, the long-term persistence of many of them is entirely dependent upon continued funding from the federal or provincial governments, which is often allocated on a yearly basis. As a result, many of these programs are subject to funding limitations, and may be suspended or discontinued over time, being replaced by new initiatives as funding becomes available.

In addition to the variety of stewardship and conservation programs currently in place in the province, riparian lands are also actively managed by both Watershed Planning and Advisory Councils (WPACs) and Watershed Stewardship Groups (WSGs). WPACs are independent, not-for-profit, multi-stakeholder organizations that have been designated by the Government of Alberta to lead watershed planning at a regional-scale. WPACs are required to undertake a State of the Watershed report, as well as develop an Integrated Watershed Management Plan that sets the vision and best practices for water resource management in their watershed. In contrast, WSGs are community-based volunteer organizations that operate at a local-scale to manage watershed resources and develop on-the-ground solutions to issues of concern in the community. Both WPACs and WSGs are engaged in education and stewardship activities, and work collaboratively with stakeholders to manage the watershed according to common goals, which often includes issues associated with riparian land management. While WPACs and WSGs are effective watershed advocates and stewards, it is important to note that the watershed management plans developed by these organizations are not statutory, and thus, conformity to these plans is strictly voluntary.

Table 2.8. Examples of voluntary stewardship and conservation programs that currently exist for riparian land management in Alberta.

Program	Description
Watershed Planning and Advisory Councils (WPACs)	There are 11 WPACs in the province of Alberta, and each of these organizations is at a different stage in their State of the Watershed Reporting and Integrated Watershed Management Planning. Riparian land management is an important consideration for many WPACs, with many recognizing the importance of maintaining or enhancing riparian land area and/or condition.
Watershed Stewardship Groups (WSGs)	There are over 140 WSGs in Alberta, many of which have specific recommendations set out for the management of riparian lands. For example, the Nose Creek Watershed Partnership has developed a Watershed Management Plan that recommends riparian setbacks for permanent and intermittent streams based on the greatest of three criteria: 1:100 year floodplain; meander belt (20x bankful width), and width of escarpment (>15% slope) that lie adjacent to the meander belt. For slopes >15%, additional setbacks are required based on bank height.

3. Current State of Riparian Lands in Alberta: Extent

3.1. Approaches for Delineating Riparian Land Extent

Taking conceptual definitions of riparian lands and turning them into maps with crisp boundaries is a challenge given the transitional nature of these lands at either the aquatic or upland interfaces. The challenge is compounded when tools are sought to be able to delineate boundaries across diverse regions with different physical characteristics. In the following chapter we discuss the different site-specific and landscape-scale approaches that have been used to delineate the extent of riparian lands in the province of Alberta.

3.1.1. Site Specific Mapping

The most common approach of delineating riparian lands in Alberta is an expert based approach using aerial photos, topographic maps and field-based checking. The mapping is performed as part of a riparian health assessment (both detailed inventories and more rapid surveys) developed by Alberta Riparian Habitat Management Society (hereafter referred to as *ARHMS-Riparian Health Assessments)* or by other assessment tools. The goal is not the measurement of precise areas, but rather a reasonable approximation of the extent of riparian lands based on which indicators of health will be assessed. In the case of *ARHMS-Riparian Health Assessments* the boundaries are determined by considering a combination of vegetative features (e.g., dominance of facultative and obligate hydrophytic plants), hydrologic and channel features (e.g. staining or flood debris lines, flood prone areas), and historical information (e.g., area frequently inundated in regular high water events) (Figure 3.1).

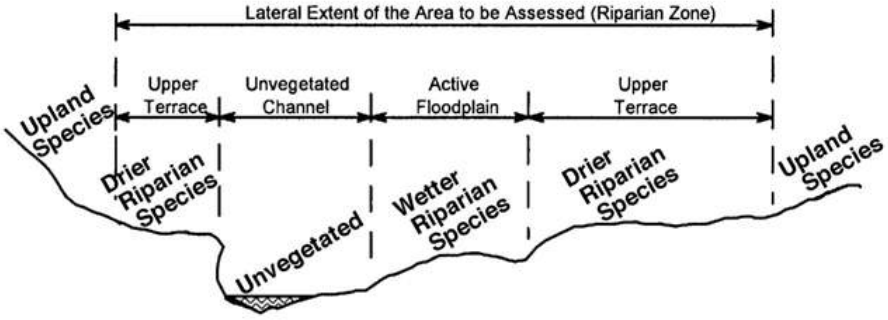

Figure 3.1. Cross-section of riparian zone schematic as defined by Alberta Riparian Habitat Management Society (from Fitch and Ambrose, 2003).

In water bodies with emergent vegetation (mostly lentic systems) the edge of the riparian lands is drawn where persistent emergent vegetation gives way to open water. Persistent emergent vegetation consists of species that normally remain standing at least until the beginning of the next growing season (e.g., *Typha* species [cattails] or *Scirpus* species [bulrushes]). For the determination of outer (upland) boundaries, there are additional considerations, such as how to define the riparian edge of meandering lotic systems. Determining the boundary longitudinally is a function of land use and logistical, rather than hydrological, ecological, or geomorphic considerations. For example, most sites are approximately 1km in length and aim to capture one particular land use under the same management. As a result, the actual area estimate of the riparian lands delineated this way is not useful for assessing the areal coverage of riparian lands in watersheds. However, average width (which is recorded), in combination with the length of the hydrological system could be used to provide estimates of riparian extent for that

water body, provided there are assessments conducted at regular intervals from the headwaters to the mouth.

The Alberta Conservation Association (ACA) developed an airborne riparian assessment tool based on low-level videography (Mills and Scrimgeour, 2004). They adopted a different definition of riparian land extent than the one used by *ARHMS-Riparian Health Assessments,* as illustrated in Figure 3.2. The 'riparian zone' excludes the emergent vegetation zone. Instead of a purely ecologically based interpretation of riparian lands, they use the concept of Riparian Management Area, which comprises not only the riparian zone, but the emergent vegetation zone, as well as a buffer zone on the upland side of the riparian zone (Figure 3.2); however, the quantification of the extent of riparian lands only includes the longitudinal component (i.e., estimation of shoreline length).

Figure 3.2. Pictorial representation of riparian land extent as defined by the low-level videography assessment tool developed by the Alberta Conservation Association in partnership with AB-SRD (from Mills and Scrimgeour 2004).

3.1.2. Watershed Specific Mapping

There are currently no watershed-specific approaches to mapping riparian land extent; however, there are some mapping initiatives that do capture different aspects of riparian lands including vegetation, soils, and hydrology. While all these tools have the potential to help identify riparian lands in the province, it is important to note that these tools are not currently being used for the specific purpose of delineating riparian lands in a systemic fashion across the province.

a. Riparian Plant Community and Associated Soil Classification Guides

One of the tools used by the ARHMS to identify riparian lands is a set of comprehensive vegetation guides developed by Thompson and Hansen (2002 and 2003). The riparian plant communities described in the guides are based on approximately 400 site-specific locations spread across the Grassland, Parkland, and portions of the Boreal natural regions. These vegetation guides are complemented by another guide focusing on the soils within the context of these plant communities (McNeil 2008). There are also other descriptions of upland plant communities, developed by Public Lands and ARHMS, which can be used to help delineate riparian land extent. Some of these descriptions also include soils-related information.

b. Grassland Vegetation Inventory (GVI)

This mapping product, developed by Alberta Sustainable Resource Development, offers a comprehensive and detailed geospatial representation of land cover and land use focusing on the southernmost portion of the White Zone. The inventory is derived from the analysis of digital colour-infrared stereo photography. At its core, GVI is comprised of ecological range sites based on vegetation and soils information for areas of native vegetation and general land use for areas of non-native vegetation, namely those associated with agricultural, industrial, and residential developments. This inventory system includes different riparian classes for lentic and lotic systems, generally distinguishing dominant plant types for lotic and water permanency for lentic systems. In addition to the 10 riparian classes, there are upland and anthropogenic land use/land cover classes used in the inventory. GVI data collection began in 2006 and is currently more than half way completed (Figure 3.3). Once complete, the GVI is intended to replace the existing Native Prairie Vegetation Inventory; it will eventually be extended to include the Aspen Parkland natural region as well.

Figure 3.3. Spatial extent of current and planned Grassland Vegetation Inventory data collection.

c. Wet Areas Mapping

"*Wet Areas Mapping*" was originally developed for the forest industry to identify potential wet-areas on the landscape, including unmapped streams and wetlands, and wet areas surrounding existing water bodies. The technique uses high-resolution digital elevation models, combined with existing spatial information of permanent streams, lakes, and wetlands, to predict the depth-to-water table using a series of terrain analysis and GIS steps (Murphy et al. 2007). Wet areas maps depict all areas with a depth-to-water table of less than one meter (all other areas are classified as upland), including those areas where surface water may not be present, but where soils are moist. A large area of the Green Zone of the province has been mapped using this technique with an end goal of mapping approximately 15 million hectares of forested lands in the foothill and boreal regions of Alberta. This tool offers promise to map riparian lands from a hydrological perspective throughout the province, although it has not yet been tested for this specific purpose. Given that this technique relies on topography to model water flow, special attention must be paid in areas where geology, surficial geology, and soils have a more dominant control on water flow (Devito et al. 2005).

d. *Boreal Wetland Mapping*

Wetland mapping efforts developed by Ducks Unlimited have resulted in a mapping product generally referred to as an Enhanced Wetland Classification. This map is derived at a 30m resolution using Landsat TM imagery and encompasses nearly the entire boreal and boreal transition area of Alberta. The classification scheme that is used includes up to 19 detailed wetland classes conforming to the Canadian Wetland Classification System. In addition to wetland classes, the map includes derived soil and hydrologic features that are based on generally accepted properties of each class. As a result, the landscape can be analyzed in a variety of ways to serve user-specific needs (e.g. treed vs. non-treed wetlands). The wetland inventory has been used for a variety of applications, including: industry operational planning

needs (e.g. road placement planning to avoid or minimize impacts on wetlands); input to government led land-use planning and policy development; scientific research (e.g. helping understanding boreal hydrology or the role of wetland habitat relationships to species of concern such as caribou, understanding the role of wetlands to water budgets in any given catchment, carbon sequestration, storage and climate change, etc.), and; supporting DU's goal to identify key waterfowl habitats for focusing directed conservation efforts. So far this mapping has not been used to delineate the extent of riparian lands surrounding wetlands and shallow lakes, but given the detailed vegetation classes present in this classification system, there is an opportunity to test this dataset for this specific purpose.

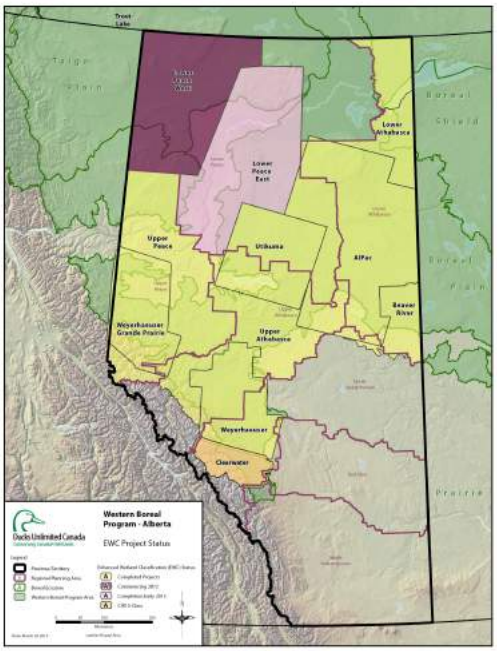

Figure 3.4. Spatial extent of boreal wetland mapping completed by DUC.

e. ABMI Wetland Sampling

Alberta Biodiversity Monitoring Institute (ABMI) conducts systematic sampling of 1656 wetlands across the province. The sampling is based on the 20km National Forest Inventory (NFI) grid, and the nearest suitable wetland to the NFI point is selected for sampling (ABMI 2010). ABMI targets permanent Class 4 to 5 wetlands, with a minimum of 1.0ha of open water, and the goal of the Institute is to sample all 1656 wetlands on a 5-year rotation. ABMI does not specifically sample riparian areas, but they delineate the wetland into four distinct zones: Open Water, Emergent, Fen, and Wetland Margin. The Wetland Margin zone corresponds more or less to the definition of riparian areas. Between 2007 and 2010 ABMI sampled 307 wetlands, 75% of which contained the Wetland Margin. The wetlands sampled to date are located throughout the province with concentrations of sampling occurring the north-east, and southern areas. Zones are mapped by field crews at each site based on the presence/absence of water above the ground, water levels, and by the presence of indicator plant species. The focus again is not on riparian zones per se, but this wetland sampling strategy would be something to emulate in terms of mapping the extent and health of a number of sites on a regular basis to determine temporal trends.

f. Fixed-Width Buffers

Fixed-width buffers around water bodies have been used in many jurisdictions around North America, including Alberta to protect aquatic resources. The focus is on protecting aquatic ecosystems and not necessarily in protecting riparian ecosystem functions. As discussed in Chapter 2, the amount of buffer or setback varies greatly between different municipalities and the provincial government. The general concept behind these buffer widths is that they should be wider for increasing size and importance of water body; thus, in the case of forested lands with timber extraction, large rivers and lakes receive 60m and 100m buffers, respectively, while smaller rivers receive 30m buffers. Unfortunately, most of the buffer-widths chosen are not based on hydro-ecological realities and thus they can result in large inaccuracies in determining actual extent of lands performing riparian functions. The Riparian Setback Matrix Model (RSMM) is an exception, as it models Environmental Reserve setbacks based on slope, height of bank, groundwater table level, soil type and texture, and vegetation/ground cover (Aquality

2010) (see Section 2.2.3 for further discussion); however, in its current form, the RSMM is largely based on field data and is unsuitable for use in regional applications using GIS models.

3.1.3. Other Approaches Currently in Development

a. Variable-width Model for Urban Riparian Land Delineation

The City of Calgary is currently engaged in a project to predict and map the extent of riparian lands in the city using a variable-width model based on terrain and hydrography information. The model inputs include stream channel and shoreline location and elevation, and is calibrated using floodplain data and riparian field studies. Specifically, the model uses a cost distance approach (Hemstrom et al. 2002) where model inputs include spatial information on stream location and order, water body location, and elevation data (ideally derived by LiDAR technology for best resolution). The model is being calibrated with ancillary data (e.g., other floodplain/riparian model outputs and data from previously conducted *ARHMS-Riparian Health Assessments*) in order to select the most appropriate cost distance threshold. This model is currently being tested on the Bow and Elbow Rivers in the South Saskatchewan River basin.

b. Remote Sensing Tools to Map Non-cultivated Areas in Agricultural Landscapes

The North Saskatchewan Watershed Alliance has tasked the Alberta Terrestrial Imaging Center (ATIC) to develop remote sensing tools to determine riparian lands extent and condition. This project is ongoing, using the Vermillion sub-watershed as a study area. ATIC is currently developing methods to remotely sense the following parameters of extent and condition: impervious surface, road density, land cover/land use, canopy continuity, extent of bare ground, sinuosity, riparian vegetation width, canopy cover, composition, leaf area index, number and height of trees, vegetation overhang, and number of channels.

c. Integrated Riparian Lands Mapping Tool

West Fraser Mills Ltd. industries is in the process of developing an integrated mapping tool for the purpose of delineating riparian lands in forested landscapes. The mapping combines hydrological, pedological, and ecological information from different sources including wet-area maps, high-resolution digital aerial photographs, ecological land classifications, Alberta Vegetation Inventory, and the wetland classification and inventory compiled by Ducks Unlimited Canada. Using spatial overlays, the riparian land boundaries are digitized on-screen by a GIS analyst using heuristics on what constitutes the riparian edge. Once the outer boundaries are defined all landforms and vegetation classes within the riparian lands are classified as well including hill slope, terrace, wetland, floodplain, channel, and open water. While the mapping tool is not yet automated, the end goal is to fully automate the process and make it applicable to mapping riparian lands across the province. After completing field verification, a report and accompanying methodology guide to the mapping process will be released in 2012.

3.2. Riparian Land Extent in Alberta

There are currently no systematic measurements for the extent of riparian lands in Alberta, although there are some rough estimates available from the literature; for example, it is estimated that riparian lands cover approximately 4% of the provincial land-base (NSWA 2005) and riparian lands in the Milk River watershed are estimated to make up less than 2% of the land base (Milk River State of the Watershed 2008). Based on first principles, it is reasonable to expect that riparian areas make up no more than 10 to 20% of a watershed, with the actual percentage highly dependent on the physical characteristics of the region. An important step in delineating riparian lands across the province is to first map the location of all of existing water

bodies. Given the paucity of data on the extent of riparian lands in the province to-date, one of the objectives of this project was to quantify the longitudinal extent of water bodies in the province by major watershed.

3.2.1. Methodology

In order to calculate the longitudinal extent of water bodies in the province, we first derived the Strahler stream order for each stream/river segment of the Alberta Base Simplified Linear Stream Network layer using an ArcGIS script. Next, we summarized stream length by Stralher Stream order for each of the seven major basins of the province. For lentic water bodies, we removed island polygons, which was especially important for the large wetland complexes in the Peace-Athabasca Delta (PAD). Only polygons larger than 0.5ha were selected for calculating shoreline lengths. Finally, we summarized lake and wetland perimeter lengths for each of the seven major basins of the province.

It is important to note the limitations of this analysis: the provincial hydrography layer (Alberta Base Features, Hydrography Polygons) contains all streams, rivers, lakes, and larger wetland complexes that are readily identifiable from aerial photos; however, smaller hydrologic features such as ephemeral streams, small lakes, and wetlands hidden by the canopy are not captured in this spatial data. Also, most wetlands are missing from the hydrography layer because they were not the focus of that original mapping effort, with the exception of the large wetland complexes of the PAD. Another shortcoming of the spatial data is that it represents a snapshot in time of the hydrologic conditions. As most of the provincial mapping was completed in the 1970s and early 1980s, the hydrography layer captures a wet period in hydrological history of the province. Nevertheless, this analysis gives a conservative estimate of the longitudinal extent of water bodies in the province of Alberta, which is a first step towards better understand the potential extent of riparian lands that may occur in the province.

3.2.2. Results

Based on the provincial hydrography layer, the lotic water body lengths have been computed for each of the seven major watersheds of the province, categorized by small streams (Strahler order 1-5), large rivers (Strahler order 6 and up), and lentic water body perimeters (Table 3.1). Here we need to note that not all watersheds are contained in their entirety within the province, which may skew some of the inferences made below (all the analyses were completed with data covering the Province of Alberta only); in particular, the Milk and Hay River systems have large areas outside of the Province of Alberta.

The longest shoreline length is found in the Peace/Slave River basin and the shortest within the Milk River basin. Interestingly total shoreline length is directly proportional to total basin area (r=0.99). In addition, we computed the shoreline density for each basin in order to normalize for the effect of area on the potential abundance of hydrological features and the riparian zones associated with them (Table 3.1). What the data show is that the greatest abundance of shorelines can be found in the Hay/Great Slave River basin (1.56 km/km^2) and the lowest abundance found in the Beaver River basin (1.03 km/km^2). This result is interesting because one would have expected to see the lowest density in the drier southern watersheds. Clearly this shows that surface water availability is governed by factors other than climate alone. One could quickly apply fixed-width buffers to these shoreline lengths to get rough estimates of total *potential* riparian lands; however, this would be a gross estimate of riparian extent given that riparian land extent varies greatly, even along the length of a single hydrological feature (e.g., river system), and across hydrological systems from different physiographic regions.

Table 3.1. Physical characteristics of the seven major river basins of Alberta as derived from provincial hydrography layer (Alberta Base Features, Hydrography Polygons and Simplified Linear Stream Network). Small stream and large river lengths are based on Strahler stream orders 1-5 and 6-10, respectively.

Watershed	Area (km^2)	Lake shoreline length (km)	Small stream length (km)	Large river length (km)	Total shoreline length (lentic & lotic) (km)	Shoreline density (Total length/ area) (km/km^2)
Athabasca River	144,406	29,855	125,484	5,364	160,703	1.11
Beaver River	17,775	7,075	10,963	355	18,392	1.03
Hay/Great Slave	65,245	33,090	65,789	3,091	101,970	1.56
Milk	11,885	3,097	13,922	433	17,452	1.47
North Saskatchewan	92,799	41,123	70,757	2,926	114,805	1.24
Peace/Slave River	214,070	95,644	178,925	9,798	284,368	1.33
South Saskatchewan	116,781	26,636	104,618	4,944	136,199	1.17
Provincial total	662,961	236,520	570,457	26,911	833,889	1.26

3.3. Data Gaps and Limitations

The biggest data gap in terms of the status of the extent of riparian lands in Alberta is that there is no standardized province-wide mapping effort to delineate the extent of riparian lands that is applicable to hydrologic features of all scales and types. The site-specific delineation employed for health assessments cannot be scaled up. The existing regional-scale mapping initiatives all have merit but to date, none of them are fully operational or have the potential to be applied across the province. For example, the GVI focuses only on the vegetative component of the landscape and has been developed for the grasslands region, while the Boreal Wetland Mapping by DUC focuses only on boreal wetlands. Wet areas mapping on the other hand does not consider vegetation, nor does it consider differences in soils or surficial geology, which can have large effects on the location of wet areas. The integrated mapping tool being developed by West Fraser Mills Ltd has great potential, but still needs verification as well as greater automation.

The province-wide mapping of riparian lands would be greatly aided by high spatial resolution and up-to-date geospatial data. AltaLIS and the federal government have hydrography data available; however, these data do not capture water bodies obscured by canopy cover or ephemeral water bodies, such as Class I and II wetlands. In addition, these basic map layers need to be extended to include the headwaters and ephemeral water bodies. Given the dynamic nature of hydrological systems, this will be a challenge; however, new mapping techniques and data sources will greatly aid the derivation of these mapping products. Once developed, these maps would need to be updated regularly to keep pace with the changes in climate and human uses of the landscape. A province-wide hydrography dataset along with digital terrain information will at least allow the estimation of the approximate numbers of water bodies based on hydro-geomorphic setback models, and will give rough estimates of riparian extent, which can then be improved with dedicated riparian land mapping exercises based not only on hydrology, but on vegetation, land use, soils, and geomorphology.

4. Current State of Riparian Lands in Alberta: Health

4.1. What is Riparian Health?

Like the concept of human health, riparian health considers the condition and related functions of riparian ecosystems. While some may still question the use of the term 'health' outright as applied to a complex and ever evolving system like an ecosystem, there is now widespread support for its use and it is undeniably a good concept for ecological literacy.

If one accepts the use of the concept of health in the context of ecosystems, a simple definition of health can be: "*the ability of an ecosystem to perform a number of key ecological functions*". For riparian ecosystems, these functions may include dissipation of stream and wave energy associated with high water levels, filtering of sediment and biotransformation of nutrients, recharging groundwater aquifers, stabilizing stream banks, and provision of habitat. Function is joined at the hip to the concept of ecosystem state, where function is usually inferred from status or condition. The state of full cover by native vegetation, as one would expected to occur in a natural setting with minimal anthropogenic disturbance, is typically interpreted as indicating that a wide range of functions are occurring with minimal impairment (see also the first row of Table 4.2). From a more anthropocentric perspective, we can consider the ecological goods and services (EGS) that flow from riparian ecosystems, such as potable water, edible fish and wildlife, adequate water for irrigation, flood protection, filtering of pollutants, and aesthetic landscapes. From this perspective, a healthy riparian ecosystem is one that can provide the full breadth of EGS. Table 4.1 presents some of the definitions of riparian health that have been used previously in Alberta, and these definitions highlight the concepts of function and structure, status (preferred state), integrity, and resilience.

Table 4.1. Commonly used definitions of riparian health in Alberta.

Source	Riparian Health Definition
Fitch et al. (2001)	The ability of a riparian area (including the channel and its riparian zone) to perform certain functions.
Scrimgeour & Wicklum (1996)	The preferred state of sites modified by human activities" (e.g.,cultivated beaches, lawns, decks) and integrity, i.e., "sites with little or no influence from human actions; the organisms living there are products of the evolutionary and biogeographic processes influencing that site.
Stantec (2005)	A healthy aquatic ecosystem is sustainable and resilient to stress. It maintains its ecological structure and function over time similar to the natural (undisturbed) ecosystems of the region, and provides an array of unimpaired ecological services that continue to meet social needs and expectations.

As with the definition of riparian land extent, the difficulty of quantifying riparian health comes in operationalizing the definition. How do we decide which functions are the most important given the natural variation in riparian lands in space and time? How do we know what the preferred state of an ecosystem is when almost all ecosystems around the world have now been influenced to some degree by human activities? What ecological goods and services are most important in a given region? These complex questions make it a difficult task to select a standard and universal set of criteria, indicators, and metrics that can be used to "measure" or quantify riparian health. What follows is a short discussion of some of the approaches and tools that have been used to measure riparian health in Alberta.

4.2. Conceptual Approaches & Technical Tools for Evaluating Riparian Health

4.2.1. Conceptual Approaches

a. Proper Functioning Condition

Although there have been a number of different technical tools used to assess riparian health, when carefully examined, there is really one main conceptual approach that underpins most of the technical tools. This conceptual approach is based on the definition of health emphasizing *proper* ecological functioning. In practice, the functions are inferred indirectly from the ecological condition of riparian ecosystems, measured by a set of indicators, such as vegetation cover and bank stability (Table 4.2). The measurements are made by evaluators who answer a set of questions, either in the field or by analyzing remotely sensed images in the form of aerial photography, videos, or satellite images. This approach of assessing health by measuring "proper functioning condition" comes out of work initiated by US Department of the Interior (USDI 1998) and has now spanned many different iterations (Hansen et al. 2000).

Table 4.2. Correspondence between indicators of riparian health and ecological functions based on *Alberta Riparian Habitat Management Society – Riparian Health Assessments* (from Fitch and Ambrose, 2003).

Measurement \ Function	Trap Sediment	Bind Banks	Store Water	Recharge Aquifer	Filter/Buffer	Dissipate Energy	Biodiversity	Primary Productivity
Vegetation cover	✓	✓	✓	✓	✓	✓	✓	✓
Weeds	X	X	-	-	-	X	X	X
Disturbance Species	-	X	-	-	-	X	X	X
Woody regeneration	✓	✓	✓	✓	✓	✓	✓	✓
Wood utilization	-	X	-	-	X	X	X	X
Dead wood	-	X	-	-	-	X	X	X
Deep roots	✓	✓	✓	✓	✓	✓	-	-
Bare ground	X	X	-	X	X	X	X	X
Compaction	-	X	-	X	-	-	-	X
Site alteration	X	X	X	X	X	X	X	X
Floodplain accessible	✓	✓	✓	✓	✓	✓	✓	✓
Water manipulation	X	X	X	X	X	X	X	X

✓ major role in performing this function

X major impact on, or impairment of this function

\- minor effect or impact

b. Disturbance Model

This conceptual approach is based on the idea that ecosystems showing no or little anthropogenic disturbance are generally "healthier" than more disturbed ecosystems. It is an approach that is being implemented in the Green Zone of Alberta where the original ecosystems are more intact than in the White Zone; thus, assessing the extent and amount of disturbance could be a useful indicator of health (Antoniuk et al. 2009).

4.2.2. Technical Tools

While there have been several different tools used in riparian health assessment in Alberta since the start of the collection of such information in the 1990s, there are currently only two tools used to assess riparian health in Alberta: one field-based and the other remotely sensed (Table 4.3). Of these, the field-based Riparian Health Assessment, originally developed by Hansen et al. (2000) and modified for use in Alberta by the Alberta Riparian Habitat Management Society (more commonly known as Cows & Fish), is the most widely used, with approximately 96% of provincial assessments conducted to date using this method (Figure 4.1). A second tool that has been used in Alberta includes low-level videography, which was developed by the Alberta Conservation Association in partnership with Alberta Sustainable Resource Development. In fact, on a longitudinal extent basis, low level videography has been used to cover a much greater proportion of shoreline in Alberta than it appears from adding up the number of sites (e.g. one site could cover 300km of shoreline). At the heart of each of these tools is a questionnaire that is completed by well-trained evaluators that measures different aspects of riparian function. Each question in the survey is weighted in a scoring system that is classified into three health categories, ranging from healthy to unhealthy. In the section that follows, we will describe these two tools in greater detail.

Table 4.3. Technical tools used to conduct riparian health assessments in Alberta.

Assessment Tool	***ARHMS - Riparian Health Assessment***	**Riparian Habitat Assessment using Low Level Videography**
Origin	Fitch et al. (2001) and Ambrose et al. (2004); based on Hansen et al. (2000)	Mills and Scrimgeour (2004)
Organizations applying method	ARHMS, SRD, City of Calgary and other municipalities, ACA, NCC, Consultants	ACA, SRD
Methodology-brief description	Field-based assessment of functional attributes of site based on visual clues obtained by walking around; trained evaluator completes either detailed inventory or shorter survey; different versions depending on water-body type; site selected based on aerial photography or other detailed spatial data;	Remote assessment (helicopter or light-weight aircraft) of functional attributes of site based on visual clues obtained by analyzing video footage; trained evaluator completes short survey; different versions depending on water-body type; entire length of hydrologic feature may be sampled
Definition of riparian zone	Riparian areas are the portions of the landscape strongly influenced by water and are recognized by water-loving vegetation along rivers, streams, lakes, springs, ponds and seeps. Riparian areas can be described as the “green zones” around lakes and wetlands and bordering rivers and streams. Also see Table 1.1.	Areas closer to the water’s edge are more likely to be riparian.
Definition of riparian health	It is the ability of a riparian area (including the channel and its riparian zone) to perform certain functions.	The preferred state of sites modified by human activities” (e.g., cultivated beaches, lawns, decks) and integrity, i.e., “sites with little or no influence from human actions.
Criteria; Indicators; Metrics	Four main criteria: ecological status, community structure, site stability, and flood control and water use. Depending on water-body type; there are between 9-15 indicators; each indicator may have 1 to 2 corresponding metrics.	Four main criteria: ecological status, community structure, site stability, and flood control and water use. Depending on water-body type; there are between 7-8 indicators; each indicator may have 1 to 2 corresponding metrics.
Comments	Scoring is subject to training of evaluator; does not consider water quality and other aquatic indicators.	Cannot consider the whole range of indicators one could glean from a site-visit. Some parameters cannot be seen through the video such as the soil and young vegetation.

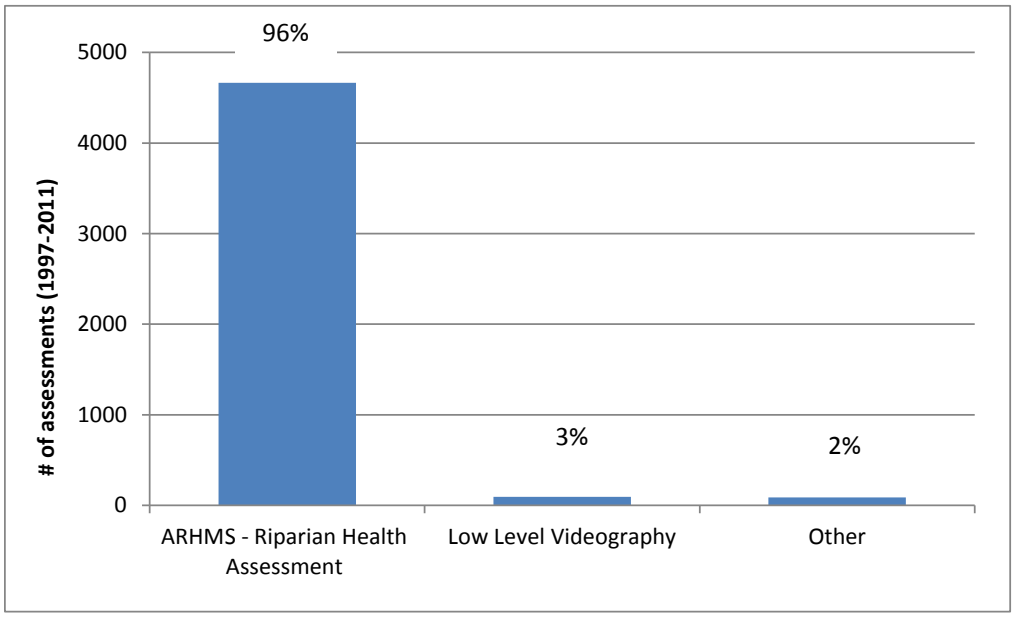

Figure 4.1. Technical tools used in assessing riparian health in Alberta in decreasing order of prevalence (measured by total number of assessment completed, n=5343).

a. ARHMS - Riparian Health Assessment [survey and inventory]

ARHMS, in collaboration with scientists from Montana, developed a series of both rapid (survey) and more detailed (inventory) riparian health assessments. These have been the mainstay of riparian health assessment in Alberta for the past two decades, with more than 5000 evaluations having been completed using this tool up to the end of 2011. In fact, the generic term '*riparian health assessment'* has become synonymous with the Riparian Health Assessments that was adapted for Alberta by ARHMS following Hansen et al. (2000). This comprehensive assessment approach evaluates riparian health using a variety of biotic and abiotic criteria that are related to ecological status, community structure, site stability, and flood control and water use. Depending on the type of hydrologic system (lentic or lotic) and the size of the hydrologic system, there are between 9 and 15 indicators that are considered in an assessment (Table 4.4). For each indicator, there are one or two corresponding metrics (also named parameters) with associated scores (or weights). In order to compute an overall health score, the scores are added up and converted to a percentage, which is then classified into one of three health categories: '*Healthy*', '*Healthy, but with problems*', or '*Unhealthy'* (Table 4.5).

The strength of this tool is the fact that comprehensive information is collected on most aspects of riparian health. Although the metrics are not actually measured, but are estimated visually, the estimation is made on the ground, which allows for a fairly accurate evaluation except at sites with large brushy vegetation, which can hinder visibility. The strength of this approach in terms of on-the-ground estimates can also be its weakness if inexperienced users are applying the surveys and have difficulty in applying consistent standards. Thus, while the rating categories are broad, evaluators do need to calibrate their visual assessment skills with practice.

Table 4.4. Criteria, indicators and metrics for *ARHMS – Riparian Health Assessment* surveys (detailed inventories can also be simplified into survey format in order to compute an overall-score). The numbers shown within the brackets indicate a range of discrete and discontinuous values that can be selected for a particular metric (e.g., for the range 0-6, the evaluator must choose either 0, 2, 4, or 6). The overall health status is computed by the addition of scores for each metric, conversion into a percentage by dividing into total possible score for a given water-body type, and classification according to categories in Table 4.5.

Criteria	Indicators	Metrics	Water-body type		
			Lakes and Wetlands	Streams & Small Rivers	Large Rivers
Ecological status	vegetative cover	% of the site covered by live plant growth	[0-6]	[0-6]	--
	invasive plants	**a:** % of the site covered by invasive plants; **b:** density/distribution pattern of invasive plant species	a [0-3] b [0-3]	a [0-3] b [0-3]	a [0-6] b [0-3]
	disturbance plants	% of the site covered by disturbance-increaser undesirable herbaceous species	[0-3]	[0-3]	[0-3]
	human-caused alterations to vegetation	% of polygon vegetation community composition is altered by human activity	[0-6]	--	--
Community structure	preferred tree/shrub regeneration	% of the total canopy cover of preferred trees/shrubs is seedlings and/or saplings	[0-6]	[0-6]	--
	preferred shrub regeneration	% of the preferred shrub species cover is seedlings and/or saplings	--	--	[0-6]
	preferred tree/shrub utilization	**a:** % of available second year and older leaders of preferred species are browsed; **b:** % of live woody vegetation expected on the site is lacking due to cutting	a [0-3] b [0-3]	a [0-3] b [0-3]	a [0-3] b [0-3]
	dead/decadent woody material	% of the total canopy cover of woody species is decadent and/or dead	--	[0-3]	[0-3]
	cottonwood and poplar regeneration	% of the cottonwood and/or balsam poplar cover is established seedlings and/or saplings	--	--	[0-6]
	regeneration of other tree species	% of the other (non-cottonwood/balsam poplar) tree cover is seedlings and/or saplings	--	--	[0-3]
	total canopy cover of woody plants	% of the total area occupied by all woody species	--	--	[0-3]
Site stability	human-caused bare ground	% of the polygon is human-caused bare ground	[0-6]	[0-6]	[0-6]
	human-caused alterations to the physical site	**a:** % of the polygon is physically altered by human activity; **b:** severity of human alterations	a [0-12] b [0-3]	--	--
	root mass protection	% of the streambank has a deep, binding root mass	--	[0-6]	[0-6]
	human-caused alterations to banks	% of the bank is structurally altered by human activity	--	[0-6]	[0-6]
	human-caused alterations to rest of site	% of the polygon is altered by human causes	--	[0-3]	[0-6]
	floodplain accessibility	% of the floodplain accessible to flood flows	--	--	[0-6]
	channel incisement	Incisement class	--	[0-9]	--
Flood Control and Water Use	artificial water level change	Severity of water level change	[0-9]	--	--
	dewatering of the river system	% of average river flow volume changed during the critical growing season	--	--	[0-9]
	control of flood peak/timing by upstream dams	% of the watershed upstream of the reach controlled by dams	--	--	[0-9]
		TOTAL Score	63	60	87

Table 4.5. Riparian health status categories used in *ARHMS – Riparian Health Assessment* surveys. Each individual metric may be rated or the total score may be converted into an overall health status category.

Percentage	Status	Descriptions
80-100	Healthy	Little or no impairment to any riparian functions
60-79	Healthy, but with problems	Some impairment to riparian functions due to human or natural causes
<60	Unhealthy	Severe impairment to riparian functions due to human or natural causes

b. Low-level Videography

Low-level videography is a remote sensing tool that uses spatially referenced continuous video of a hydrologic system that is evaluated on screen by a trained analyst. Instead of observing the site on the ground by walking around, the observation takes place through the video images, which have been acquired at altitudes of 60m or less from an oblique angle. Like the field-based *ARHMS-Riparian Health Assessment*, the evaluator answers a series of questions regarding different functional attributes of the riparian lands in question (Table 4.6) and converts it into a score that is classified according to three health categories akin to the ARHMS approach (Table 4.7).

Two different organizations have developed riparian health assessment methodologies based on low-level videography. The Alberta Conservation Association, in partnership with Alberta Sustainable Resource Development Fish and Wildlife Division, developed a method for spatially describing characteristics of riparian health as part of the Riparian Habitat Assessment Project (Mills and Scrimgeour 2004). ACA/SRD initially developed the tool for lakes, but the tool has been expanded to assess lotic systems as well. Alberta Environment has also completed a pilot study to test the application of low-level videography in the South Saskatchewan River basin (AENV 2010).

The benefit of low-level videography is that the entire riparian area of a lake or river can be assessed at one time, while providing a permanent geo-referenced video record of the current status of shoreline. It provides a rapid method to produce “coarse filter” assessment of riparian health. This approach is not intended to replace field-based assessments, but rather, complement them by allowing large areas to be evaluated in an approximate fashion, to be followed by more detailed checks on the ground. In terms of cost, low-level videography can be very cost-effective per kilometer of shoreline observed, especially if ultra-light aircraft is used instead of a helicopter. The goal is to provide low cost information of large areas so that management at larger scales (i.e. entire lake or river system) can be directed by standardized, repeatable measurements.

Low-level videography cannot replace field-based assessment because some of the metrics that are evaluated during a field-based evaluation cannot be remotely sensed, either because of limitation of the technique, or because of obstructions in the image. Some of the most difficult metrics to observe remotely include tree recruitment and the density and height of forbs and grasses. In many cases, because of the oblique vantage point, a large part of the riparian habitat may not be observable and it can be difficult to observe physical alterations that are obscured by vegetation. This tool works best where there is minimal cover of woody vegetation and where stream channels are wide enough to see sideways into tree and shrub stands. Severe sinuosity may also make maintaining video contact with the stream difficult.

Table 4.6. Criteria, indicators and metrics for low-level videography based riparian health assessments developed by ACA/SRD and AENV.

Criteria	Indicator	ACA/SRD		AE
		Lakes	Streams	Streams
Ecological status	vegetative cover	[0-2]	[0-2]	[0-40]
	invasive plants	--	--	--
	disturbance plants	[0-1]	--	--
	human-caused alterations to vegetation	[0-2]	[0-4]	--
Community structure	preferred tree/shrub regeneration	--	[0-2]	--
	preferred shrub regeneration	--	--	--
	preferred tree/shrub utilisation	--	--	--
	dead/decadent woody material	--	--	--
	cottonwood and poplar regeneration	[0-1]	[0-2]	--
	regeneration of other tree species	--	--	--
	total canopy cover of woody plants	[0-1]	--	--
Site stability	human-caused bare ground	[0-3]	[0-4]	[0-15]
	human-caused alterations to the physical site	[0-1]	[0-4]	[0-15]
	root mass protection	--	--	--
	human-caused alterations to banks	--	[0-4]	[0-10]
	human-caused alterations to rest of site	--	--	[0-10]
	floodplain accessibility	--	--	[0-10]
	channel incisement	--	--	--
Flood Control and Water Use	artificial water level change	[0-2]	--	--
	dewatering of the river system	--	--	--
	control of flood peak/timing by upstream dams	--	--	--
	TOTAL score	13	22	100

Table 4.7. Riparian health status categories used in low-level videography assessments of riparian lands.

Percentage	Status
>70	Healthy
50-70	Moderately impaired
<50	Highly impaired

c. Other Tools Under Development or Not Widely Applied

Best Judgment Panel

Best Judgment Panel is an assessment tool that was used for assessing the health of riparian lands in the South Saskatchewan River basin (Golder Associates 2003). This assessment tool is based entirely on the opinions of experts who answer a set of questions based on their knowledge of the riparian lands in question. The participants of the workshops during which these questionnaires were administered were asked a series of questions grouped according to five major themes or high-level objectives, including: hydrology, limnology, habitat connectivity, sustainability/resilience, and biodiversity. The assessment design was based on a similar study conducted by the US Geological Survey (1998) in the upper Mississippi River. Health status was ranked according to four categories reflecting the degree of impact or degradation for each river reach (Table 4.8).

Table 4.8. Riparian health status categories used in best judgment panel assessments of riparian lands.

Score	Status	Descriptions
0	Unchanged/ Recovered	Most factors have either remained relatively unchanged over time or recovered from any disturbance
-1	Moderately Impacted	Most factors have changed measurably over time and some are near or approaching ecologically unacceptable values
-2	Heavily Impacted	Many factors have degraded over time and are below or forecasted to be below ecologically acceptable values
-3	Degraded	Most factors are now below ecologically acceptable values

Riparian Disturbance Model

This tool quantifies the direct footprint of human activity within the riparian zone and has been developed for application in the oil sands (Antoniuk et al. 2009). The riparian disturbance indicator provides an erosion, habitat loss, and mortality risk index for aquatic ecosystem function (Table 4.9). This is also a course filter assessment tool that is based on the idea that the riparian footprint is linked to an overall risk of negative ecosystem effects.

Table 4.9. Riparian health status categories used in riparian disturbance model (Antoniuk et al. 2009).

Disturbance percentage	Risk ratings
0-9% of riparian area disturbed	Low Risk of Adverse Ecological Effects
9-18% of riparian area disturbed	Medium Risk of Adverse Ecological Effects
>18% of riparian area disturbed	High Risk of Adverse Ecological Effects

Remote Sensing of Riparian Lands Condition

As described in Section 3.1.3, the Alberta Terrestrial Imaging Center is developing a monitoring system using remote sensing technologies. This approach maps the extent and specific health indicators of the non-cultivated components of the agricultural landscape, including riparian areas, remnant areas, and wetlands. The monitoring system will provide specific health indicators, vegetated (e.g., native and invasive species) and non-vegetated (soil, water) component types and proportions (percent cover), as well as an ability to map changes of these indicators over time. This project is ongoing in the Vermillion subwatershed, located in the North Saskatchewan River Basin, and is currently focusing on the following parameters: impervious surface, road density, land cover/land use, canopy continuity, extent of bare ground, sinuosity, riparian vegetation width, canopy cover, composition, leaf area index, number and height of trees, vegetation overhang, and number of channels.

4.3. Current Status of Riparian Health in Alberta

The systematic collection of information on the health of riparian lands in Alberta began in 1997 and was led by the efforts of the Alberta Riparian Habitat Management Society. Since then, more than 5300 sites have been assessed for health by a variety of government and non-government agencies, and a more comprehensive picture of riparian health has begun to emerge. This chapter pulls together and summarizes information on riparian health assessments that have been conducted throughout Alberta. To our knowledge, this is the most current and comprehensive summary of riparian health that has been compiled to-date.

4.3.1. Methodology

For this analysis, a comprehensive dataset on riparian health assessments conducted in Alberta was compiled by contacting the major stakeholders who have been engaged in conducting riparian health assessments throughout the province, as well as by literature searches conducted on the internet. The two organizations that have collected over 78% of riparian health assessment data in Alberta include ARHMS (n= 2075) and SRD (n=2066). Other important stakeholders in the collection of assessment data include the Alberta Conservation Association, Alberta Environment, Alberta Agriculture and Rural Development, Nature Conservancy of Canada, and the City of Calgary. The key variables of interest to this analysis included: the number of sites sampled, the length of riparian lands assessed, the number of sites within each health category, and average health score. Unfortunately, much of the desired information in the compiled data was either missing or not available from the various sources. As a result, this data synthesis (presented below) is not based on all assessments that have been completed to date. Methodological differences also presented challenges in combining and comparing results. Consequently, the synthesis of health data is based only on the data collected using the *ARHMS-Riparian Health Assessments* methodology that have been completed by ARHMS or by other organizations following the prescribed protocol.

In total, our records indicated that 5343 unique riparian assessments have been conducted throughout the Province of Alberta between 1997 and 2011 (Appendix A). Of these, 5160 were collected using a version of the *ARHMS-Riparian Health Assessment* protocol. Of the 5160, a total of 4102 reported average scores, but only 2520 reported on the distribution of health categories. In the discussion that follows, the figure caption indicates which subset of the data are being discussed. Also, not all of the compiled data included information on the water body type being assessed or the watershed in which the assessment was being conducted. In terms of creating the figures that follow, we used the largest sample size available in light of the constraints listed above. In Section 4.3.2, we first discuss the locational attributes of the assessments that have been completed to-date, then discuss the synthesis of health data by watershed, and then present the detailed tables on health for each major watershed in Alberta.

4.3.2. Current Riparian Health Status: Location and Water Body Type

There is a strong north-south bias in the spatial density of assessments collected across the province (Figure 4.2). While there have been some riparian lands assessed for health in more northerly watersheds, including the Peace River watershed, the majority of assessments (58%) have been completed in the South Saskatchewan River basin. As mentioned earlier, the tool of choice throughout Alberta has been the field-based *ARHMS-Riparian Health Assessment* inventory and survey. This tool has been applied not only by the ARHMS, but by other organizations as well, and most notably by SRD. Whereas the majority of the assessments completed by ARHMS have been located in the White Zone, most of the SRD assessments

have been conducted in the Green Zone on public lands leased for grazing, as riparian health assessments are required as part of a grazing lease renewal.

Although not evident from Figure 4.2, the majority of assessments conducted to-date have been located in the White Zone, as compared to the number that have been completed on forested lands in the Green Zone. This bias in assessment location has been addressed to some degree by low-level videography, which has been used extensively in some regions of central and northern Alberta. In particular, this technique has been used on many of the major rivers, tributaries, and the bigger lakes in the Lesser Slave Lake watershed. Unfortunately, the data did not allow for this calculation, but an assessment density map based on site length, rather than number of sites, would reveal a much higher assessment density for the Athabasca basin given the high number of low level videography assessments conducted in that watershed. The breakdown of assessments based on water-body type shows a fairly reasonable distribution (Figure 4.2), although small features such as springs, seeps, as well as wetlands with limited open water such as fens and bogs, are not well represented. The dataset did not allow for a breakdown of water body type by watershed.

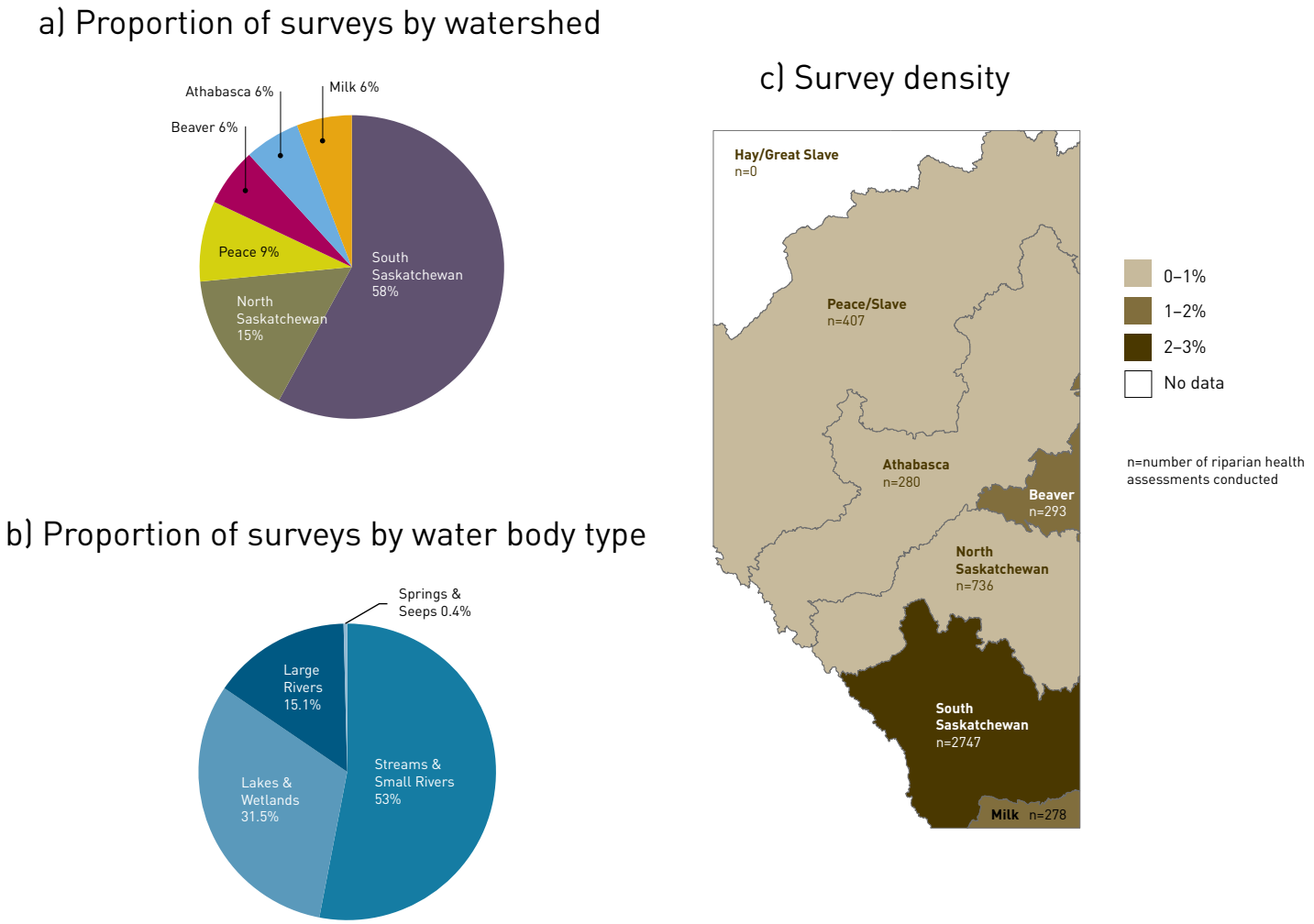

Figure 4.2 (a-c). Proportion of riparian health surveys that have been conducted using the *ARHMS- Riparian Health Assessment* method summarized by (a) watershed and (b) water body type. Assessment density, which is the number of assessments conducted by watershed normalized by length of shoreline, is presented in (c). Assessment density was calculated by dividing the total number of assessments by total length of shoreline (small stream, large river and lake/wetland shorelines combined) within the watershed (see Table 3.1). Data for A and C were drawn from health assessments with information about watershed location (n=4741). Data for B were drawn from health assessments with information on water-body type (n=3577) (see Appendix A for more detail).

4.3.3. Current Riparian Health Status

a. Provincial Synthesis

Based on a summary of riparian assessments with available data collected between 1997 and 2011 (n=2520), the distribution of riparian health across the province reveals that approximately three quarters of the sites assessed are Healthy, although many of them with problems, with just over a quarter of the sites being reported as Unhealthy (Figure 4.3).

It is important to note that this estimate of provincial riparian health is crude at best, and thus, should not be taken as a definitive statement on the condition of riparian lands in the province. It is very difficult to get a comprehensive picture of riparian health in Alberta, primarily due to a lack of commonly applied assessment methods and a lack of data. For example, the South Saskatchewan River basin, which has the highest density of assessments conducted to date, has only had approximately 2% of its rivers and lakes assessed, while there are no data available on riparian health in the Hay/Great Slave watershed (Figure 4.2 c). Even in areas where a larger number of assessments have been conducted, the sampling has not been systematic, which makes it very difficult to generalize the results to give an overall picture of riparian health at either the watershed- or provincial-scale. Further, many of the assessments that have been included in this provincial summary were conducted over a decade ago, and thus, the status of these lands may have changed over time. With the exception of a few locations in the province, there is no long-term repeat sampling of riparian sites; thus, there is a lack of information on how riparian health trends have changed over time.

Despite the limitation of this analysis, the results do suggest that there is a clear need to focus on riparian land management to ensure that those sites listed as “Healthy, but with problems” do not decline further into the “Unhealthy” category. If the ARHMS draft target of 60% Healthy, 25% Healthy, but with problems, and 15% Unhealthy is to be reached by 2030 (Fitch and Ambrose 2003), a network of permanent sample sites needs to be established that can be used for repeated sampling in order to determine trends in riparian health status over time.

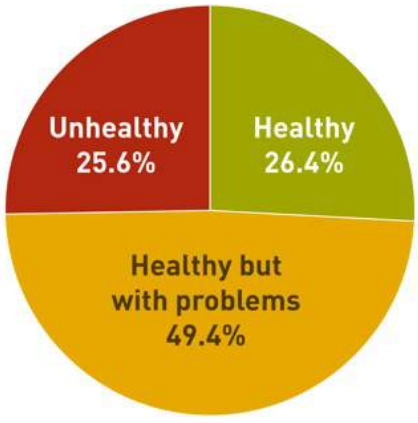

Figure 4.3. Current status of riparian lands In Alberta based on a summary of data collected between 1997 and 2011, using the *ARHMS – Riparian Health Assessment* method, for which relevant data was available [n=2520].

b. Watershed Synthesis

In the following section we discuss riparian health status broken down by major river basin (Figure 4.4 and Table 4.10). More detailed health information summarized by project and presented by watershed can be found in Appendix A.

When the distribution of health scores by watershed is examined, some interesting trends can be seen, particularly when comparing health scores in the southern watersheds (Milk, South Saskatchewan, North Saskatchewan) to the more northerly watersheds (Beaver, Athabasca, Peace). The data show a greater proportion of healthy assessments in the more northern watersheds (Figure 4.4); however, this trend could be confounded by the fact that the sample density decreases substantially as one moves north (Table 4-10). The average health scores by watershed are not as informative as the health class distributions (Figure 4.4), although even the average scores suggest that riparian lands in northern watersheds are healthier than those in more southerly watersheds (Table 4.10).

As stated in Section 4.3.3 (a) above, this analysis has serious limitations, and thus, should not be considered a definitive statement of riparian health at the watershed scale. Much of the data used in this analysis has not been systematically sampled, but rather, was collected at the request of individuals, groups, and organisations. Only within the South Saskatchewan River watershed has there been an effort to sample river systems in a representative fashion, but even in this case, extrapolating from site-based assessments to the whole watershed is questionable, particularly if one is interested in making generalizations about riparian health for all stream orders. While a large number of riparian assessments have been collected throughout the province, overall, even in those watersheds with the highest sampling density, less than 3% of the total shoreline length has been sampled. Further, as we discussed in Chapter 3, the estimate of total shoreline length is likely conservative (i.e., is an underestimate) given that it excludes most ephemeral streams and wetlands. Thus, these results should be interpreted with caution, as they are likely not an accurate reflection of riparian health at the watershed scale.

Table 4.10. Current status of riparian health by watershed (n=2520) as well as information on assessment density (see also Table 3.1). Average health scores of between 80 and 100 are considered “Healthy”; scores of between 60 and 79 are considered “Healthy, but with problems”; and scores of between 0 and 59 are considered “Unhealthy”.

Major Watersheds	Total Length of shoreline (km)	Assessment Density (sites/km)	Assessment Density Sample Size	Average Health Score	Average Health Score Sample Size
Athabasca River	160,703	0.17	280	72	171
Beaver River	18,392	1.59	293	76	22
Hay/Great Slave	101,970	0.00	0	na	0
Milk	17,452	1.59	278	68	219
North Saskatchewan	114,805	0.64	736	69	384
Peace/Slave River	284,368	0.14	407	75	22
South Saskatchewan	136,199	2.02	2747	69	1702
TOTAL	833,889	0.57	4741	69	2520

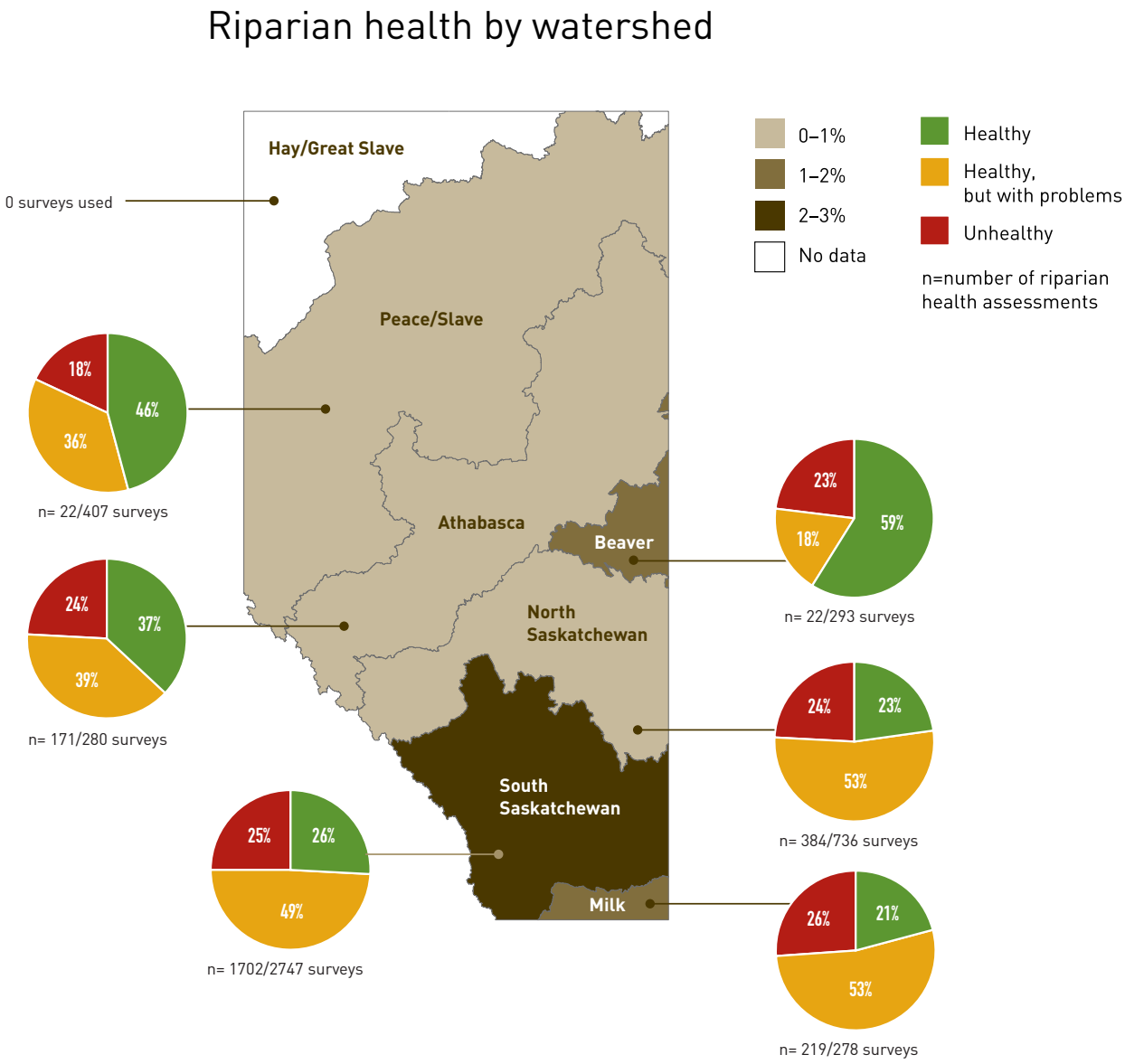

Figure 4.4. Current status of riparian health summarized by watershed (n=2520), based on data collected between 1997 and 2011 using the *ARHMS – Riparian Health Assessment* method. Assessment density was calculated by dividing the total number of assessments conducted in each watershed by total length of shoreline (small stream, large river and lake/wetland shorelines combined) within the watershed using data from health assessments that included watershed location information (n=4741).

4.4 Data Gaps and Limitations

The biggest data gap in terms of the health of riparian lands in Alberta is the lack of assessment data, particularly as one moves north. Large portions of the province are not being evaluated using a common assessment standard, and this is particularly true of assessments on forested lands. In the settled region of the province, where agricultural activity dominates, there is a large focus on grazing lands at the expense of croplands. Even in areas where assessment density is high, sampling is not systematic, which means that apart from the immediate lands for which the assessments are conducted, we know little about the overall health of riparian lands in the province. The South Saskatchewan River basin, where assessments have been conducted for the longest period of time, is the only region of the province where sampling programs have been designed to characterize the major rivers and their tributaries.

The use of low-level videography offers some promise of rounding out riparian health assessments in areas where far fewer assessments have been conducted. The continuous nature of low-level videography data, which addresses data representativeness as entire river systems, can be assessed fairly quickly and is relatively cost-effective, as has been demonstrated in the Lesser Slave Lake watershed. While low-level videography addresses the question of collecting a representative sample, it does not use the same comprehensive assessment as a field based assessment. At present, there is a large knowledge gap with respect to how closely field-based and aerial videography based assessments correlate to one another. Such comparisons will be needed for determining the usefulness of other remote sensing techniques that are needed to scale up field-based results.

5. Riparian Conservation in Alberta: Barriers to Success & Strategies for Improved Outcomes

A key objective of this riparian assessment project was to engage a broad range of stakeholders to uncover what they perceive to be the key barriers or challenges that limit the success of riparian stewardship and conservation in Alberta. Based on their knowledge and experience, stakeholders were also asked to provide suggestions for how these barriers could be overcome, and to comment on whether they believe the province of Alberta needs a new policy that specifically addresses riparian land management.

5.1. Methodology

Given the diversity and geographic dispersion of key informants, an online survey was considered the most cost-effective method for reaching the largest number of participants. The online survey was administered using the open source survey software LimeSurvey (2012), and study and question design followed accepted qualitative methodologies for web-based surveys (Dillman 2007). Working in consultation with the Alberta Watershed Council Riparian Land Conservation and Management Team, a list of key informants was compiled, which included participants from a variety of backgrounds and with a broad range of experiences working in the area of riparian land management in Alberta. Prior to administering the survey, a pre-test with members of the Project Team was conducted to ensure that survey questions were clear and the instructions for conducting the survey were understandable. Modifications to the wording of questions were made as a result of the pre-test feedback, and all pre-test responses were excluded from the final results.

An invitation letter was sent to each participant via email on February 15, 2012. The invitation provided rationale for the survey, as well as a general description of the goals and objectives of the survey. The invitation letter also explained that participation was voluntary and that all responses would be held in strict confidence. In order to control access to the survey, each participant was assigned a randomly generated unique token, and this token was required at the time of survey log-on. The survey was active on-line between February 15 and March 9, 2012, and email reminders were sent out to participants on February 24 and March 5, 2011. Participants who had not completed the survey by the email reminder dates were also targeted by members of the Project Team and may have received personal reminders from members of the committee in addition to the survey email reminders.

The survey consisted of four parts: Part 1 focused on questions related to the participants experience in, and knowledge of, riparian land management in Alberta. Part 2 asked participants to rate the effectiveness of existing riparian land management programs and policies on both private and public land. If participants indicated that they felt existing programs could be improved, they were asked to specify what they considered to be the top three barriers preventing improved outcomes, and were asked to identify strategies that could be employed to overcome these barriers. Part 3 of the survey asked participants whether they think the province needs a new riparian land policy, and included an open-ended question asking each participant to elaborate on the reasons for, or against, adopting a new riparian land policy. Part 4 of the survey invited participants to provide any final thoughts about the survey or any other aspect of riparian land management in Alberta.

Survey responses were coded by a single researcher into conceptual themes using NVivo 8 (QSR International Pty Ltd 2008). The major themes that emerged from the survey were

summarized, and quotations that were considered to be representative of the discourse surrounding the major themes were selected and included in the results. Quotations were corrected for spelling and only minor changes were made to the original text to improve overall comprehension and readability.

5.2. Results

5.2.1. Response Rate

In total, 136 people were invited to participate in the Riparian Land Conservation and Management Survey. Of those invited to participate, 109 individuals completed the survey, for a response rate of 80%. Two participants opted out of the survey and one response was excluded from the analysis because the response was incomplete. Of those respondents who completed the survey, the majority stated their organizational affiliation as Non-Government (NGO; n=44), with Private Industry (n=25), Government (n=24), and Academic Institutions (n=6) also being represented in the sample (Figure 5.1). In addition, 10 respondents stated their organizational affiliation as "Other", with this category largely being made up of people who work in the agricultural sectors as ranchers or farmers.

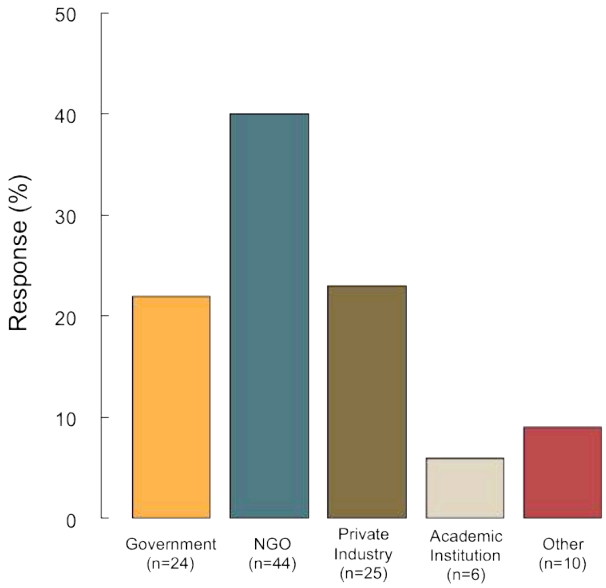

Figure 5.1. Response by organizational affiliation.

5.2.2. Riparian Management Outcomes: Perceived Effectiveness

When asked to rate the overall effectiveness of existing riparian land management programs and policies, the majority of respondents felt that outcomes to date have been "Somewhat Effective", with this percentage being slightly higher on public (69%) versus private (66%) land. As many as 25% of respondents felt that existing management programs and policies have been "Not at all Effective" on public land, with this proportion increasing to 36% for private land (Figure 5.2). Only a very small number of respondents (n=6) felt that existing programs and policies have been "Very Effective" on public land, with only one respondent indicating that riparian management on private land has been "Very Effective".

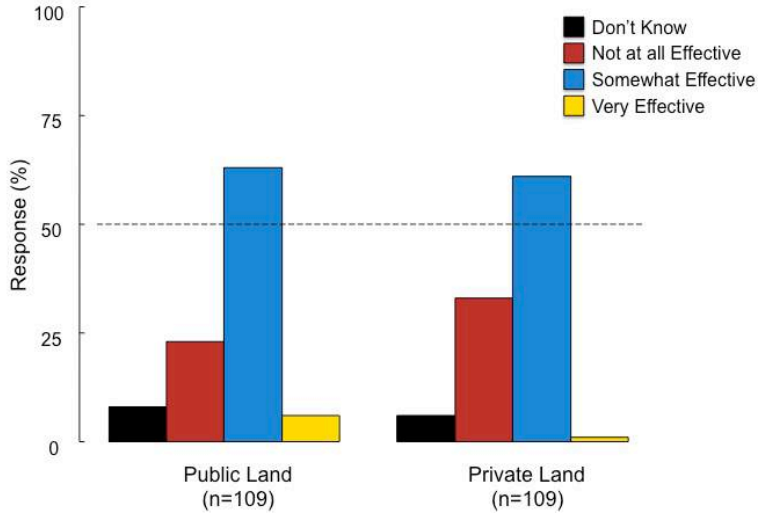

Figure 5.2. Perceived effectiveness of existing riparian programs and policies on public and private land in Alberta.

5.2.3. Barriers to Successful Riparian Conservation Outcomes

When respondents were asked to identify the top three barriers that currently limit the success of riparian land management in Alberta, a number of common themes and concepts emerged. The most commonly expressed barriers included:

j) Jurisdictional Fragmentation
k) Insufficient Public, Scientific, & Technical Knowledge
l) Insufficient or Ambiguous Regulation
m) Economic Constraints & Lack of Incentives
n) Lack of Financial & Human Resources
o) Misplaced Government Priorities
p) Agency Capture & Lack of Government Legitimacy
q) Inappropriate or Unrealistic Planning and Management Scales
r) Insufficient Compliance & Enforcement

a. Jurisdictional Fragmentation:

One of the barriers most frequently cited by respondents is the fragmentation of jurisdiction over riparian land management in the province. This fragmentation was identified as being an issue across all levels of government (i.e., federal, provincial, and municipal), as well as between departments within government (e.g., Alberta Environment and Sustainable Resource Development). Respondents reported that this fragmentation has created a great deal of uncertainty as well as inconsistent decision-making across the province, such that there are no clear "rules" for how to manage riparian lands:

> *"There are no clear guidelines with respect to management of the resource. Conflicts in legislation and policy create confusion. It should translate into clear guidance documents for management/setbacks in specific situations"*

> *"There is a lack of (or perception of lack of) a coordinated approach by all of the levels of government that are responsible for managing riparian lands. Each of them has a role to play and I don't feel that it should become one job, but being better at communicating and*

coordinating between departments and then getting that message out to people would be something to continue to work towards."

"For public land there are too many hands involved. There is no focus because every organization in all these levels has different priorities."

"Better clarity is needed for 'buck stops here' responsibility between all levels of government, and cross ministry silos need to be removed."

"There is a lack of integrated regulatory tools and processes (e.g., policy, legislation, regulation, enforcement, education, etc.) across all levels of government and a political reluctance to support their use."

"We continue to bang our heads against politicians at all levels of government, and launch the occasional legal action, in the hopes of strengthening environmental regulation. One major impediment surrounds the division of powers among the three - the rationalization of which is an ongoing project."

Confusion over the role and jurisdiction of municipal governments in the management of riparian lands was often cited, with particular reference to interpretation of the *Municipal Government Act*. This legislation gives authority to municipalities to manage riparian lands, but many people who work for municipalities expressed frustration over the lack of guidance over how municipalities should be making decisions for riparian land management. In many cases, this lack of clarity was cited as a barrier to decision-making:

"The Municipal Government Act provides minimal direction with respect to setbacks to protect water bodies (minimum of 6m in a subdivision to prevent pollution). The setback does not reflect current knowledge with respect to effective setback widths, nor does it define pollution, so it is unclear as to what standard is expected in municipal development. In addition, there is no clear link between the Acts that have clear direction in this regard, namely the Water Act and EPEA. These set standards for protection of water and water bodies, but a clearer link to the MGA would be beneficial - e.g., upholding the requirements of the Water Act/EPEA in a residential development could be translated into a clear taking of setbacks adjacent to a water body in a development."

"There are many provisions in the MGA that are currently underutilized because private land developers do the planning and consider subdivision and development a 'right'. The laws and regulations are not correlated, such that lands under municipal jurisdiction are treated differently than public lands. As a result, every jurisdiction thinks the other is managing these landscapes and [the result is] no-one is."

Respondents also expressed concern over the lack of provincial standards for measuring and assessing riparian health, as they feel that this lack of standardized methodology leads to inconsistent decision-making and confusion. Others expressed concern over the inconsistent application of regulation and standards across the province, as well as between the various industries that work on the landscape:

"There is a lack of consistent regulations, conventions or understanding regarding riparian health, monitoring, or targets."

"There is an incredible amount of non-parity from one area to the other and one industry to the other. For example, forestry operations are not required to conduct rare plant surveys, whereas oil & gas MUST. Provision of guidelines for riparian impact assessments are non-existent

forcing varying levels of assessment and NO real method of discipline if a so-called QWAES provides sub-par assessments"

b. Insufficient Public, Scientific, & Technical Knowledge:

One of the most widely cited problems with riparian land management in Alberta is a lack of knowledge or understanding about riparian lands. Within this theme, there were various "kinds" of knowledge identified as being critically important, but currently lacking. This included a general public understanding of what constitutes riparian land, how riparian lands function on the landscape, the ecological importance of riparian lands, and the contribution these habitats make to the economic well-being of Albertans:

"The general public has limited knowledge of what a riparian area is, how it functions, and what it takes to protect these sensitive areas. Not only do people have to attempt to understand these complex issues and concepts, but they should also understand the role of government departments in facilitating these projects moving forward so they can understand the decision making processes."

"There is a lack of knowledge and understanding of functions and importance of these lands, i.e., they are not 'buffers' but important landscapes in their own right."

"A better recognition that riparian areas are not limited to moving water. Most riparian management strategies focus on functional restoration of degraded stream banks etc., which are important but does not address the often overlooked fact that every time a wetland is lost through drainage or infilling, its associated riparian area is not only degraded, but lost as well."

Respondents also acknowledged the serious lack of scientific and technical information that is currently available to help make planning and regulatory decisions. This ranges from a lack of science-based recommendations for development set-backs, to a complete lack of inventory data documenting the extent and condition of riparian lands in Alberta:

"An adequate regulatory environment at all three levels of government is predicated on actual knowledge of natural systems; our current state is rudimentary or almost unknown at best."

"There is a lack of scientific understanding of current condition/health of riparian areas. We need to have a clear understanding of the condition of riparian areas and the potential benefits that restoration projects will bring in order to justify budget allocations. Without detailed assessments and studies however, this is not possible."

"Lack of watershed scope inventories that identify impairments and what needs to be protected to support a cumulative effects management strategy for land & water use. Current approach remains reactionary to proposed projects that usually results in flurry of quickly assembled data to support a proposed land use project and in some cases by opponents of the project."

Finally, respondents cited the lack of understanding of current legislation and policy as it relates to the management of riparian lands as a major barrier to improved conservation outcomes:

"There is a lack of knowledge about what policies, legislation and regulations help manage riparian lands, and how each sector can utilize this information towards best management practices."

"Counties/municipalities know very little about the Water Act and approval processes as they pertain to riparian areas on private lands, and there is very little education of County/MD's by the province on this account."

c. Insufficient or Ambiguous Regulation:

While coordination between various levels of government was cited as being a problem, many respondents also indicated that in many cases, they felt that existing regulations or policies were insufficient in moving the province towards improved riparian land conservation:

> *"It all starts with statutes and regulations. Absent an effective statutory (legal) environment, other considerations (assessment, monitoring, management protocols, mitigation measures, etc.) are moot"*

> *"There is a lack of regulation surrounding agricultural use of riparian areas. Studies have shown again and again that the largest polluters is Alberta's agricultural sector"*

> *"For private lands, there is very little regulation that pertains to management of riparian lands and what does exist is inconsistent."*

In particular, municipal regulation was cited most frequently as being insufficient to protect riparian lands in the face of rapid urban development:

> *"We need bylaws to force municipalities to develop riparian setbacks and to provide clear direction to staff in how to deal with riparian lands."*

> *"There are no over-riding provincial laws/regulations that compel municipalities to manage for these areas. Although the broad Land Use Policy document directs municipalities to consider various environmental elements in their planning, it seems incongruent then to make many provisions in the subdivision regulations so discretionary. The current Municipal Government Act has far too many discretionary provisions that limit ability to effectively deal with conservation measures"*

d. Economic Constraints & Lack of Incentives:

Many respondents raised the issue of costs as a barrier to riparian conservation on private land. Many landowners, and in particular agricultural producers, bear the direct costs of riparian conservation, either through direct costs of implementing best management practices or through foregone economic opportunities. While landowners may be interested in participating in stewardship programs, some respondents felt that cost may be a barrier for some individuals whose operations are economically marginal:

> *"The burden of costs goes to the landowner. A farmer who wishes to set aside his riparian areas must sacrifice the production from that land base and the profit there-from. The majority of the benefit goes to the downstream user… however, the cost is to the landowner alone. To make this even more costly, a landowner who decides to set aside some of their land base for conservation purposes runs the risk of being heavily taxed when the property is no longer taxed at its agricultural use value, but rather at its market value."*

> *"Many of the changes that are required by a producer to make involve a cost that the producer may not see a return on, as such these changes are not as high a priority to make."*

Overall, there was a general perception that incentive programs are either lacking, or are entirely nonexistent. For those incentive programs that do exist, respondents felt there are problems with the scope or duration of the programs:

> *"There are no provincial programs in Alberta that offer direct incentives for conserving and protecting riparian lands, nor are there strong disincentives for exploiting them … Furthermore,*

there are no provincially managed programs that offer economic incentives to Albertans for improving or restoring degraded riparian lands."

"Grant programs to help landowners manage their land often change or end."

A lack of understanding about the economic benefits that flow from riparian lands, both to individual landowners and to society, was cited as a major barrier. In addition, several respondents felt that a lack of proper valuation of the ecosystem services and benefits that flow from riparian lands prevents proper benefit-cost analysis from occurring, which leads to degradation and impacts to riparian lands:

"There is a lack of awareness as to the importance or economic value of riparian functions and lack of understanding as to the cumulative impacts to water quality and fish/wildlife habitat from degraded riparian health."

"Landowners, whether public or private, require alternative market instruments that induce land use practices that maintain or reclaim riparian habitat. Current policies reward the extraction of commodities (beef, crops, gravel, oil, gas, forest fiber) but do not reward landowners to maintain water quality. By including water quality, water quantity and carbon as Ecological Goods and Services, riparian habitat management can become an equal player in land use decision making."

"Better conservation for riparian lands on private land will only be achieved if full cost accounting (true long term monetary value of natural capital to the health and prosperity of Albertan -living in their place in the watershed) is accepted, respected and acted upon by the regulators and industry. There must be recognition of the entire natural function of environmental systems."

e. Lack of Financial & Human Resources:

A lack of financial and human resources at all levels of government was cited as a significant barrier to achieving better riparian management outcomes. In particular, small rural municipalities were identified most frequently as facing the most serious challenges with respect to having the appropriate resources available for managing riparian lands:

"Cutbacks in government funding affect the number of people on the ground to control abuse of public land, as well as weeds on public land along riparian areas."

"Reduced funding for Forest Rangers / Enforcement officers in Public Lands to better manage, regulate and interface with public and industry (e.g. forestry) land users."

"Little guidance is available for municipalities on how to implement effective riparian conservation planning and management. Rural municipalities rarely have sufficient human resourcing in the planning departments to support this kind of work."

A lack of financial resources and personnel was also cited as a significant barrier to the success of on-going stewardship programs in the province. In particular, many respondents cited the work that is currently being done by Cows and Fish, and the limited capacity of this organization to reach more individuals who actively manage riparian areas on private lands:

"Most people know about Cows and Fish programs but they are understaffed for the work that needs to be done. Other programs need to be better advertised in order to spread out the work."

"There are not enough skilled staff available to give producers the individual attention needed to make appropriate, practical changes to their operations."

"Cows and Fish has been tasked with inventorying riparian health; however, they are underfunded and stretched. They are only covering a small fraction of riparian lands and a more widespread, systematic provincial riparian inventory is needed."

"More funding and more stable, long-term funding needs to be in place or accessible for groups working on riparian management at the grassroots level. Both private and public landowners need information to make good decisions with regard to riparian management. They need clear messages about riparian management multiple times, from a trusted source."

A further barrier that was identified includes a lack of funding for the provincial government to collect rigorous and scientifically robust information to document the extent and condition of riparian lands in the province:

"There is a lack of scientifically defensible monitoring of environmental change and performance once mitigation (or restoration) has been completed. Lacking such data, I find public officials making decisions based on assumptions rather than reality. I don't fault them for this - they don't have the money/staff to go out in the field or to commission good studies of outcomes."

"We need dollars available to benchmark the health of riparian areas in the province, as to date, only a small amount of work has been done … We also need dollars available to monitor changes in riparian health to determine trend and locate those "good news" stories which can be shared and learned from."

f. Misplaced Government Priorities:

Many respondents expressed an opinion that the conservation or protection of riparian lands was not a high enough priority for provincial and municipal governments, particularly when weighed against other priorities, such as economic growth:

"There is a profound lack of provincial government leadership for managing riparian lands, and not enough buy-in from municipal governments to do their part with the policies and tools they presently have. There has been a lot of attention focused recently on the environment in the context of the oil sands, while other environmental issues have taken a back seat to health, jobs and the economy. But that does not mean that important environmental issues such as riparian land degradation should be neglected."

"In my opinion and experiences, Alberta is a pro-development province (open for business), and any suggested 'protective' or 'precautionary actions' taken to preserve important riparian areas prior to development is often seen as limiting progress."

"As long as the political constituency is agriculture and oil/gas and not the people, we will have this problem. As long as the government believes that the economy is the solution to all our problems and does not frame economic activity within an ecological framework, attach the "true" cost of industrial and agricultural development to those services and products, then the problem will continue."

The development of a new provincial wetland policy, which has been on going since 2005, was cited as one example of the provincial government's unwillingness to prioritize environmental protection ahead of economic considerations:

"The dealings with the provincial wetland policy have demonstrated that there is a lack of political will in getting real progress implemented. Policies are not worth the paper they are written on if there is no stick associated with it. Typically, the short-term gain for a few developers or resource companies outweighs the long-term gain for communities by having appropriate riparian areas preserved."

g. Lack of Government Legitimacy & Capture of Government by Industry:

The perceived inaction of the provincial government to prioritize riparian land conservation or protection above the interests of industry has contributed to the perception expressed by many respondents that the government has lost the confidence of the public to effectively manage the environment:

> *"GOA pays only lip service to 'Healthy Aquatic Ecosystems', 'World Class Monitoring' and 'Cumulative Effects Management'. "*
>
> *"Political interference with the government's own departmental environmental advice and responsibilities i.e., muzzling of expert staff and their recommendations; no open, honest or transparent discussion."*
>
> *"GOA excludes the public interest and public trust from hearings, withholds public information, and imposes unfair time constraints on the public."*

The loss of legitimacy is not limited to the provincial government. Many respondents pointed to municipal governments as having lost the confidence of the public to effectively manage riparian lands, primarily due to the perception that development interests largely drive and control municipal politics:

> *"Even in those communities that have policies in place, one can see compromises time and time again where staff is overruled by political expedience of short-sighted politicians who are not necessarily endowed with a deep understanding of all issues involved"*
>
> *"There is a lack of authority of local governments to make land use decisions and such decisions are vulnerable to being influenced by local interests and short-term outcomes in absence of a land use framework which limits what can occur, where, how, and how much."*
>
> *"Municipal Government: Sec 60 of MGA states they are in control of the water bodies and what happens on the land. The elected representatives are not accepting that responsibility. They are not educated or knowledgeable in environment, water, or land conservation. They are intimidated by the corporations who behave as bullies and threaten municipalities with legal action as a development strategy."*

h. Inappropriate or Unrealistic Planning & Management Scales:

The temporal and spatial scales at which land use planning and riparian land management are carried out was frequently cited as a problem. Many respondents felt that the lack of large scale planning (e.g., watershed or regional scale) has seriously limited management success, and the lack of awareness with respect to how riparian lands interact with both upland and aquatic habitats has resulted in sub-optimal management outcomes:

> *"We focus on issues at the wrong scales. There is no appreciation of the importance of timescales beyond a few years and spatial scales beyond a single site."*
>
> *"Part of this hit-and-miss approach is there are too many funding bodies who seem to think the riparian management is about planting trees by a water body and do not support the cost of undertaking broad watershed analysis studies to understand the scope of the problem and where to focus resources to best address the problem in the short term and long term. Furthermore, funding programs are typically short termed and addressing the problem is long term, which is needed to support a watershed approach to riparian management."*

> *"There is a lack of a coordinated and integrated watershed approach (uplands, aquatic habitat and groundwater interface as part of riparian management). The current approach is still hit-and-miss, largely relying on individual landowners and local resource-stressed volunteer stewardship groups to take action on private lands."*

As well, many respondents felt that the temporal scale at which stewardship programs are rolled out, and the time period for which "success" of the program is measured, is inappropriate given that reclamation or restoration of riparian land is a long-term proposition:

> *"There is no effective, long term way to move from problem assessment/awareness to action/protection/enforcement. We need to acknowledge that ecological degradation is usually a slow and incremental process, and protection and recovery is also a slow and incremental process."*

> *"It takes time for people to change and for landscapes to respond: 3 to 5 years is the minimum, and often this is not enough time to see results that might show that improvement is happening, and thus, the perception is that it didn't work."*

> *"Another challenge is simply adequate time and resources to let improvements happen and recognizing that it will take time for riparian areas to improve, even once strategies/management changes have been applied. This time-lag is not often recognized in program development, delivery, and design, including government or other funding, yet it is critical to enable honest evaluation of success. It will take time (perhaps more time than people are willing to recognize) and yet we must keep adding to changes/improvements, as we wait for improvement to occur."*

i. Insufficient Compliance & Enforcement:

Finally, respondents identified a lack of enforcement and compliance with existing laws and policy as a serious barrier to improved outcomes for riparian land management in the province. Respondents felt that this lack of enforcement is related to both a lack of provincial government resources (personnel and money), as well as a lack of political will to follow through with enforcement action against those who violate existing laws and regulations:

> *"Alberta simply lacks any desire or system for the comprehensive compliance and enforcement to conserve these areas in the face of all the on-going pressures."*

> *"There is a lack of direction and enforcement by provincial government agencies in regards to supporting and promoting and or applying legislation already in place to protect private and public lands. (i.e., Public Lands Act s.60 Prohibitions and the Public Health Act)"*

Respondents also highlighted what they perceived as a disparity in the enforcement efforts of government, with a lack of enforcement directed towards agricultural producers:

> *"Recognizing some legislation already exists, the commitment to enforcing them is generally not there in terms of funds and manpower. The perception (and in some cases reality) is that even though laws exists no one is going to enforce them on small operators, the focus is on the big operators."*

> *"There is a lack of enforcement of legislation around riparian areas. Is the GOA willing to start cracking down on ranchers and farmers? I doubt it."*

5.2.4. Strategies for Improving Riparian Land Management Outcomes

The strategies put forth by respondents for improving riparian land management in Alberta are largely a corollary to the barriers identified above. In some cases, respondents provided very specific thoughts and recommendations for how to overcome the barriers they identified, while others offered more general thoughts and recommendations for consideration. The key themes and concepts expressed by respondents with respect to strategies that could be used to overcome barriers to improving outcomes or riparian land management included the following:

a) Improve coordination of governments, information, and programs
b) Increase public awareness and scientific knowledge
c) Provide clear guidelines, rules, and direction
d) Encourage conservation through incentives
e) Increase the capacity of government and other agencies
f) Update existing legislation, regulation, and policy
g) Increase government accountability & empower front-line decision makers to say 'no'
h) Utilize watershed scale planning & cumulative effects management
i) Improve compliance & enforcement of existing laws and regulations

a. Improve Coordination of Governments, Information, and Programs:

In general, respondents recognized that there are a number of programs that currently exist that have led to satisfactory outcomes for riparian land management; however, some respondents suggested that with better coordination and cooperation between the various agencies, even greater success could be achieved:

> *"There are already leaders in riparian management throughout the province, let's try to coordinate the efforts to make Alberta seen as a leader too."*

> *"I believe we have sufficient 'non-regulatory' tools to be successful now. We just need to use them in a more dedicated, integrated way."*

> *"There are many programs and organizations with fairly similar mandates that if they were combined would be more effective. This would mean some groups would have to compromise a bit to make this happen."*

Many respondents also suggested that the collection and dissemination of information should be better coordinated, such that it is more accessible to different organizations involved in riparian land management, as well as the general public:

> *"Create a website linking all the riparian programs and documents available for Albertans working in energy, agriculture, forestry, local municipalities, etc."*

> *"Implement databases that include projects undertaken as part of initiatives and results of projects, i.e., where have riparian health assessments been completed, changes in management undertaken, and on-going results of the riparian management. This would require volunteering information, which may not be desirable from landowner perspective but municipalities etc. would be good candidates for participation."*

In response to concerns about a lack of standardized approach and/or method for managing and measuring riparian health, several respondents suggested that the government adopt the approach and tools that are currently in use by the Alberta Habitat Management Society:

"Use of the Cows and Fish 'process' by all groups and agencies involved in riparian programming."

"End the intransigence of some government departments to the use of the Cows & Fish riparian health metrics."

In order to address issues of coordination of riparian land management between various levels and departments of government, a more direct and 'streamlined' approach to regulation was suggested by one respondent:

"Develop a 'one-window approach' for riparian regulatory tools and processes, like being developed under the provinces Regulatory Enhancement Project. It is conceivable that riparian legislation integration could be one element of this body. Failing that, establish a cross-ministry (federal, provincial, municipal, local) governance body to oversee, integrate, and guide shared policy driven delivery of riparian education, compliance, and enforcement."

"Better communications between GOA departments and agencies is needed to develop effective policy - ensuring that riparian protection is an important consideration in the development and delivery of regional land use plans."

"Promote consistency in riparian management policy across jurisdictions who permit or manage land and water use. Make a dedicated effort to promote this policy and support it through associated stewardship and conservation implementation programs to make effective changes on the ground."

b. Increase Public Awareness & Scientific Knowledge:

Respondents identified a lack of public awareness around the value and importance of riparian lands as being a major barrier to improving conservation outcomes. Many of those who provided suggestions for improving outcomes recommended that greater efforts be placed on developing focused education and outreach strategies that are sufficiently resourced:

"Recognition that awareness programming is the fundamental step that has to occur first and that staff have to be adequately trained to be effective, credible messengers."

"There needs to be more open dialogue with Albertans, more awareness-raising of what riparian lands and functions are, how they contribute to our environment and communities, what the costs are of preserving them vs. the risks and causes of continued degradation."

Several respondents specifically identified a need for more targeted awareness building and education for large and small municipal governments:

"Better education of Urban and Rural Planning Staff as to the ecological functions of riparian areas and appropriate science based methods for developing adequate riparian buffers and/or adequate networks or corridors of interlinked riparian habitat."

"Educational programs and initiatives not only to landowners but also to municipal planners, recreational development planners, recreationists, schools, and the general public."

In addition, many respondents suggested that there is a lack of both natural and social science information around riparian land extent, health, and function in the province. This includes a need for better mapping of the location and extent of riparian lands, as well as a prioritization of important habitats.

"Dedicated social research into the cause of riparian owner/user management choices, positive and negative, using an environmental indicator (e.g., riparian area 'health and integrity' is correlated to social choice and the rationale used when those choices were made."

"Municipalities should identify and map all significant public lands, water resources and lands in the vicinity, including all natural water bodies such as rivers, streams, lakes, watercourses, aquifers, riparian lands, wetlands, flood zones, reserve lands, natural recharge and discharge areas located within its jurisdictional boundaries."

"Increased emphasis on riparian health surveys across the province to determine the state of riparian areas, particularly on major rivers and their tributaries."

Finally, several respondents highlighted the need for better baseline information, and more appropriate technical tools, such that outcomes can be better monitored and decisions can be better informed by appropriate information:

"Implement unbiased qualified monitoring of baseline conditions and existing and future destructive activities, and make all monitoring and cumulative impacts data freely available to the public."

"Better hydrological data layer is required."

"Promote the development of layers of watershed inventories to better understand available ecological assets and their interconnection, as well as to document current land use to establish a baseline understanding of what we are trying to manage."

c. Provide Clear Guidelines, Rules, and Direction for Riparian Land Management:

Many respondents highlighted the need for more clear and concise guidelines for riparian land management in the province. Respondents feel that much of the confusion and lack of coordination that currently exists around how riparian lands are managed is manifest out of a lack of clear "rules" or direction for decision-makers:

"A clear and concise regulatory standard that provides direction for industry, municipalities, and private landowners and other users regarding conservation/preservation, maintenance and restoration of riparian areas in Alberta."

"Reduce the number of discretionary provisions in the regulations."

In particular, respondents cited the riparian setback distance as one area of policy or regulation that could be better articulated with respect to what the expectation is around how setbacks are determined, and what that setback distance is, particularly in municipalities:

"Develop a provincial policy framework for the conservation of riparian lands in municipalities and on public lands with clear articulation of the required setbacks based on riparian function and values to habitat and watershed health objectives."

"Clearer policy statements to or from municipalities would allow planners to facilitate riparian conservation."

"In the urban context, the move from prescriptive (standards) code to PERFORMANCE and FORM-BASED code, where every site is INDIVIDUALLY studied by appropriate consultant/experts and designed (including mitigation) to meet minimal performance, would be a start. An example relating to the hydrology of riparian areas (particularly our ravine system, which constitutes about 80% of Edmonton's riparian length) would be to scrap the current "top

of bank" prescriptive (one-size-fits-all) standards which create the City's single largest compromise to ravines - and replace them with short, easily stated, conservation (performance) goals."

d. Encourage Conservation Through Incentives:

A large number of respondents suggested that riparian management outcomes in Alberta could be improved by creating incentives for riparian land conservation. The type of incentive suggested varied, but there was general agreement that private landowners often incur financial risk or forgo financial opportunities to pursue riparian land conservation activities, and many respondents felt that offsetting these costs through incentives would result in improved outcomes:

"Fund incentive programs that help landowners improve riparian management, and support local extension based programming and WPACS who are assisting extension agents with targeted BMP implementation with better funding."

"Put yearly incentives in place for farming/ranching along riparian protected spaces so farmers/ranchers are rewarded for installing fencing or buffer zones that enhance the stream banks to an adequate number of metres from the water way."

One particular type of incentive that was mentioned by several respondents included a tax credit for setting aside riparian lands for conservation. Currently, private landowners in Alberta are taxed on all land, regardless of whether the landowner has taken land out of intensive production and has set it aside for lower impact activities or conservation. Changing how land is taxed was suggested as one way to improve conservation outcomes:

"Government needs to create a program that rewards landowners for protecting riparian areas. The assessment and taxing structure could have an additional 3rd category, for example: 1) Market Value, 2) Agricultural Use Value and 3) Conservation Value. Conservation value could be taxed at a rate closer to the agricultural use value so producers aren't forced to develop farms or continue to farm to enjoy a tax haven. We should be encouraging conserving valuable lands not penalizing for it."

"Transfer of tax credits. Unless you have a very large income, tax credits from conservation easements are often of little benefit. If one could sell these tax credits, more agricultural operations would be in a position to benefit."

While many of the respondents supported the use or creation of incentives for riparian land management, there were others who viewed this issue in a different light. One respondent articulated the need to better account for the true cost of development activities that impact riparian lands, such that these costs are not simply viewed as externalities:

"Charge real fees and taxes for riparian land and water use that reflect real costs of protecting and maintaining them. Real costs include law and regulation enforcement, monitoring and surveillance, access controls, signage, and court time where required."

Still another respondent cautioned against relying exclusively on economic incentives when other tools, such as regulation and moral persuasion, can be used as an alternative:

"I caution against using financial incentives where regulation is possible or there is Crown ownership -- people should not be paid to do what they are legally or morally obliged to do (though awards and recognition for superior behavior are, of course, acceptable and should be encouraged)."

e. Increase the Capacity of Government and Other Agencies:

Many respondents recognized that riparian land management in Alberta is a complex task, given the diversity of users and actives that occur on the landscape. This complexity requires not only clear and concise regulatory and policy direction, but also the human and financial capacity within the provincial government to carry through with education programs, enforcement, and monitoring activities:

> *"Any riparian policy or planning initiative in Alberta should allow for resources to fund staff and programs that are instrumental to on-the-ground action and awareness. Policy statements without implementation or monitoring mechanisms are essentially futile."*

> *"More resources should be made available to the departments in charge of managing public lands so that they can actually evaluate leaseholder riparian management, and where there are problems, they should enforce changes or fines."*

While the government has a clear role to play in the development and enforcement of law and policy, respondents also recognized the important role that other non-governmental organizations play in the management of riparian land in Alberta. Many respondents felt that these organizations require additional financial support in order to maintain or increase the level of service that they currently deliver:

> *"There is a need for ongoing funding and support for Watershed Stewardship Groups, WPACs, NGO groups, and on-the-ground community based initiatives that further riparian awareness and research programs in support of improved riparian management and stewardship."*

> *"Increase direct grants and educational opportunities to livestock producers to fence and install offsite watering, also to Cows and Fish to educate and do assessments, and increase monies to WPACS for planning and distribution to stewardship groups to restore areas formerly disturbed."*

Providing additional resources to municipalities in the form of qualified and knowledgeable personnel was also cited as a way to improve riparian land management outcomes in Alberta:

> *"Municipal Affairs needs to provide more support to small governments like summer villages or MD's where riparian areas need to be conserved/managed (e.g., around our lakes small areas are governed by summer village councils that have full authority to grant development permits along the lake shore). Make sure they have someone to draw on to make the best decision for the area and not just say yes to whatever development is being proposed."*

> *"More Rural Extension Specialists out there talking to landowners. The AESA program started this and it has been hugely successful in many counties. But some counties do not have them anymore and so there is no one out there on the land everyday chatting with landowners, working with Cows and Fish to do health assessments and then helping get projects on the ground. Change happens through direct contact with landowners not advertisements in a newspaper. There needs to be a Rural Extension Specialist in each County again."*

f. Update Existing Legislation, Regulation and Policy:

Riparian land management in Alberta is currently being achieved through a number of existing laws, regulations, and policies, and several respondents suggested that updating some of these existing policy tools could bring about better outcomes for riparian land conservation:

> *"The second objective in Water for Life, i.e., protection of aquatic areas, should be broader and be expanded to include riparian areas. Right now, the emphasis is too much on fish - we need healthy riparian areas to have healthy river systems."*

> *"Update the MGA with an appropriate setback from water bodies. A "minimum of 6m" is normally interpreted as 6m only. This is not nearly enough."*

Several respondents also suggested that the Alberta Land Stewardship Act (ALSA) provides new opportunities for riparian land management through regional plans, which would then direct the management of riparian lands at more local scales:

> *"As a part of regional plans under the land use framework there needs to be specific riparian management goals that will then be added into municipal bylaws by local government and can then be enforced on a local scale."*

One respondent, however, felt strongly that the opportunities presented through ALSA are currently constrained by the existing water allocation system, and changes to the water management system is needed before the full potential of ALSA for riparian land management can be realized:

> *"To integrate riparian conservation and health into ALSA requires flexibility in Alberta's water allocation system and under conservation offsets that enable landowners and downstream/upstream water rights holders to adopt innovations voluntarily. This will most likely achieve better results for environmental outcomes should those outcomes be stated in a clear evidence-based in stream flow needs policy."*

Finally, several respondents suggested that the adoption of a province-wide wetland policy would go a long way towards improving riparian land management in the province:

> *"A provincial wetland policy that halts further loss of natural wetlands and enables some level of their restoration. That single act would address most issues of loss of riparian areas."*

g. Increase Government Accountability & Empower Front-line Decision Makers to Say 'No':

Increasing government accountability was brought forward as a strategy to improve outcomes by several respondents. This increased accountability could come in the form of stronger department mandates for managing public land, and more open and transparent reporting and monitoring programs:

> *"A stronger provincial mandate is needed to show leadership with respect to appropriate use and management of Public Lands to ensure protection of public resources (fish and wildlife habitat, headwaters protection etc.)."*

> *"More transparent reporting and independent monitoring mechanisms to ensure accountability with respect to intensive, large scale industrial development (forestry, oil sands development etc)."*

Increased government accountability can also come through providing government decision makers with regulatory and policy tools for denying development applications or permits. Some respondents also indicated that decision making authority should also be extended to include non-governmental organizations such as Watershed Planning and Advisory Councils (WPACs):

> *"Empower approvals officers to refuse applications for destructive activities."*
>
> *"WPACs should get more powers, similar to Conservation Authorities in Ontario or regional watershed organizations in other parts of the world. If we don't want to go there, AENV and SRD should get more powers (including manpower) to deal with these issues."*
>
> *"Government must eliminate the 'consensus' approach to decision making that they impose on the government implemented bodies such as the Alberta Water Council or others. The consensus approach works best in theory but when there are stakeholders that do not want these initiatives to succeed it is very easy for them to undermine their success with stalling tactics, avoidance and fixed contrary positions that do not yield to the concepts of compromise or the greater good of the province."*

h. Utilize Watershed Scale Planning and Cumulative Effects Management:

For several of the respondents, the successful riparian land conservation requires management at larger spatial scales, and should include consideration of other ecological landscape components:

> *"Promote riparian land management within a watershed context that takes into consideration uplands, nature of water body and groundwater aspect that link to and support riparian areas. Riparian areas are transition landscape units, hence understanding their terrestrial-aquatic-subsurface interconnection is part of the management strategy."*
>
> *"Place riparian conservation within the land-use context and ensure that it is incorporated into land use planning. We tend to target individual components in the environment (e.g., groundwater, or wetland, or riparian areas, or energy use, etc.), and we need to really get the sense of how riparian areas fit into the broader environmental picture and how to approach conservation in a more holistic way that recognizes the balance between environment and economic development."*

Within the context of watershed management, several respondents articulated the need for nested watershed planning, whereby municipalities are responsible for planning and management activities within their municipal boundaries, with the goals of these municipal plans directed by targets set out by larger watershed-scale plans:

> *"Master Drainage Plans should be prepared for all municipalities. These should be based on watershed and sub-watershed targets for all watersheds within the White Zone."*
>
> *"Municipalities in the White Zone should prepare Open Space/Green Space plans identifying wetland and stream riparian lands of interest and preservation. Subsequently, municipalities - i.e., not by consultants working on behalf of developers at the time of development - should establish riparian setbacks."*

Consideration of cumulative effects, as well as natural disturbance regimes, was also identified as being important for improving riparian land management outcomes:

> *"Although it may be impractical to limit rate of development, we need to develop a strategy that limits the impact we have on riparian areas that accounts for the combined use of all sectors,*

not each sector individually. The impact of development form one sector may not seem like much but when combined with all others the result is loss of a critical amount of riparian areas."

"Alberta has an opportunity to develop a riparian management approach that incorporates the latest science which points to approximating natural disturbance regimes as the best way to maintain healthy ecological function over the long term."

i. Improve Enforcement and Compliance:

Respondents frequently cited the need to improve enforcement and compliance of existing laws, regulations, and policy:

"Replace the self-regulation and reporting model for addressing non-compliance. Alberta is very soft on those who are non-compliant. Apply similar standards across industries. Identify key pressures by region, assess conditions, involve stakeholder groups and hold them accountable."

"Enforcement of existing laws needs to occur; there are some individuals that will never change and are impacting water quality. The industry is only as strong as its weakest link and until some of these blatant polluters are dealt with, the industry's reputation is at risk."

5.2.5. Success Stories

While this survey was focused on uncovering the barriers and challenges that limit riparian conservation success, there were several respondents who pointed to success stories:

"My heroes for riparian management are Cows & Fish who I first met in 1998. They have changed my entire perspective in not only how I manage our riparian areas, but also the entire farm. Their 'awareness' is double-barreled and all encompassing. They are, without a doubt, the best success story in the conservation side of agriculture."

"I'm not sure that I can identify barriers, so much as suggest that the most effective programs are aimed at voluntary participation, rather than legislation. We need to work with our neighbors, to demonstrate the benefits, and assist them in installing suitable systems. Red Deer County has done a good job with its Off the Creek Program, providing financial assistance to landowners to implement protective systems. I think that for long-term protection we need to have the landowners buy into the benefits and voluntarily maintain the systems."

5.2.6. The Need for a New Provincial Riparian Policy

When respondents were asked whether they thought there was a need for a new provincial government to direct riparian land management in the province, the overwhelming majority was in favor of adopting a new policy (Figure 5.3). Support for a new riparian policy ranged from 68 to 83%, with the lowest level of support coming from those who specified their organizational affiliation as "Private Industry", and the highest level of support expressed by those who specified their organizational affiliation as "Academic Institution".

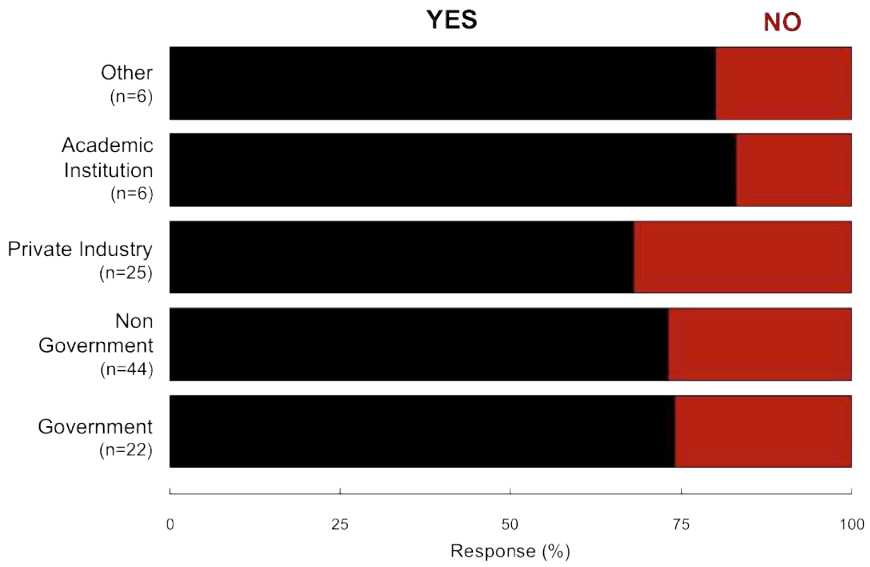

Figure 5.3. Percentage of respondents by organizational affiliation who answered 'yes' or 'no' to the question of whether the province of Alberta should develop a new riparian policy.

5.2.7. Support for a New Riparian Policy

When respondents were asked to elaborate on their reasons for why they thought the province needed a new riparian land management policy, two major themes emerged from the data, including the notion that a new provincial policy would create greater clarity for both regulators and the regulated community:

> *"At present, the MGA and Watershed Management frameworks are not clear or impactful enough. A new policy would integrate with provincial mandate for water courses and water quality protection and would help standardize approaches across jurisdictions and likely accelerate uptake of best practices."*

> *"A provincial policy would ensure that riparian areas are managed consistently in all sectors. There is a concern that riparian area protection might be lost if it is left up to larger scale initiatives (regional land use plans) to implement riparian protection measures."*

> *"The Province should take a leadership role and provide direction for Albertans to follow. Currently municipalities are left to develop their own policies and procedures (and kudos to them for taking the lead), leaving riparian conservation open to interpretation. These policies and procedures are being developed by individual municipalities, leading to inconsistencies in approach and some confusion for landowners and industry. The Province should provide clear and timely direction on how riparian lands will be managed and conserved."*

> *"I say yes with some trepidation as my confidence in policy as a panacea is pretty well extinguished. That said, Alberta needs a tool for all types of riparian area managers - recognition for the leaders, incentives for the 80% that is average, and a legislative hammer for the 5-10% who will not conserve riparian areas no matter what. A meaningful policy would provide greater clarity and direction, which would be beneficial."*

The second major theme that emerged from the data was that a new provincial riparian policy could be developed to fill important gaps in existing laws and policy:

> *"The current Public Lands Act does not even mention 'riparian', and any reference to water is specific only to title, or watershed capacity, or bed and shore. Wetland Policy does not specifically address riparian areas adjacent to the more distinct channeled watercourses. Municipal Government Act only refers to the direction, control and management of water bodies. There is a need for policy more specific to the protection of the riparian feature."*

> *"Public Lands Act is limited to 'shore' and may not equate with riparian management (via Surveys Act), i.e. there is a need to assess whether the shore adequately captures 'riparian' sufficiently. More problematically the Public Lands Act is not enforced; of the instances of prosecutions it appears the federal government has usually taken the lead (under Fisheries Act), interim wetland policy only includes white (settled area) and has broad allowances to impact riparian lands, and MGA leaves it to municipal discretion (which may not have the scientific capacity and motivation to alter the status quo). None of these instruments have proven effective, either through lack of enforcement, excessive discretion, or inadequate policy approach to ensure conservation of riparian lands."*

> *The current legislation does not provide enough means for protection of riparian areas. The Public Lands Act for ownership of the bank and shore is not enough of a buffer. Interim Wetland Policy does a poor job of actually conserving wetlands, let alone surrounding lands, and the MGA is interpreted as only requiring 6m setbacks. The only good tools have been municipally led policies that require greater setbacks upon subdivision (e.g., Calgary, Rocky View County, Lac la Biche County). The province should be leading the appropriate management of riparian areas as they are responsible for the management of water quantity and quality, both of which are affected by appropriate land and riparian management."*

It is important to note that within the group of respondents who responded positively to the question of whether the province needed a riparian policy, there was a small minority who qualified their answer. These respondents suggested that with improved enforcement and compliance, or with modification to existing laws and policies (such as the Municipal Government Act), improved riparian land management could be achieved without the development of a new riparian policy:

> *"We have wetland policy in this province that prohibits drainage of wetlands with penalties. Wherever I go I see farmers draining wetlands in full view of the road or highway year after year with no apparent penalties. I read about wetlands being drained in all prairie provinces with not even a slap on the wrist. If the wetland policy has no teeth, why would you bring forth policy on riparian areas unless it was going to be enforced?"*

> *"Perhaps the existing legislation could suffice, but probably not without revisions. Minimally, the authorities behind these Acts and policies need to show more willingness to implement them and wield their powers over (i.e., enforce) the provisions contained within them."*

> *"Current legislation and policies affecting use of the public land portions of riparian areas appear to be adequate, as are policies affecting oil and gas activities adjacent to water bodies, and for protecting fish habitat. What is needed is an amendment to the Municipal Government Act to keep new development further than the current six metres from permanent water bodies. Scientific studies from around the world have shown that six metres is not enough to prevent pollutants such as nitrogen from entering surface waters. A provincial policy that discourages new development on the floodplain portion of riparian lands is also needed, and to encourage relocation of development that is at high-risk, as opposed to paying compensation for flood damage."*

5.2.8. Opposition to a New Riparian Policy

Those respondents who were in opposition to a new provincial riparian land management policy reiterated the notion that sufficient law and policy already exists in the province, and that greater effort needs to be placed in enforcement, rather than on developing new policy:

> *"Policies add counterproductive layers of complexity to legislation. What is needed is for GOA to enforce existing legislation, rather than continually looking for means to evade or castrate Acts designed to protect communities and ecosystems."*

> *"The policies that are in place just need to have more punitive teeth and a willingness to apply these teeth. Some tweaking may be needed but the bones are good."*

> *"Current regulations just need to be enforced. If environmental reserves were enforced there would be a significant decrease in riparian impacts. Creating a new policy that will not be enforced does not fix the problem, just need to enforce current policy and regulations."*

Apprehension over the development of a new riparian policy was also linked to the concern that in an effort to try provide a policy that was sufficiently flexible enough to address all areas of the province and all land uses currently impacting riparian lands, that the policy would inevitably be so vague that it would be ineffective at providing direction for management:

> *"A provincial policy would be too broad and would not be specific enough to deal with the various land types and management. Just the differences between the Green Area and White Area alone would lead to a vague policy. Each land management type (forestry, agriculture, oil and gas) has a different impact on riparian areas and their management is going to be unique."*

> *"The risks and potential long term effects are very different and would be hard to manage under a single policy. The white area is vastly different again in the uses and pressures put on riparian areas and lumping them under a single policy would most likely create a policy that is the average and doesn't have the flexibility or protection required for the diverse users out there."*

Finally, several respondents felt strongly that riparian land management should not be teased apart from the management of larger ecosystem function and process, but rather, more effort should be put into the management of riparian lands as a component of a larger watershed and landscape:

> *"Stop trying to make 'riparian management' a special, unique issue. Integrate water and riparian management with the management of the rest of the landscape."*

> *"The protection of riparian areas should be incorporated into land use planning frameworks so that a more holistic approach is enabled. New policies developed in isolation from the broader perspective tend to fail and not be implemented because in isolation they are seldom realistic."*

> *"Stop managing ecosystems in pieces - yet another new guideline or policy will only make it worse. Alberta needs an effective provincial policy on how to manage landscapes FIRST."*

5.3. Summary

Results from this survey suggest that while the majority of stakeholders believe that riparian land management on both private and public land needs to be improved. While many of the respondents recognize the value of the work that has been, and continues to be done by the many organizations engaged in riparian land assessment and management, most feel that there are significant barriers to realizing an adequate level of riparian land conservation or protection. Many of these barriers are institutional in nature, and would require investment of both human and financial resources in order to move riparian land management forward towards the goal of improving conservation and stewardship of riparian lands.

In the minds of many respondents, introducing a new provincial riparian policy would go a long way to improving riparian management in the province. However, it is important to note that many of those respondents who supported the idea of a new riparian policy also acknowledged that improved riparian management outcomes could likely be achieved through better enforcement and implementation of existing law and policy. Several respondents also noted that small changes to existing laws and policies, such as the Municipal Government Act or the Public Lands Act, could result in improved outcomes without the need for a new riparian policy. Still others pointed out that the development of a new riparian policy would be effective only if it was accompanied with the human and financial resources required to ensure that it was properly and effectively implemented. Regardless of how respondents felt about the need for a new riparian policy, there was overwhelming consensus that riparian lands are important ecosystems components, and that more attention and effort needs to be placed on the conservation of these habitats

6. Alternative Approaches and Tools for Managing Riparian Lands

The building blocks for the successful management of riparian lands in Alberta are in place, be they science-based assessment tools, economic incentives, stewardship programs, or policy and regulation. Therefore the aim of this chapter is not to offer a comprehensive list of alternative approaches and tools for managing riparian lands that would replace the current system. Instead, this chapter focuses on providing alternatives that consider the gaps and limitations of riparian land management in Alberta that have been identified in previous chapters. As such, this chapter focuses on providing examples of innovative scientific, economic and social approaches and tools that have been summarized from other jurisdictions and the scientific literature. It is important to note that this chapter does not include an exhaustive list of alternatives, but rather, focuses on the gaps and limitations determined to be the most limiting in the efforts to improve outcomes for riparian land management in Alberta.

6.1. Scientific

Science is at the root of many natural resource management programs around the world, in the form of principles, tools, and techniques that are based on the central ideas of repeatable measurements using standard methodologies and a system of falsifiable conceptual models. Two critical pillars of science-based management are the conceptual frameworks driving management programs and the assessment tools that measure management outcomes.

6.1.1. Conceptual Approaches

The fundamental goal of riparian management programs is the protection or restoration of the structure and function of riparian lands (Figure 6.1). Protection entails either preservation or maintenance, whereas restoration is the process of repairing the condition of degraded riparian lands. As the data on assessments show, approximately 75% of the sites assessed for riparian health in the province of Alberta show signs of degradation and may need restoration.

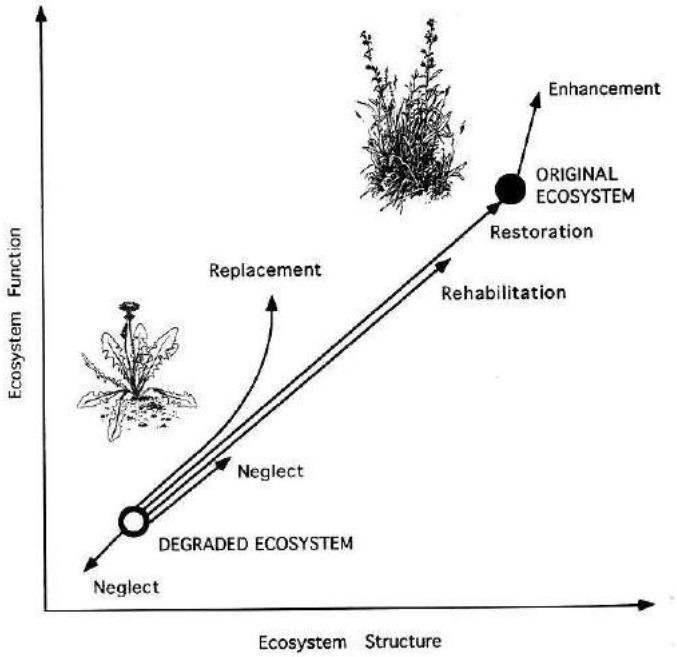

Figure 6.1. Degraded and restored riparian ecosystems and the trajectories that connect them (from Bradshaw 1984).

There are three main ideas driving the current scientific thinking behind management frameworks with the goal of achieving healthy ecosystems. These ideas are:

a. Thinking in systems,
b. Incorporating natural variability,
c. Integrating the management of ecological and social systems.

These three ideas are not new, but they are worth emphasizing repeatedly because so much of Western thought about how we interact with nature has tended to reduce natural systems into component parts, which are managed for the maximization of one ecosystem function (e.g. yield

of a resource), and have generally left out either nature (e.g. traditional extractive industries) or the human component (e.g. fortress conservation) of management strategies. Successful management of riparian lands in Alberta will need to fully embrace these ideas. Although most management plans may discuss these critical ideas, they vary in strength in actually implementing them.

The first key idea is that riparian lands are embedded within a larger system - the watershed - with which they interact in different physical, chemical, and ecological ways. What happens on terrestrial land upstream of riparian land has very large implications on riparian structure and function, as well as downstream aquatic processes. Focusing just on riparian lands at the expense of upland terrestrial lands can result in surprises. For example, riparian lands that are considered healthy (i.e. functioning with no impairments) may have large nutrient inputs from adjacent uplands by-pass them through preferential surface or sub-surface hydrological pathways, resulting in large negative impacts on downstream aquatic ecosystems.

As the definitions of riparian lands presented in the first chapter stressed, these lands are transitional between aquatic and terrestrial ecosystems, and as such, are part of a continuum of processes that are interdependent, and need to be managed as such. Riverine systems also have a longitudinal component, which means that upstream impacts may totally overwhelm the healthier reaches downstream. As a result of these long distance and cumulative effects, there is growing recognition that the management of terrestrial and aquatic ecosystems needs to be integrated within entire watersheds. Riparian land management, as it deals with both terrestrial and aquatic facets of ecosystems, is the logical place where the two may be reconciled and brought under an integrated watershed management system that treats ecosystems as continuums.

The second key idea in ecosystem management is the incorporation of natural variability in achieving some prescribed ecosystem state or functionality. The best illustration of this concept is to consider hydrologic flow in rivers. Numerous studies have now shown that it is not enough to manage for total flows and average flows, but that extremes - low flows and high flows – are critically important in maintaining ecological processes (Poff et al. 1997). In practical terms, the natural range in flow needs to be assessed for non-impacted systems, and management of flow needs to target the bounds of the natural range of variability (NRV). The natural variability paradigm thus aims to manage for ranges of certain ecosystem attributes, be they hydrological flows, biodiversity indices, or disturbance on forested lands. Emulating natural disturbance regimes is now a key component of forest management in many landscapes, including riparian lands (Sibley et al. 2012).

The management challenge comes in estimating the NRV given the ubiquitous nature of anthropogenic effects. It is difficult to find reference systems that are ‘pristine’. The second major difficulty in finding reference conditions is historical (long-term) evolution of ecosystems, which may mean that the shorter-term natural ranges are constantly changing, resulting in moving baselines. On top of these challenges, climatic change is pushing many systems out of their historical ranges, so the critical question is: What baseline do we select as the basis for management? Nonetheless, accepting variability in the management of natural systems is a must, and managers need to consider the latest scientific findings when incorporating this key concept into management plans.

The third key idea is that humans are an integral component of most ecosystems around the world, and we can no longer think of management regimes where human activity is considered outside of ecosystem function. Management needs to revolve around socio-ecological systems (SES) that takes the view that for healthy ecosystems, the processes of all ecological, physical and chemical systems as well as the needs of humans (physical, social, economic, and spiritual) needs to be considered (Berkes and Folke 1998). Clearly, tradeoffs need to be made in the management of natural resources, but neglecting either side of the equation could result in undesired outcomes that can threaten the stable (fluctuating within the range of natural variability) functioning of the entire system. As a result, this conceptual approach emphasizes the emergent property of resilience, which is the ability of systems to respond to change in such a way that does not compromise the overall structure and key functions. If a riparian system can keep its most important functions and overall structure in the face of perturbations (e.g., drought or dewatering by a dam), then the system is resilient. Central to the concept of resiliency is the idea of redundancy. For example, high biodiversity means that there are multiple species that can fill similar ecological niches; therefore, if individual species are lost, others can fill the ecological vacuum left behind. A statement of commitment to ecosystem-based management (EBM) is now common in many government and corporate policy documents both around Canada and in Alberta. Now is the time to fully embrace the central tenets of ecosystem based management and put it into action, not only for riparian ecosystems, but all of Alberta's ecosystems.

6.1.2. Technical Tools for Assessing and Monitoring Riparian Lands

Assessing the status of riparian lands is a fundamental component of management. We need to be able to measure the extent and health of riparian lands on a consistent basis across space (all watersheds of Alberta) and across time (over many decades). Assessment of status (extent and health) tells us whether we are on track in terms of our management goals and alerts us of potential new effects. Assessment is needed at a variety of scales to inform different stakeholders (Figure 6.2). For example, assessment at the site-level and at the scale of the reach informs local property owners, municipalities, and industry groups about the status of their riparian lands. As one increases scale to the watershed and regional level, the parties more interested in the status of riparian lands across these larger units are higher levels of government, WPACs, and non-governmental agencies. Assessing riparian status at these different scales require different tools. Consequently, successful management of all riparian lands across Alberta will need a framework of assessment tools that creates reliable and comparable data at the various scales. In the following section we discuss some of the tools that could be used to assess both the extent and health of riparian lands at various spatial scales.

a. Assessment at Site and Reach Scales

Alberta, like some of the neighboring provinces and states, has adopted a rapid assessment method based on the conceptual approach of Proper Functioning Condition that grew out of work by USDI (1998). There have been many adaptations of this questionnaire-based method that is conducted by trained evaluators in the field, and it now includes a much stronger biological component. Given that this tool uses ocular estimation, adequate training must precede its use, such that practitioners consistently apply the methodology and estimates are standardized and comparable. As the tool is increasingly applied in more northerly and forested regions of Alberta, particular attention will need to be given to new circumstances arising from changes in physiography. Organizations such as ARHMS provide a vital educational service in this regard.

One way this assessment method could be improved upon is by expanding the zone of observation to include the aquatic as well as the terrestrial upland zone. Looking downstream and upland would complete the consideration of the entire hydrologic system, at least from the vantage point of riparian lands. Given that the *ARHMS-Riparian Health Assessments* are fully developed, expanding the observation could come in the form of surveys dedicated at assessing the stream itself. An example is the Stream Visual Assessment Protocol (SVAP) that has been used successfully to assess the stream condition in Montana (Miller 2005). In addition, in-stream assessments of biotic integrity in the form of aquatic invertebrates could add a substantial amount of information, since this species assemblage is an ideal candidate for tracking the cumulative effects of land use and other anthropogenic effects along a river system. SVAP assessments could be performed by the same team collecting the riparian assessments and at selected sites (based on the results of the SVAP), in-stream measurements of aquatic invertebrates could be conducted. Collecting multiple layers of information along the watershed continuum would go a long way in addressing the needs of integrated watershed management.

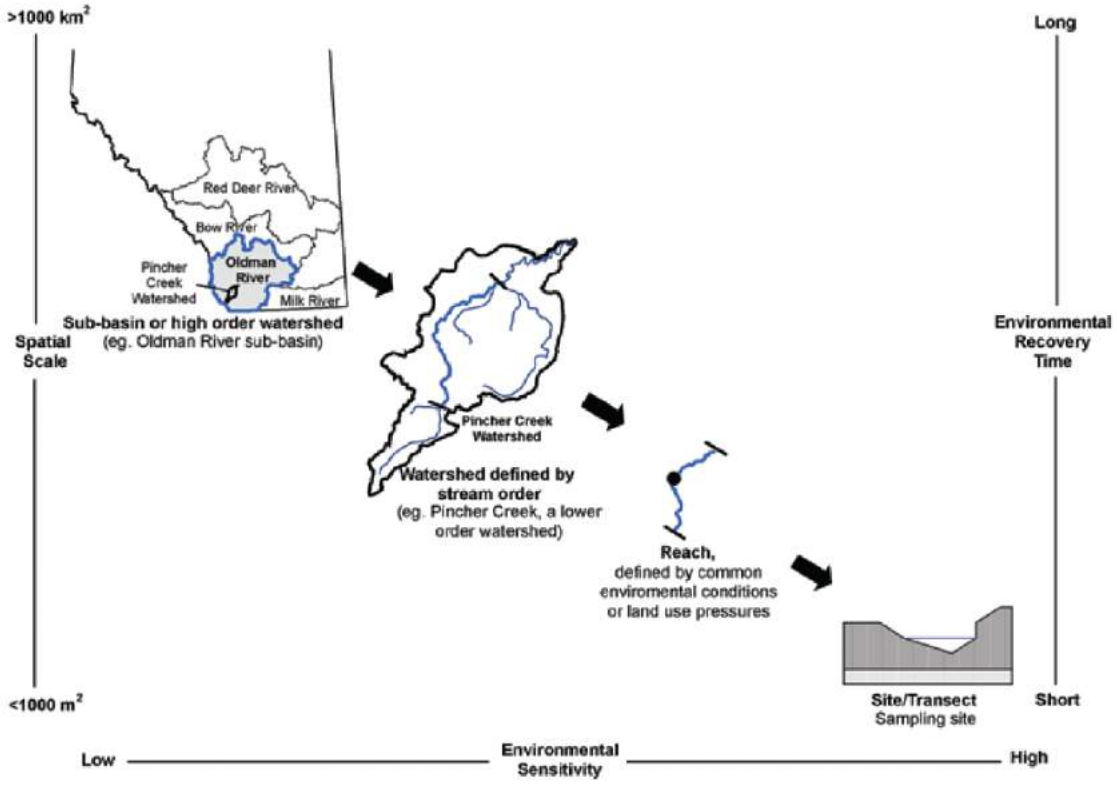

Figure 6.2.. Range of spatial scales at which assessment of riparian lands needs to take place (from AENV 2008).

b. Assessment at Watershed and Regional Scales

Moving up in scale, ground-based methods become very expensive and impractical from logistical considerations when trying to sample entire watersheds. Low-level videography has been the tool of choice to sample entire hydrologic systems in Alberta, especially in the Lesser Slave Lake region. As with any tool, low-level videography has its strengths and weaknesses. Given its oblique vantage point, it cannot be used to assess the same suite of indicators as in a ground-based assessment tool and offers a coarse assessment that can give focus to areas

where more detailed ground-based assessment is needed. For example, a forested reach with little other human influence might need only a handful of field-based assessments to validate the remotely sensed health assessment. A very valuable exercise would be to go down the list of indicators and test the efficacy of the remotely sensed methods in a number of different places across the province using a large enough sample size to be able to make valid inferences. This would clearly demonstrate how the field and remote sensing tools compare. Once these ground-truth datasets are in place, remote sensing of given components of riparian health (vegetation cover for example) can be made across larger regions without further ground checks.

c. Remote Sensing

Other than low-level videography remote sensing methods have not been tested for riparian land management in Alberta, although there are now efforts underway in the City of Calgary and in the Vermillion watershed to develop such tools. The reasons have to do with both the remote sensing tools themselves, as well as the perception of what remote sensing may offer for natural resource management.

The reasons for why remote sensing tools have not been extensively applied to the assessment of riparian lands in Alberta and around the world is that the earliest remote sensing imagery were too coarse in spatial resolution (25m or greater), or had limited spectral range (e.g., black and white photography). The past decade, however, has seen an explosion of new instruments with much higher spatial resolution (sub-meter in many cases) as well as a greater diversity of spectral information (optical, microwave, and hyperspectral) (Goetz et al. 2006). In temporal resolution as well, the newer systems have quicker repeat times between image acquisition of the same part of the earth, some of it due to sensors that can be made to 'look' in different directions. In short, there are now ample satellite and aerial images of riparian lands that can be used to detect different aspects of those lands.

Unfortunately, the negative perception of remote sensing grows when people make false claims about what a sensor can and cannot detect. In most remote sensing applications, variables of interest cannot be measured directly, instead inferences have to be made based on established correlations between spectral measurements (e.g., reflectance) and a variable of interest (leaf area index); consequently, the analyses are subject to uncertainty. Despite this, as long as the uncertainties still fit within the accuracy requirements of the question at hand, remote sensing data offer great value. Although remote sensing tools have been recognized as useful for mapping the status of riparian lands (Goetz et al. 2006), there are limited number of studies in the scientific literature and correspondingly in riparian management case studies, mostly for the reasons outline above. Here we will discuss some of the systems available for remote sensing different components of riparian lands.

Aerial Photography

While aerial photography has always offered exceptional spatial resolution, the important missing component was the different spectral channels, and in particular, the infrared channel. Whereas most recently acquired photography is acquired in colour (much better than B&W photography), very few systems have infrared bands. Infrared bands permit the mapping of vegetation extent with great accuracy and therefore are invaluable. Building on the work of USDI (1998), the US Department of the Interior developed a riparian health assessment using the Proper Functioning Condition approach based on the analysis of infrared photography (USDI 1994, 1996). The cost of acquiring infrared photography across the province may be cost

prohibitive; however, piggy-backing with other projects could make it affordable. For example, the grassland vegetation inventory uses infrared photography, and this program could be extended across the province. Real savings could be achieved if multiple instruments were placed on airplanes, such as placing an infrared camera on board with other instruments such as LiDAR sensors used for collecting high-resolution topography data. In urban areas, infrared photography might already be established and could be utilized to map riparian vegetation extent in these areas.

Satellite Remote Sensing

There are now a plethora of high resolution sensors including IKONOS, Quickbird, SPOT, and OrbView although not all of them have the critical infrared band that is very useful in differentiating vegetation from other land covers (Sass and Creed 2011). SPOT is one sensor that does have the infrared bands with a 2.5m spatial resolution, which is slightly coarser than the other high resolution systems, but is still useful in detecting riparian vegetation and other land cover types. One SPOT image covers approximately 2500km^2 and is therefore applicable to regional mapping, whereas aerial photos would be more applicable to mapping individual watersheds. Some of the other land cover types that could be mapped using satellite sensors include impervious covers and open water.

Two other promising remote sensing systems for the characterization of riparian lands include LiDAR and hyperspectral sensors. LiDAR sensors collect data on surface and vegetation heights at very high spatial resolution and are useful not only in characterizing vegetation structure, but surface topography derived from the LiDAR 'returns' can be used for mapping location of water bodies, streambed width, riparian zone width, and bank stability (Johansen and Phinn 2009). Hyperspectral sensors acquire reflectance information in hundreds of unique spectral bands, allowing for the mapping of vegetation stress and even vegetation composition. Unfortunately, because both LiDAR and hyperspectral systems are operated from airplane platforms, they are costly to operate, but piggy-backing multiple mapping projects would go a long way in cutting down costs. This underlines the need to have a coordinated mapping strategy in Alberta, such that multiple objectives can be met within single projects.

While we advocate for the implementation of remote sensing tools to map the status of riparian lands, it needs to be stressed that remote sensing tools are not a panacea and do not replace the need for collecting ground-based information. In fact, remote sensing methods are highly dependent on ground-based datasets for ground-truthing of new applications and in new geographic areas. Once calibrated, remote sensing images can be a cost effective and quick solution for mapping a select number of physical aspects of riparian lands, particularly its extent, over large areas. Real innovation will come when multiple data layers, land cover, digital topography and derivatives (i.e. slope) are integrated and used to model different characteristics of riparian lands.

CASE STUDIES

Oregon Riparian Assessment Framework

Oregon's Watershed Enhancement Board has developed a comprehensive set of planning documents with the intention of providing direction for the successful management of Oregon's watersheds. This initiative is symbolized by the pacific salmon, which integrates beautifully the watershed continuum from terrestrial headwaters, where the fish spawn, to the ocean where they spend the rest of their lives. Riparian lands are of course a critical component of the watershed continuum and OWEB has released a foundational document on designing and

implementing a framework for riparian lands assessment (Figure 6.3). The assessment framework discusses the entire process of moving from the planning stage to data evaluation. It is a framework that deals explicitly with scaling-up from site-based rapid assessment methods to regional remote sensing methods, and considers the different types (uses) of riparian assessments, be they for baseline mapping, trend detection, implementation or effectiveness assessment.

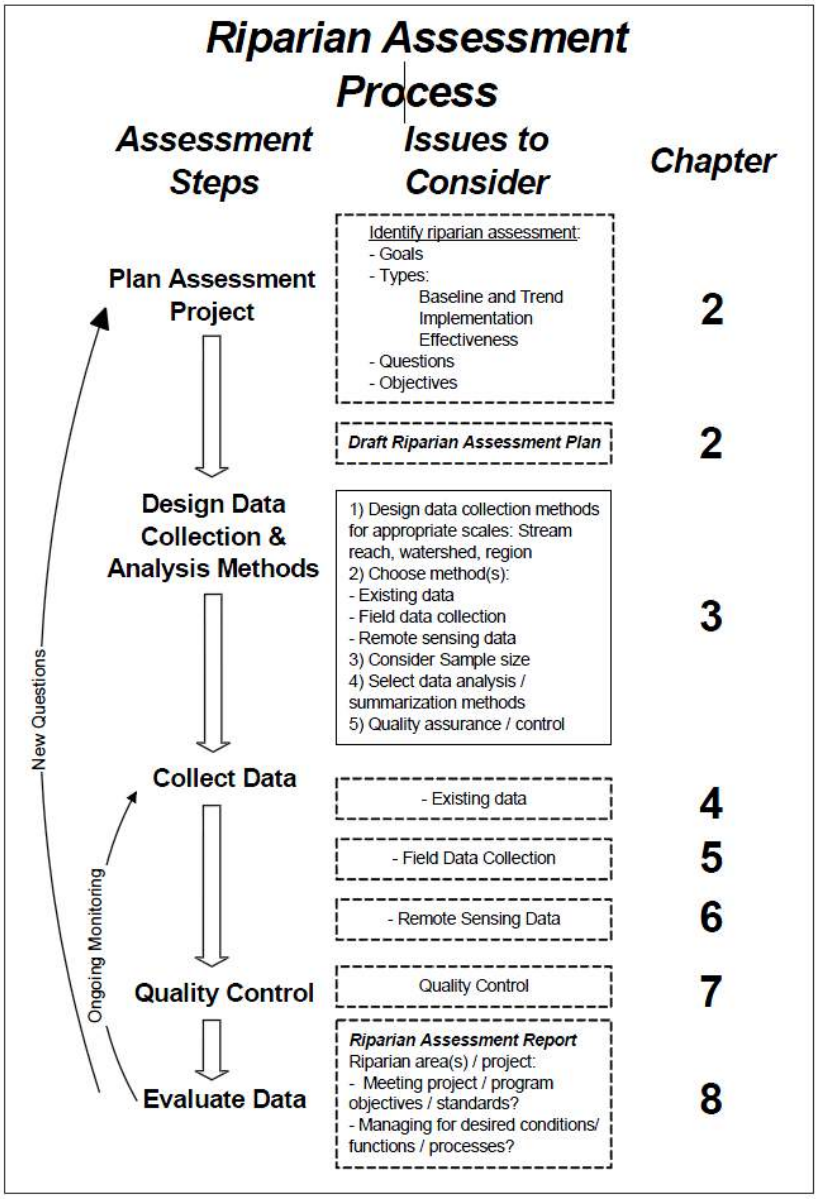

Figure 6.3. Riparian assessment framework as presented by the Oregon Watershed Enhancement Board in its comprehensive planning for watersheds and salmon (OWEB 2004).

Riparian Health Information Development Project (RHIDP)
RHIDP is a joint project of Agriculture and Agri-Food Canada (Agri-Environmental Services Branch) and Manitoba Habitat Heritage Corporation to test whether riparian health can be assessed using remote sensing techniques. The project is essentially developing a classification tool to detect different cover types from aerial photography, and potentially model riparian health based on those cover types. The predictive capability of the classification product is being tested at various creeks around Manitoba. Apart from feeding into predictive models on riparian health, the vegetation classifications will be used to target riparian workshops, enhance communication and feed into riparian BMP or Conservation Agreement projects. The project is closely linked to the Green Banks Clear Waters program which is run by the Manitoba Habitat Heritage Corporation in partnership with four conservation districts to provide necessary riparian vegetation cover data to complement the Integrated Watershed Management Plans that each of these conservation districts have developed. This is a great example of a project that applies a remote sensing tool for assessment and then implements the information for planning and management.

6.2. Economic Policy Tools

While there has traditionally been a reliance on command-and-control style management of natural resources in industrialized countries over the past century, there is increasing interest by governments to include economic tools in the mix of policy instruments that are used to manage for desired environmental outcomes. While economic policy tools have been in use since the early 1970s, there has been a rapid expansion in their use over the last decade, and many governments see market-based instruments as a way to help move towards the goal of achieving sustainable development. Unlike the more common 'command-and-control' approach to regulation, economic policy tools are intended to encourage a particular (desired) behaviour through market signals and/or economic incentives.

Despite the growing interest in economic policy tools, the use of many of these has only been recent, and as such, there is a paucity of data that critically evaluates their success at achieving desired environmental outcomes. Below is a summary of some of the most commonly used economic tools, along with examples of how these tools have been applied in other jurisdictions. In this discussion, we make the distinction between market-based instruments and economic incentives. While both of these tools are based on the premise of economically rewarding individuals for certain outcomes or behaviours, the tools differ regarding the mechanism by which the economic reward is derived. Market-based incentives rely on the creation of a 'market' within which supply, demand, and price must be managed, whereas, economic incentives do not rely on the existence of a market.

6.2.1. Market-based Instruments

In theory, the use of market-based instruments results in outcomes that create economic benefits for the individual, as well as environmental benefits for society. If properly designed, these markets would be expected to achieve the desired environmental outcome using the most efficient (least-cost) approach. While market-based instruments show promise as tools for managing environmental resources, they are not without their challenge (Brauer et al. 2005). In particular, a great deal of thought and consideration needs to be put into the design of the 'market' within which environmental resources or services are bought, sold, or traded. These designer markets require careful construction and regulation to ensure that the market performs as expected, and that market conditions do not create unintended outcomes for the resource

being managed, or for the larger socio-ecological system within which the market is imbedded. In order to ensure the credibility of any market-based program, consideration also needs to be given to the overall goals of the program, the time scale over which the program is expected to enrol participants and achieves realistic environmental outcomes, as well as how the program will be monitored and success evaluated.

The type of market-based instrument that will be utilized to achieve the desired outcome also requires important consideration. While the concept of market-based instruments is fairly straightforward, there is a diversity of market-based instruments that can be used within an environmental market scheme. A summary of some of the more commonly used market-based instruments is provided below, along with examples of how these instruments have been used to manage environmental resources in other jurisdictions.

a. Conservation Auctions or Tenders

Conservation auctions are price-based instruments that target conservation activities on private land where individuals are unlikely to undertake the desired work without an incentive. These programs can be designed to target a single environmental outcome (e.g., improved water quality) or can be more sophisticated programs designed to target environmental 'bundles' (e.g., water quality, biodiversity, and riparian vegetation restoration).

Auctions are typically used as a price discovery mechanism in areas where there are not pre-existing markets or prices established. Auctions operate through the solicitation of bids from individual landowners, and each landowner declares the price for which they are willing to undertake the required works. The resource management agency (government or non-government) overseeing the auction then ranks the bids, and money is allocated according to the available budget. Once a bid is selected, the landowner enters into a contract with the resource management agency to deliver the works for the specified price.

The benefits of using conservation auctions over the use of fixed-price grants or cost-sharing programs is that auctions tend to be more cost effective because landowners are competing for limited budgetary resources, and are thus driven to provide a bid that reflects actual costs of adoption. The approach also ensures that the landowner is paid adequately for adopting the desired practices, rather than paying only a portion of the costs, as with many cost share programs. Auction programs also allow the resource agency to specifically set targets and objectives for desired environmental improvements, and are underpinned by enforceable contracts that can be used to monitor and evaluate performance.

CASE STUDIES

The Assiniboine Watershed Pilot Program

The Assiniboine Watershed Stewardship Association ran a pilot program that paid farmers to restore wetlands in the Assiniboine River Watershed (ARW), an important target area for wetland restoration in the North American Waterfowl Management Plan (NAWMP). The wetland restoration program was launched in 2008 as a joint initiative of Ducks Unlimited Canada and the Saskatchewan Watershed Authority.

The program used a reverse auction format that invited farmers in the Assiniboine watershed area to submit bids stating how much money a farmer would require to restore a drained or inoperative wetland and leave the restored wetland in its natural state for 12 years. The

process was discriminative, with sealed bids and two rounds of bidding. Each bid was submitted by quarter section (160 acres), and could be either in cultivated cropland or perennial forage, and were evaluated using an environmental benefits index based on the incremental increase in predicted hatched waterfowl nests relative to bid price. In the first round, 20 bidders submitted 118 bids to restore 713 wetlands, totaling 670 acres at a price of $837,000. Bid prices to restore drained wetlands within cultivated land were higher than for perennial forage. In the second round, 30 bids from seven bidders were approved to restore 211 wetlands, totaling 211 acres in perennial forage at a price of $182,000. The price of successful bids varied from $20.83/acre/yr to $391.22/acre/yr (average $118.52/acre/yr). The reverse auction provided information on cost variability and funding required for achieving NAWMP wetland restoration objectives in the ARW. The program's second phase will be a multi-year study of the restored wetlands by University of Guelph researchers to determine the impact on water quality, ground water quantity and the wetlands' ability to sequester carbon.

b. Environmental Offsets

Environmental offsets are quality-based market-based instruments that have been used to manage a range of different environmental resources, including biodiversity, wetlands, and carbon dioxide (McKenney and Kiesecker, 2010, ten Kate et al. 2004). Offset programs are typically used in conjunction with land development where the goal is to achieve 'no net loss' or a 'net environmental benefit' by offsetting the residual environmental impacts of development, after first making efforts to avoid or minimize impacts. Mechanisms employed in these offset programs commonly include off-site compensation, habitat banking, or in-lieu payments (Gibbons and Lindenmayer, 2007).

Offset programs are fundamentally premised on the idea that the units being traded are in some way fungible (i.e., mutually exchangeable or substitutable), and environmental offsets are typically achieved through purchasing and protecting land, or through restoring or rehabilitating habitat. The challenges associated with the effective design and implementation of offset programs include determining the appropriate timing, location, duration, currency, or equivalency of the trade (McKenney and Kiesecker, 2010; Walker et al. 2009).

While offsets are increasingly being used, particularly in areas with high growth rates and development pressure, many of these programs have been plagued with failures attributed to the use of inadequate assessment and exchange currencies, exchange rules that are poorly structured or otherwise disregarded, and a lack of enforcement and compliance (Burgin, 2010; Walker et al. 2009; Robertson, 2000; Salzman and Ruhl 2000). In Alberta, offsets are used to compensate for the loss of wetland habitat; however, recent work has shown that the social practices around the implementation of compensation guidelines tend towards selective enforcement or regulator acquiescence through nonenforcement of some of the most important guideline principles (Clare and Krogman, Under Review). For example, we found a general tendency to skip over any serious consideration of wetland avoidance, in favor of using in-lieu fee payments as compensation (Clare et al. 2011). This has frequently lead to the replacement of natural wetlands with out-of-kind compensation, resulting in a net loss of wetland area and function.

CASE STUDIES

US Wetland Mitigation Banking

Wetland mitigation banking is used extensively in the United States as a form of compensation for wetland loss. Banking reveals the value of wetlands through the establishment of 'wetland

credits', which are bought and sold in a wetland market. Mitigation banks are collections of wetlands that have been created, restored, enhanced or preserved for the purpose of earning compensatory credits permitted under the federal government programs in the United States, the Section 404 or similar local wetland regulations. These compensatory mitigation credits could be owned by landowners or be sold on the market to those needing to compensate for unavoidable negative impacts to another wetland (Hansen, 2007). Credits are usually measured in terms of wetland acreage to represent the level of service it provides (Hansen, 2007).

6.2.2. Incentives

a. Conservation Easement

Conservation easements are voluntary agreements between landowners and a conservation organization that allows landowners to protect natural features without giving up ownership or use of the land. Conservation easements typically place restrictions on land use or development activities that would negatively impact the natural feature of interest, but does not limit the landowners right to own, use, sell, gift, or will the property. A binding legal agreement is signed between the landowner and the land trust (the organization holding the easement), which outlines the terms of the easement and allows the land trust to inspect the property to ensure compliance. Typically easements are signed in perpetuity; however, the length of the easement can be negotiated between the landowner and the land trust. A conservation easement can either result in a tax benefit to the landowner, or it can include a paid easement whereby the land trust pays the landowner the value of the land at its appraised value, which is typically lower than the market value of the land. While the compensation for conservation is less than a landowner would receive if the land was sold, the benefit of the easement includes the retention of many of the rights associated with continued land ownership.

CASE STUDIES

Wetlands Reserve Program (WRP)

The WRP has been operating in the United States for nearly 20 years and is administered under the USDA Natural Resources Conservation Service (NRCS). The program offers landowners an opportunity to engage in voluntary wetland restoration and protection through three different conservation easement options: 1) an easement in perpetuity; 2) a 30-year easement or contract; or 3) a 10 year restoration cost-share agreement. Depending on the conservation option selected, NRCS may pay between 75 and 100 percent of the easement and restoration costs. Easement compensation is based on the lower of fair market value, a geographic area rate cap, or landowner offer. Landowners pay taxes on the property and retain title to the land; thus, landowners maintain the rights to control access and recreational use. NRCS technical specialists work cooperatively with landowners and use the latest wetland restoration science to maximize wetland and wildlife benefits.

Since 1992, NRCS has voluntarily enrolled over 11,000 private landowners to protect over 2.3 million acres of wetlands and associated habitats. The WRP is most suited for frequently flooded agricultural lands, where planned restoration will maximize habitat for migratory birds and other wildlife, as well as improve water quality. The voluntary nature of WRP allows effective integration of wetland restoration on working landscapes, providing benefits to farmers and ranchers who enroll in the program, as well as benefits to the local and rural communities where the wetlands exist. Studies from the Prairie Pothole Region in North Dakota, South Dakota, and Minnesota show that WRP projects in these states have the potential to reduce soil

loss by as much as 124,000 tons per year, which could prevent over 400 tons of nitrogen and 5.5 tons of phosphorus from washing downstream in the area alone.

Manitoba Heritage Corporation Wetland Restoration Incentive Program

The Manitoba Habitat Heritage Corporation (MHHC) is a non-profit Crown Corporation established in 1986 by *The Manitoba Habitat Heritage Act* and is responsible to the Minister of Water Stewardship. Its objective is to work in partnership with public and private agencies and organizations, as well as individual landowners, to conserve, restore, and enhance fish and wildlife habitat in Manitoba.

The MHHC runs several conservation programs including the Wetland Restoration Incentive Program, which is a partnership between Manitoba Water Stewardship, Ducks Unlimited Canada, and MHHC. The goal of this partnership is restore former wetlands in cultivated areas of Manitoba to allow for additional carbon storage. In the program, the landowner must be willing to sign a Conservation Agreement (CA) in perpetuity on the land that is being restored. CA's are voluntary legal agreements between the landowner and a conservation agency that provides long-term protection of habitat, but does not interfere with activities on the landowner's more productive agricultural lands. As well, activities like haying, grazing, trapping and hunting may continue on lands designated under the Conservation Agreement. Each agreement is individually negotiated and tailored to meet the needs of the landowner. Moreover, the landowner retains title to the land, controls access, and may continue to use the land under the terms of the agreement.

A minimum of 40 acres of habitat should be included in the Conservation Agreement, which can include existing wetlands and grasslands, as well as restored wetlands. The landowner receives payment for the Conservation Agreement based on the assessed value of the land, with a premium paid for restored wetland acres.

6.2.3. Tax Incentives

Tax incentive programs encourage environmentally sensitive practices through one of two mechanisms: tax credits or rebates (reduction in the amount of taxes owing) or tax deductions (reduction in yearly income earned). Tax incentive programs are administered by the government and are not associated in any way with conservation organizations or easement programs; thus, the landowner retains full rights of ownership, but may be required to enter into an agreement for a period of time in order to be eligible for the tax incentive.

CASE STUDIES

Manitoba Riparian Tax Credit Program (MRTCP)

The Riparian Tax Credit Program is designed to encourage farm operators to improve management of lakeshores, rivers, and stream banks. While Riparian Tax Credit programs are relatively common throughout the United States (e.g., Arkansas, Oregon, and Virginia), this is the first riparian tax credit program of its kind in Canada. The MRTCP is 100% voluntary and landowners must commit to a 5-year agreement to protect riparian buffer strips along water bodies. The riparian buffer strip includes a 100-foot (30.5 m) wide area that must be permanently fenced. Within this exclusion area, no agricultural activities other than haying may occur, and livestock must be excluded from grazing and watering. Incentives for enrolling in this program include a property tax credit that ranges from $20/acre/year to $28/acre/year, depending upon the current land use.

Maryland Waterfowl Restoration Program

The Maryland Waterfowl Restoration Program administrated by the Maryland Department of Natural Resources (DNR) is a tax incentive program that is designed to enhance waterfowl and habitat management on private lands. The program objective is to provide technical assistance to private landowners for developing and managing waterfowl habitats for breeding, migrating, and wintering waterfowl, and to improve wetland habitat to ensure diverse wetland plant communities. All costs associated with Waterfowl Restoration Program are tax deductible and are eligible for a tax credit. To be eligible for the program, landowners must have a minimum of 10 contiguous acres with the potential to provide food and/or cover for waterfowl, and at least 1 acre of semi-permanent water with nesting and resting habitat. Once accepted into the program, DNR develops a license agreement with participating landowners and approves the Waterfowl Habitat Management Plans and habitat projects included within the agreements. The license agreement remains in effect for a period of 10 years and is renewable. The proposed project area is inspected for eligibility upon application to the program, and DNR annually documents the status of the approved projects and measures.

6.2.4. Grants and Cost-sharing Programs

These programs are funded by money that is allocated by governments or conservation agencies to support a specific objective, outcome, or action. Typically applicants must qualify for the funds, and the amount given to each individual may or may not cover the full cost of undertaking or implementing the desired action. These programs are designed to stimulate changes in behavior by reducing the cost of adopting the desired behavior.

CASE STUDIES

Lake Simcoe Farm Stewardship Program (LSFSP; Ontario)

This program provides partial funding to agricultural landowners in the Lake Simcoe Watershed for voluntary restoration and rehabilitation activities, and infrastructure improvements in order to improve riparian and watershed health. The program encourages the implementation of Best Management Practices that contribute to improving water quality and wildlife habitat. The eligible activities include improved agricultural practices (i.e. improved manure storage and handling), and riparian rehabilitation and protection (improving erosion control, shelterbelt establishment, and riparian habitat management). Typically 25% to 45% of the cost of various upgrading projects will be covered under LSFSP.

Colorado Wetlands Initiative

This is a cost-sharing program run by the Colorado Division of Wildlife (CDW) designed to create, enhance, and restore wetlands. The program has been running since 1997, and is open to all public agencies, non-government organizations, and private landowners. In this program, landowners often contribute cash and usually contribute labor or materials. Project costs are handled on a reimbursement basis such that the landowner constructs the project and receives payment following a successful inspection by CDW. The landowner is paid only for actual costs backed by invoices. Agreements are for no less than 10 years with efforts made to get 15 to 20-year commitments. The landowner is responsible for project maintenance over the length of the agreement. Since inception, the Colorado Wetlands Program has preserved, restored, enhanced or created almost 220,000 acres of wetlands and adjacent habitat, and more than 200 miles of streams, at a cost of almost $40 million in total funding devoted to wetland and riparian preservation in Colorado.

California Waterfowl Habitat Program (CWHP)

Initiated by the California Department of Fish and Game (CDFG) in 1992, the goal of this program is to protect wetlands and waterfowl habitat. Under this program, the CDFG will directly pay participating landowners $20/acre/year over a 10 year period for enrolling in a management plan to enhance waterfowl habitat on their property. Upon enrollment in the program CDFG and the participating landowner cooperatively develop a habitat management plan for each property. Within the limits of the plan, the state can establish enforceable requirements for removal of exotic vegetation and irrigation of wetland and brood water (i.e., habitat for rearing young birds) as necessary to create an ideal mix of habitats. CDFG monitor wetland conditions each spring and prescribe specific habitat management actions within the management plan. Landowners must implement all required items to receive payments. At present, the program is very popular, but enrollment is limited by available funds. To date, the CWHP has enrolled 29,295 acres of habitat on 126 properties throughout Central California.

6.3. Social

The argument that monetary valuation is essential to ensure that the environment is not simply treated as an 'externality' in government and business decision making has been met with increasing resistance from people who are wary of simply leaving environmental management in the hands of the market. Some of the biggest criticisms being leveled at the use of economic incentives to direct environmental behavior is that economic value theory too narrowly focuses the issue and often excludes the context of wider social values (Spash et al. 2005). Many scholars has argued that the rational-actor based economic model generally excludes room for consideration of social norms and social learning, and views the environment through a very narrow lens that is focused on creating economic efficiency and maximizing utility (Fletcher 2010).

For example, in the study of wetland mitigation banking in the United States, Robertson (2004, 2006) has argued that the reliance on wetland 'banks' and trading of wetland credits has redefined wetlands as 'commodities' that can be bought and sold on a market. Robertson (2000) argues that abstraction of wetlands into 'services', such as water purification and biodiversity has diminished the social and cultural meaning of wetlands, such that the relationship between society and nature has been shifted towards one in which ecosystems and the environment have been redefined in terms of what the market can 'see' (or place an economic value on). In the process, other important social and cultural values of wetlands are being lost, because these values are difficult to price using market mechanisms.

Within our modern and materialistic society, we have gradually lost sight of the ethic and values that recognize humans as an integral part of nature, rather than being set apart from or dominating over nature. The dominant social paradigm has been one in which there is a strong belief in the notion that technology can help to solve environmental problems, that economic growth and prosperity can help to address societal problems, and that governments and political offices have the ultimate authority to handle policies that effect society (Kilbourne et al. 2002). However, there is a new environmental paradigm or ethic rising which holds that the idea that humans are apart from nature is an illusion, and that we have an individual as well as collective responsibility in taking care of the 'land', including not only the human community, but the soils, waters, plants, and animals that support those human societies.

This rising ethic is manifest in individuals and communities who feel the need to get involved

and 'do the right thing' for the environment and for one another. Governments are welcoming these grassroots efforts and are showing interest in a greater reliance on self-regulation, collective action, and voluntary standards. This shift of responsibility from governments to individuals, businesses, and communities is reflected in the proliferation of stewardship programs, non-regulatory stewardship outreach programs, and community-based education efforts. Interestingly, while stewardship comes from ethics and a deep appreciation of the land and the people living on it, this ethic can result in tangible economic returns (Pretty and Smith 2004). Thus, a shift in environmental ethics may provide similar economic benefits to individuals as would be realized through the use of economic policy instruments

CASE STUDIES

Alberta Riparian Habitat Management Society (Cows & Fish)

Fostering and understanding of riparian areas as a vehicle to motivate community change through stewardship is the focus of the Alberta Riparian Habitat Management Society. This organization has been recognized as being a leader in riparian stewardship, and is a model for other jurisdictions. This voluntary program works in partnership with landowners, farmers, ranchers, cottage owners, communities, agencies and various other groups to raise awareness about the importance of riparian lands and riparian land management. The organization focuses its programs on knowledge building, conflict resolution, increasing cooperative efforts, providing technical advice and tools for management, monitoring riparian health, and helping to direct people to funding, resources, and other technical expertise. A large focus of the organization includes education and awareness extension work, as well as applied research and demonstration site involvement, ecological monitoring, and support for community based action. The ARHMS emphasis is on an integrated process or approach that recognizes the interrelationship of all elements of program delivery (awareness, team building, tool building, community based action and monitoring/evaluation), with an underpinning that local landowners and communities should drive the process.

National Riparian Service Team (NRST)

The NRST is an umbrella program created by the U.S. Bureau of Land Management, leads the stewardship and outreach programs to accelerate cooperative riparian restoration and management. The program is an inter-agency effort comprising teams from federal and state governments, non-government organizations, universities, and private individuals. The program is leading the Creeks and Communities Strategies that involves outreach, training, and educational programs for landowners.

NRST team members have all the expertise needed for riparian protection, management and restoration, including Hydrology, Ecology, Fisheries, Wildlife, Range Management, Soils and Geology, Forestry, Social Science, Conflict Management, Public Affairs and Communication. The program approach is designed to address the technical dimensions of riparian issues while at the same time recognizing and addressing the social context within which these issues exist by providing place-based problem solving, training, assessment, monitoring and grazing management relative to riparian-wetland resources. NRST members are available for mentoring and coaching, which results in a more effective integration of technical information into collaborative problem solving.

The NRST provides several training programs and workshops, including programs on riparian health and management, monitoring, grazing management, and consensus training. In addition NRST provides mentoring on the collaborations and partnerships needed for successful riparian

management. An effort called "'Collaboration Learning Lab" has been running since 2006, which provides training and mentoring in the general principles and practices of collaborative problem solving as well as riparian assessment, management and monitoring. Activities include service trips, participant shadowing of NRST support teams, one-on-one coaching, and consensus building training.

Australian Landcare Program
The Landcare Program is an umbrella organization that brings together hundreds of locally based environmental stewardship community groups, with the over-riding goal of working together to restore and manage natural resources. The rehabilitation and conservation of waterways and riparian areas is one of the major focuses of Landcare Australia. Landcare Australia is funded from the Australian federal government, corporate organizations, and private donations. The organization provides open and closed grants, in addition to brokering partnerships between corporate organizations and local community groups. Open grants are typically small value grants to local communities for implement environmental stewardship projects, while closed grants are limited to targeted projects or partners based on priority environmental issues.

Youth Riparian Education Initiative (YREI)
The YREI is a collaboration of U.S. federal agencies and three universities that provides youth education and stewardship activities in support of the Bureau of Land Management (BLM) and U.S. Forest Service riparian restoration goals. The BLM is charged with improving public understanding and management of riparian areas, and resources were needed to help land manager communicate with the public about management techniques and decisions. To support this work, education programs for schools and youth programs were created, and the resulting curriculum is called "Holding Onto the GREEN Zone". The program emphasizes awareness and question asking, and includes hands-on activities to help youth understand the science underlying riparian ecology. Through the application of the scientific method and experiential learning, students enhance their science knowledge and come to understand the importance of preserving and restoring riparian ecosystems.

Farmland-Riparian Interface Stewardship Program (FRISP)
The FRISP program is an initiative of the Fraser River Basin Salmon and Watersheds Program that was established in 2004. FRISP promotes the use of Beneficial Management Practices for riparian/salmon habitat improvement and sustainability, and emphasizes greater understanding of riparian function and the negative impact that riparian mismanagement can have on an agriculture operation, a fishery, and general watershed health. As of 2011, over 200 ranch or farm operations have been assisted with riparian management issues ranging from improved habitat for salmon, to stream bank restoration.

The program promotes riparian restoration and management through: 1) direct project implementation, and 2) conflict resolution between landowners, regulatory agencies, and other stakeholders. The program provides technical information and project prescriptions, and assists with project partnerships, support, and management for riparian enhancement and waste management issues. A key aspect of the program is facilitating joint participation between landowners, resource management agencies, and others in the planning of riparian habitat restoration and agriculture land use activities. An FRISP advisor is assigned to each project, who works with landowners to recommend solutions, identify potential partners, assist with preparation of prescriptions, cost estimates and required permits, and assist with project

implementation. The program has also produced educational materials to assist in riparian management.

6.4. Integration of Ecological, Economic, and Social Considerations

The future of management of riparian lands will be about the integration ecological, economic, and social factors. One innovative project that integrates these factors and applies it to riparian management comes from the City of Calgary, and we would like to end this chapter by presenting the City of Calgary Riparian Land Management strategy as a progressive model for the management of riparian lands.

City of Calgary Riparian Land Management

The City of Calgary's Water Resources department has been very active with initiatives to improve and protect riparian habitat in the City and is currently following elements of the European Water Framework Directive to give direction for riparian land management.
This project has implemented an integrated management approach using cutting edge science to map riparian lands, assess the health and integrity of riparian lands (including bank stability), and has used economic and social factors to identify sites for restoration.

As a first step in achieving riparian management goals, the City initiated a comprehensive riparian mapping project. All existing spatial information has been compiled in a GIS system, including Environmental Reserve setback maps, river valley plans, fish habitat and wetland maps, digital elevation models, and aerial photos. New mapping products were produced depicting land use and land cover, and riparian land cover was mapped using high-resolution colour aerial photos. The probable extent of riparian lands was also mapped using a variable width riparian delineation model that employs a terrain analysis based on slope (Hemstrom 2002). The model outputs can be compared with current riparian setback requirements (as per City of Calgary's 2007 ER Setback Policy) to identify areas of mismatch between the variable and static buffer width approaches, and may also be used to determine the amount of riparian land that has been lost to development over time.

Another major component of this project includes riparian health assessments that were conducted by the Alberta Riparian Habitat Management Society between 2007 and 2009. This work was built upon in 2010 when the City commissioned the "Streambank Stability/Riparian Assessment" study to compile baseline information on riparian health and bank condition, as well as prioritize design enhancements and management activities on a site specific basis. This study included 230km of stream bank along the Bow River and Elbow River, as well as West Nose Creek and Nose Creek. The ARHMS study classified and mapped health scores along the cities major waterways and based on the bank assessment study, identified hot spots in area of bank instability and slumping where restoration efforts could be focused. Combining the bank hot spots with the riparian health inventory, sites were prioritized for restoration. For each site, restoration targets were set for woody cover, human-caused bare ground reduction, and structural alteration remediation.

In choosing which sites to restore, (given that there are limited financial resources) the City used a Triple Bottom Line (TBL) prioritization model. The model considers not just ecological, but economic, and social factors as part of the assessment of cost and benefits associated with stream bank and riparian restoration. This tool uses a Net Present Value (NPV) approach to prioritization, which takes into consideration not only the initial cost, but also the future costs and benefits that will flow from the project. The future costs and benefits are discounted or adjusted

to account for uncertainty associated with changing values over a 50-year evaluation period. A total of 19 metrics are considered in the TBL Prioritization, including nine economic, four environmental, five social, and one safety factor; these were selected based on previous projects, discussion with the City, consultation with internal and external stakeholders, and input from literature and economic experts. Of the 456 stream bank sites and 59 riparian polygons assessed as part of the “Streambank Stability/Riparian Assessment” study, 134 stream bank and 21 riparian polygons were identified as high priority and requiring remedial work to restore bank stability and riparian habitat using the TBL Prioritization method (i.e., there was a net TBL benefit).

7.0 Conclusions and Considerations

This report has summarized and evaluated the current state, conservation tools, and management approaches as they relate to riparian lands in the province of Alberta. As is the case in many other jurisdictions, riparian lands in Alberta are threatened by not only land development, but by other stressors such as climate change. At nearly three quarters of the sites that have been assessed by the Alberta Riparian Habitat Management Society, some riparian functionality has been lost. This loss appears to be more severe in the southern portions of the province, although this trend is difficult to determine given the disparity in sampling intensity and a lack of systematic sampling across the province.

Fortunately, there are many important governmental, non-governmental, industry-led, community, and individual efforts that have prioritized the protection or conservation of riparian lands in Alberta. While individually these efforts are important, a more coordinated effort is required if riparian land management outcomes are to significantly improve over time. This coordination needs to happen within and between organizations, and needs to include all aspects of riparian management, from data collection and management, through to program funding and public outreach. The province of Alberta has some very fundamental pieces already in place for significant strides to be made in advancing riparian land management; the challenge lies in bringing these disparate pieces together in a coordinated and cohesive manner under a common and collective goal. What is evident from this work is that there are a number of existing laws, regulations, policies, standards, and programs that are already in place. Finding ways to remove the critical barriers that limit the success of existing management tools, or to creating new tools to enhance those that already exist, should be a focus moving forward.

What follows are some of the key considerations for advancing the agenda of improving riparian lands management in the province of Alberta. These considerations are informed by what we perceive to be the major gaps in existing knowledge and practice, as well as by the recommendations provided by the many informed and passionate respondents that were included in the Riparian Land Management survey. Note that many of these recommendations are interdependent and their effectiveness many be dependent upon the adoption of one or more of the other recommendations listed below. Also note that these recommendations are not listed in order of priority.

Key Considerations:

1. Riparian land management should be set within an integrated ecosystem management framework that considers riparian lands as components of a larger ecosystem.
    - Within this larger watershed context, riparian lands should be managed together with other ecosystem components including wetlands, groundwater aquifers, rivers and lakes, forests, and human systems (agricultural, urban, industrial).
    - Concepts of natural range of variability and resilience should inform and be integrated into these management plans.
2. A province-wide framework for riparian assessment should be created that addresses the scaling of information from the local to the regional scale. This framework should consider the geographic and hydrological differences across the province in order to

give managers and planners the appropriate data to evaluate and drive their management plans.

    - This framework should outline consistent standards and/or methods that should be used by all agencies engaged in collecting information on the extent and health of riparian lands in the province. This should include standards and/or methods for collecting information for both field-based and remotely sensed assessments. This standardized information will ensure comparability of data, which in turn will create reliable and consistent information that can be used to monitor and manage riparian lands across the province.

3. Establish a publically accessible repository for riparian land data that includes information related to both riparian extent and health. This repository should also include hydrological data that delineates and classifies all water bodies in the province, including all classes of wetlands, seeps, and springs.
    - This data should be freely available to the public so that it may be used to help inform land use planning at the local, municipal, and regional scales.
4. Calibrate field-based riparian health assessment methods that are currently in use against remotely sensed techniques to test the efficacy of adopting a remote sensing riparian health assessment approach, such that remote sensing information can be used to assist with planning at larger spatial scales (e.g., regional and provincial scales).
    - This calibration should be done using a number of remote sensing techniques and across different locations (i.e., natural regions) in the province, with sufficient sample size to make valid inferences.
5. Establish clear, consistent, and enforceable standards for determining riparian setback widths across the province based on the best existing science.
    - The majority of survey respondents raised concerns over the inconsistencies in how development setbacks are being determined, with particular concern expressed by land managers in municipalities. Creating clear standards or guidance for determining riparian setback widths would be beneficial.
    - Adopting an approach for determining riparian setback widths would effectively create a functional definition for riparian lands in the province, which could then be applied to riparian land management under a variety of different land uses.
6. Create more incentives for adopting behaviours that create desired environmental outcomes.
    - Many survey respondents suggested that these incentives should be economic, and consideration should be given to pilot testing a range of possible instruments for use in riparian land management. These economic instruments should be carefully designed with a clear objective, and should be sensitive to the local and regional context within which they are being used to ensure they do not produce unintended social or economic outcomes.
    - Respondents also recognized the importance of the work that is currently being done by a number of different stewardship groups and not-for-profit

organizations, and expressed their desire for continued financial support of these organizations to maintain or expand existing programs.

7. Consider developing and implementing a new provincial policy dedicated to riparian land management. As an alternative to developing a new riparian land policy, consider improving the implementation of existing legislative and policy tools that are currently in place for riparian land management. Specifically, survey respondents suggested the following:
    - Improve coordination within and between jurisdictions responsible for managing riparian lands in the province, including increased transparency in government decision-making.
    - Provide sufficient human and financial resources to government departments responsible for riparian land management.
8. Regularly evaluate the success of scientific, policy, economic, and social management actions. Such evaluations help to improve and adapt existing management strategies to deal with new realities; however, such evaluation is not possible without reliable monitoring data. Thus, consideration should be given to developing transparent monitoring programs that are designed with the intent of providing information with which to evaluate policy or program success.

8.0 Literature Cited

ABMI (Alberta Biodiversity Monitoring Institute). 2010. Wetland Field Data Collection Protocols - Abridged (10046), Version 2010-12-14. Alberta Biodiversity Monitoring Institute, Edmonton, Alberta, Canada. Report available at: http://abmi.ca [June 2012].

AENV (Alberta Environment). 2007. Aquatic and Riparian Condition Assessment of the South Saskatchewan River Basin. 137 pp.

AENV (Alberta Environment). 2008. Indicators for assessing environmental performance of watersheds in Southern Alberta. 64 pp.

AENV (Alberta Environment). 2010. Using Aerial Videography to Assess Riparian Areas in Southern Alberta: a Pilot Study. Alberta Environment, Calgary. 40 pp.

Alberta Environmental Protection. 1994. Alberta timber harvest planning and operating ground rules. Pub. No: Ref.71, Information Centre, Edmonton, Alberta.

ARHMS (Alberta Riparian Habitat Management Society). 2005. South Saskatchewan River Basin Riparian Health Overview: Part 1 - Red Deer, Bow, and South Saskatchewan Rivers and Part 2 - Oldman, Belly, St. Mary, Waterton, Crowsnest and Castle Rivers. Prepared for Alberta Environment. Lethbridge, Alberta. Cows and Fish Report No. 026. 341 pp.

ARHMS (Alberta Riparian Habitat Management Society). 2008. Overview of Riparian Health in Alberta - A Review of Cows and Fish Sites from 1997-2006. Prepared for Alberta Environment. Lethbridge, Alberta. Cows and Fish Report No. 035. 317 pp.

Ambrose, N., G. Ehlert, and K. Spicer-Rawe. 2004. Riparian Health Assessment for Lakes, Sloughs, and Wetlands - Field Workbook. 90 pp. [Modified from Fitch, L., B.W. Adams, and G. Hale. 2001.]

Antoniuk, T., K. Manuel, M. Sutherland, and J.T. Bowen. 2009. In Situ Oil Sands Footprint Monitoring Project. Prepared by the ALCES Group for Alberta Environment, Land Monitoring Team. Edmonton, Alberta. 125 pp.

Aquality Environmental Consulting Ltd. 2009. Red Deer River State of the Watershed Report. Report prepared for the Red Deer River Watershed Alliance, Red Deer, Alberta, Canada. 831 pp.

Aquality Environmental Consulting Ltd. 2010. The Riparian Setback Matrix Model. Report prepared for Municipal District of Foothills. Edmonton, Alberta. 33 pp.

Bateman, N.G. 2003. Vincent Lake Working Model Evaluation Report. Lethbridge, Alberta: NGB Evaluation Solutions Inc.

Battle River Watershed Alliance. 2011. Our Battle: State of the Battle River and Sounding Creek Watershed Report. 33 pp.

Berkes, F., and C. Folke. 1998. Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge, UK.

Bradshaw, A.D. 1984. Ecological principles and land reclamation practice. Landscape Planning 11: 35–48.

Bräuer, I., R. Müssner, K. Marsden, F. Oosterhuis, M. Rayment, C. Miller, A. Dodoková. 2005. The Use of Market Incentives to Preserve Biodiversity. A project under the Framework contract for Economic Analysis ENV.G.1/FRA/2004/0081. Ecologic Institute. Available: http://ecologic.eu/download/projekte/1750-1799/1750/1750-11_use_of_market_incentives_to_preserve_biodiversity.pdf

BRBC (Bow River Basin Council). 2005. Nurture, Renew, Protect: A Report on the State of the Bow River Basin (2005). Bow River Basin Council ISBN 0-9737429-0-9.

BRBC (Bow River Basin Council). 2010. Bow River Basin State of the Watershed Summary. 44 pp.

Burgin, S. 2010. “Mitigation banks” for wetland conservation: a major success or an unmitigated disaster? Wetlands Ecology and Management 18:49–55.

Clare, S., N. Krogman, L. Foote, and N. Lemphers. 2011. Where is the avoidance in the implementation of wetland law and policy? Wetlands Ecology and Management 19:165–182.

Clare, S. and N. Krogman. Under Review. Breaucratic slippage and environmental offset policy: The case wetland management in Alberta. Submitted to Society and Natural Resources, Manuscript ID USNS-2011-0216.R1. Submitted October, 2011.

Cows and Fish Program. 2003. Alberta Lentic Wetland Health Assessment (Survey) User Manual. Lethbridge, Alberta. 20 pp.

Devito, K.J., I.F. Creed, T. Gan, C. Mendoza, R. Petrone, U. Silins, and B. Smerdon. 2005. A framework for broad-scale classification of hydrologic response units on the Boreal Plain: is topography the last thing to consider? Hydrological Processes 19: 1705-1714.

Dillman, D.A. 2007. Mail and internet surveys: The tailored design method. Second Edition, John Wiley & Sons, Inc. Hoboken, New Jersey.

Fitch, L., and N. Ambrose 2003. Riparian Areas: A User’s Guide to Health. Lethbridge, Alberta: Cows and Fish Program. ISBN No. 0-7785-2305-5.

Fitch, L., B.W. Adams and G. Hale, 2001. Riparian Health Assessment for Streams and Small Rivers - Field Workbook. Lethbridge, Alberta: Cows and Fish Program. 90 pp. [adapted from Riparian and Wetland Research Program, School of Forestry. 2001. Lotic health assessments: Riparian health assessment for streams and small rivers (Survey) User Guide. University of Montana, Missoula, Montana, January 2001.]

Fletcher, R. 2010. Neoliberal environmentality: Towards a poststructuralist political ecology of the conservation debate. Conservation and Society.

Gibbons, P., and D.B. Lindenmayer. 2007. Offsets for land clearing: No net loss of the tail wagging the dog? Ecological Management and Restoration 8: 26-31.

Goetz, S.J., 2006. Remote Sensing of Riparian Buffers: Past Progress and Future Prospects. Journal of the American Water Resources Association 42: 133-143.

Golder Associates. Ltd. 2003. Strategic Overview of Riparian and Aquatic Condition of the South Saskatchewan River Basin (SORAC). Prepared for Alberta Environment, Calgary. 147 pp.

Government of Alberta. 2003. Water for Life. Edmonton, Alberta.

Government of Canada. 2008. Proponent’s Guide. Supra.

Halawell, A., K. Hull, K., D. White, K. Adair, and C. Wood. 2011. 2010 Riparian Health Inventory, Waiparous Creek Watershed. Alberta Riparian Habitat Management Society (Cows and Fish). Calgary, Alberta. Prepared for Ghost Watershed Alliance Society.

Halawell, A., M. Uchikura, K. Adair, and K. Hull, 2008. Riparian health inventory summary 2007 – Moose Mountain Environmental Enhancement Fund Area. Alberta Riparian Habitat Management Society (Cows and Fish). Calgary, Alberta. Prepared for Elbow River Watershed Partnership.

Hallett, J. 2011. Aerial Video Assessment of the Swan River System, Alberta. Data Report produced by Alberta Conservation Association, Peace River, Alberta, Canada.

Hansen, P.L., W.H. Thompson, et al. 2006. Alberta Lotic Wetland Inventory Form User Manual. Cows and Fish. 22 pp.

Hansen, P.L., W.H. Thompson, et al. 2006. Alberta Lotic Wetland Inventory Form. Cows and Fish. 10 pp.

Hansen, P.L., W.H. Thompson, R.C. Ehrhart, D.K. Hinckley, B. Haglan, and K. Rice. 2000. Development of methodologies to evaluate the health of riparian and wetland areas.

Proceedings of the Fifth International Symposium of Fish Physiology, Toxicology and Water Quality, November 10-13, 1998, Hong Kong, China. Vance Thurston, Editor. EPA/6000/R-00/015. United States Environmental Protection Agency, Office of Research and Development, Washington, DC, USA. 300 pp.

Hemstrom, M.A., Smith T., D. Evans, C. Clifton, E. Crowe, and M.Aitken. 2002. Midscale analysis of streamside characteristics in the upper Grande Ronde subbasin, northeastern Oregon. Res. Note PNW-RN-534. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 16 pp.

Hull, K., and A. Halawell. 2009. Riparian Health Community Report for Nose Creek and West Nose Creek. Alberta Riparian Habitat Management Society (Cows and Fish). Calgary, Alberta. Prepared for Nose Creek Watershed Partnership.

Jamison, T. 2009. State of the Lesser Slave Watershed 2009. Carson Forestry Services Inc. Prepared for Lesser Slave Watershed Council. High Prairie, Alberta. 116 pp.

Johansen, K., and S. Phinn 2009. Mapping riparian zones over large regions from high spatial resolution satellite and airborne imagery: specifications for operational mapping. ISPRS Hannover Workshop 2009, High-Resolution Earth Imaging for Geospatial Information.

Johns, T., and J. Hallett. 2006. Aerial Videography Assessment for Selected Reaches of the South Heart and West Prairie Rivers, Data Report produced by Alberta Conservation Association, Slave Lake, Alberta, Canada.

Jumpingpound Creek Watershed Partnership. 2009. Jumpingpound Creek State of the Watershed Report 2009. Compiled and edited by: Palliser Environmental Services Ltd. 91 pp.

Kilbourne, W., S. Beckmann, and E. Thelen. 2002. The role of the dominant social paradigm in environmental attitudes: a multinational examination. Journal of Business Research 55:193–204.

Lee, P., and Smyth, C. 2003. Riparian forest management: paradigms for ecological management and practices in Alberta. Report produced by the Alberta Research Council (Vegreville, Alberta) and the Alberta Conservation Association (Edmonton, Alberta) for the Northern Watershed Project Stakeholder Committee. Northern Watershed Project Final Report No. 1. 117 pp.

Leslie, T., Cuss K., Spicer-Rawe, K. 2006. Iron Creek riparian health inventory monitoring. 4 pp.

LimeSurvey Project Team. 2012. / LimeSurvey: An Open Source survey tool version 1.91 build 12170; /LimeSurvey Project Hamburg, Germany. URL http://www.limesurvey.org.

McKenney, B., and J. Kiesecker. 2010. Policy development for biodiversity offsets: a review of offset frameworks. Environmental Management 45: 165-176.

McNeil, R.L. 2008. Riparian Plant Communities of Southern Alberta; Detailed Site and Soil Characterization and Interpretations. Prepared by LandWise Inc., for Alberta Public Lands and Cows and Fish. Lethbridge, Alberta. Funded by Greencover Technical Assistance Program, Canada. 180 pp.

Milk River Watershed Council Canada. 2008. Milk River State of the Watershed Report 2008. Milk River Watershed Council Canada. Milk River, Alberta. 155 pp.

Miller, T.J. 2005. Evaluating riparian health assessment methods for perennial streams in Montana. M.Sc. Thesis. Montana State University. 72 pp.

Mills, B. 2005. An assessment of the health and integrity of riparian management zones of Moose Lake and Lac La Biche, Alberta. Data Report (D-2005-001) produced by Alberta Conservation Association, St. Paul, Alberta, Canada. 18 pp.

Mills, B. 2005. Initiation and facilitation of community based lentic riparian conservation at Moose Lake, Alberta. Data Report (D-2005-002) produced by Alberta Conservation Association, St. Paul, Alberta, Canada. 19 pp.

Mills, B. and Scrimgeour, G. 2004. The Effectiveness of Aerial Videography to Characterize Lakeshore Condition. Data Report (D-2005-017) produced by Alberta Conservation Association, Location, Alberta, Canada. 52 pp. + App.

Murphy. P.N.C., J. Ogilvie, K. Connor, and P.A. Arp. 2007. Mapping wetlands: A comparison of two different approaches for New Brunswick, Canada. Wetlands 27: 846–854.

Naiman, R.J., and H. Decamps. 1997. The ecology of interfaces -- riparian zones. Annual Review of Ecology and Systematics 28: 621-658.

NSWA (North Saskatchewan Watershed Alliance). 2005. State of the North Saskatchewan Watershed Report 2005 - A Foundation for Collaborative Watershed Management. North Saskatchewan Watershed Alliance, Edmonton, Alberta. 202 pp.

NRC (National Research Council). 2002. Riparian Areas: functions and strategies for management. National Academy Press, Washington, D.C. 428 pp.

O'Shaughnessy, K. 2010. Riparian Health Summary Final Report, Lac La Nonne. Alberta Riparian Habitat Management Society (Cows and Fish). 51 pp.

Osokin, L. and J. Hallett, 2007. Aerial Video Assessment of Lesser Slave Lake, Alberta. Data Report produced by Alberta Conservation Association, Slave Lake, Alberta, Canada.

OWEB (Oregon Watershed Enhancement Board). 2004. Oregon Riparian Assessment Framework. Oregon Plan for Salmon and Watersheds. 98 pp.

Petry, S. and S. Palechek. 2010. Oldman River – State of the Watershed Report.

Poff, N. L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime. Bioscience 47: 769-784.

Pretty, J., and D. Smith. 2004. Social capital in biodiversity conservation. Conservation Biology 18: 631-638.

QSR International Pty Ltd. 2008. NVivo qualitative data analysis software, Version 8.

Riemersma, S. and S. Andrews. 2007. Overview of Riparian Health Assessment and Other Riparian Evaluations Completed in Alberta Excluding those Completed by Cows and Fish. Prepared for Alberta Riparian Habitat Management Society – Cows and Fish by Palliser Environmental Services Ltd. Cows and Fish Report No. 031. 31 pp.

Robertson, M. M. 2000. No net loss: wetland restoration and the incomplete capitalization of nature. Antipode 32:463–493.

Robertson, M. 2004. The neoliberalization of ecosystem services: wetland mitigation banking and problems in environmental governance. Geoforum 35:361–373.

Robertson, M. M. 2006. The nature that capital can see: science, state, and market in the commodification of ecosystem services. Environment and Planning D: Society and Space 24:367–387.

Salzman, J., and J. Ruhl. 2000. Currencies and the Commodification of Environmental Law. Stanford Law Review 53:607–694.

Sass, G. Z., and Creed, I.F. 2011. Bird's eye view of forest hydrology: novel approaches using remote sensing techniques. *In:* Levia, D.F., Carlyle-Moses, D.E. and Tanaka, T. (Eds.), Forest Hydrology and Biogeochemistry: Synthesis of Past Research and Future Directions (pp.45-64). Ecological Studies Series, No. 216, Springer-Verlag, Heidelberg, Germany.

Scrimgeour, G.J., and D. Wicklum. 1996. Aquatic ecosystem health and integrity: problems and potential solutions. Journal of the North American Benthological Society 15: 254–261.

SEAWA. 2009. Assessment of riparian and wetland habitat status in the South Saskatchewan River sub-basin. SEAWA Watershed Report 2009-4. 26 pp.

Sibley, P.K., D.P. Kreutzweiser, B.J. Naylor, J.S. Richardson, and A.M. Gordon. 2012. Emulation of natural disturbance (END) for riparian forest management: synthesis and recommendations. Freshwater Science 31: 258-264.

Spash, C., S. Stagl, and M. Getzner. 2005. Exploring alternatives for environmental valuation. *In:* Getzner, M., Spash, CL, Stagl, S., Chippenham (Eds), Alternatives for Environmental Valuation. Routledge, London, UK.

Spicer-Rawe, Kelsey, et al. 2007. Iron Creek Riparian Health Inventory Final Report. Cows and Fish. 46 pp.

Stantec 2005. Alberta Environment Water for Life – aquatic ecosystems review of issues and monitoring techniques. Prepared for Alberta Environment. Edmonton, Alberta.

Teichreb C., and G. Walker. 2008. Aerial Videographic Health and Integrity Assessment of the Riparian Management Area for Selected Reaches of the Battle River. Alberta Environment Technical Report. 23 pp.

ten Kate, K., J. Bishop, and R. Bayon. 2004. Biodiversity offsets: Views, experience, and the business case. IUCN, Gland, Switzerland and Cambridge, UK and Insight Investment, London, UK.

Thompson, W.H., and P.L. Hansen. 2001. Classification and management of riparian and wetland sites of the Saskatchewan Prairie Ecozone and parts of adjacent subregions. Riparian and Wetland Research Program, the University of Montana, Prepared for the Saskatchewan Wetland Conservation Corporation, Regina, Saskatchewan, Canada. 298 pp.

Thompson, W.H., and P.L. Hansen. 2002. Classification and management of riparian and wetland sites of Alberta's Grasslands Natural Region and adjacent subregions. Bitterroot Restoration, Inc., Prepared for the Alberta Riparian Habitat Management Program-Cows and Fish, Lethbridge, Alberta. 416 pp.

Thompson, W.H., and P.L. Hansen. 2003. Classification and management of riparian and wetland sites of Alberta's Parkland Natural Region and Dry Mixedwood Natural Subregion. Bitterroot Restoration, Inc. Prepared for the Alberta Riparian Habitat Management Program-Cows and Fish, Lethbridge, Alberta. 340 pp.

Town of Cochrane. 2004. Town of Cochrane Land Use Bylaw. Cochrane, Alberta.

USDI (US Department of the Interior). 1994. Riparian Area Management: The Use of Aerial Photography to Manage Riparian-Wetland Areas. TR 1737-10. Bureau of Land Management, BLM/SC/ST-94/005+1737, Service Center, CO. 64 pp.

USDI (US Department of the Interior). 1996. Using Aerial Photographs to Assess Proper Functioning Condition of Riparian-Wetland Areas. TR 1737-12. Bureau of Land Management, BLM/RS/ST-98/001+1737. 136 pp.

USDI (US Department of the Interior). 1998. Riparian area management: a user guide to assessing proper functioning condition and the supporting science for lotic areas. TR 1737-15. Bureau of Land Management, BLM/RS/ST-98/001+1737. 136 pp.

USGS (US Geological Survey). 1999. Ecological status and trends of the Upper Mississippi River System 1998: A report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. April 1999. LTRMP 99-T001. 236 pp.

Walker, S., A. Brower, R. Stephens, and W. Lee. 2009. Why bartering biodiversity fails. Conservation Letters 2:149–157.

Appendix A:

Table A-1. Riparian health assessments conducted to date in the Peace River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool	Reference
ARHMS (C&F)	22	14.14	Various	1997-2011	45.5	36.4	18.2	74.5	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS - Unpublished data
Smoky Applied Research and Demonstration Association (SARDA)	2	na	1 river	2005, 2006	na	na	na	35	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma and Andrews (2007)
SRD (grazing lands)	368	na	Various	2006-2010	na	na	na	85.5	Healthy	ARHMS-Riparian Health Assessment	SRD unpublished data
West County Watershed Group	15	na	1 river	1999-2003	na	na	na	35	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)

Table A-2. Riparian health assessments conducted to date in the Milk River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
ARHMS (C&F)	219	204.9	Various	1997-2011	20.5	53.4	26.0	67.6	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS - Unpublished data
F&O Canada	1	na	entire main stem	2005	na	na	na	na	na	Aerial photography	Riemersma and Andrews (2007)
SRD (grazing lands)	58	various	na	2006-2010	na	na	na	77.5	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data

Table A-3. Riparian health assessments conducted to date in the Athabasca River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
ACA	1	172	Lac La Biche	2004	70	10	20	77	Healthy, but with problems	Low-Level Videography	Mills (2005)
ACA	na	na	Edson River	2010	51	12	37	na	na	Low-Level Videography	ACA website
ACA	na	na	Edson River tributaries	2010	79	7	14	na	na	Low-Level Videography	ACA website
ACA/Lesser Slave Lake Watershed Council	1	241	Lesser Slave Lake	2006	78.7	12.5	8.8	82.7	Healthy	Low-Level Videography	Osokin & Hallett (2007)
ACA/Lesser Slave Lake Watershed Council	1	90	South Heart River	2006	62	13	25	73.7	Healthy, but with problems	Low-Level Videography	Johns & Hallett (2006)
ACA/Lesser Slave Lake Watershed Council	1	16	West Prairie River	2006	43	30	27	69	Healthy, but with problems	Low-Level Videography	Johns & Hallett (2006)
ACA/Lesser Slave Lake Watershed Council	1	103	Swan River System (Moosehorn, Ivernness)	2010	88	5	7	85.6	Healthy	Low-Level Videography	Hallett (2011)
ACA/SRD	2	na	2 lakes	2002, 2005	na	na	na	na	na	Low-Level Videography	Riemersma & Andrews (2007)
ARHMS (C&F)	171	108	Various	1997-2011	37.4	38.6	24	71.5	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS - Unpublished data
ARHMS (C&F)	15	4.55	Lac La Nonne	2009	40	40	20	69	Healthy, but with problems	ARHMS-Riparian Health Assessment	O'Shaughnessy (2010)
SRD (grazing lands)	97	na	Various	2006-2010	na	na	na	73.0	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data
WCCG	5	na	2 rivers	2006	na	na	na	35	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)

Table A-4. Riparian health assessments conducted to date in the Beaver River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
ACA	1	64.1	Moose Lake	2004	63	13	24	74.2	Healthy, but with problems	Low-Level Videography	Mills (2005)
ACA/Beaver River Watershed Alliance	50	na	Beaver River and tributaries (Amisk and Sand River)	na	na	na	na	na	na	IBI assessment	ACA unpublished data
ACA/SRD	8	na	8 lakes	2001,2002, 2005	na	na	na	na	na	Low-Level Videography	Riemersma & Andrews (2007)
ARHMS (C&F)	22	14.7	Various	1997-2011	59.1	18.2	22.7	76.1	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS - Unpublished data
ARHMS (C&F)/Moose Lake Watershed Stewardship Society	na	13.4	Moose Lake tributaries (Thin Lake River, Yelling Creek, Vincent Creek, Kehewin Creek)	na	63	16	21	na	na	ARHMS-Riparian Health Assessment	ARHMS (C&F) unpublished data
SRD (grazing lands)	212	Various	Various	2006-2010	na	na	na	74.1	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data

Table A-5. Riparian health assessments conducted to date in the North Saskatchewan River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
ACA/SRD	6	na	6 lakes	2000, 2001,2002	na	na	na	na	na	Low-Level Videography	Riemersma & Andrews (2007)
ARHMS (C&F)	295	205.8	Various	1997-2011	23.4	56.9	19.7	69.8	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS - Unpublished data
AXYS	2	na	2 creeks	2006	100	0	0	90	Healthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
AXYS	10	na	10 creeks	2006	30	70	0	76	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
County of Wetaskiwin	48	na	16 creeks	1999,2000, 2001,2005	na	na	na	na	na	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
SRD (grazing lands)	208	Various	na	2006-2010	na	na	na	73.7	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data
WCCG	2	na	2 creeks	2006	0	0	100	35	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
VERMILLION											
County of Two Hills	1	na	1 creek	2006	0	100	0	70	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
Westworth Associates Environmental Ltd.	58	na	various	1999	16	30	54	54.5	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
BATTLE											
ACA	1	286.6	Battle River	2007	31.9	20.4	47.7	59.7	Healthy, but with problems	Low-Level Videography	Teichreb & Walker (2008)
ACA/SRD	1	na	1 lake	2002	na	na	na	na	na		Riemersma & Andrews (2007)
Iron Creek Watershed Improvement Society	29	28	Iron Creek	2001	10	53	37	66.2	Healthy, but with problems	ARHMS-Riparian Health Assessment	Spicer-Rawe et al. (2007)
Iron Creek Watershed Improvement Society	29	28	Iron Creek	2006	13	47	40	67.1	Healthy, but with problems	ARHMS-Riparian Health Assessment	Spicer-Rawe et al. (2007)
NCC	16	na	Streams/lake	2003, 2004, 2006	31.3	56.3	12.5	71.2	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
SRD (grazing lands)	88	Various	Various	2006-2010	na	na	na	73.7	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data

Table A-6. Riparian health assessments conducted to date in the South Saskatchewan River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
ARHMS (C&F)	1346	1228.2	Various	1997-2011	28.3	49.4	22.3	70.1	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS - Unpublished data
RED DEER											
ACA	1		Red Deer reach	2006	29	30	41	61	Healthy, but with problems	Low-Level Videography	Red Deer Watershed Report
ACA/SRD	2	na	2 lakes	2002	na	na	na	na	na	Low-Level Videography	Riemersma & Andrews (2007)
AENV/Golder	8	na	1 river (8 reaches)	2002	0	75	25	61.25	Healthy, but with problems	Best Judgement Panel	Golder Associates Ltd. (2003)
ARHMS (C&F)	19	31.3	Red Deer (8 reaches)	2003	52.6	47.4	0.0	80.5	Healthy	ARHMS-Riparian Health Assessment	ARHMS – Cows & Fish (2005); Alberta Environment (2007)
AXYS	1	na	One river	2006	na	na	na	90	Healthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
Conservation Coordinator	1	na	One creek	2006	na	na	na	70	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
Conservation Coordinator, Red Deer County	2	na	2 rivers	2006	na	na	na	35	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma and Andrews (2007)
Little Red Deer River Watershed Initiative	32	na	River system	2001-2004	28.1	31.2	40.6	61.4	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
NCC	16	na	Streams/lake	2003, 2004, 2006	31.3	56.3	12.5	71.2	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
NCC	20	na	Various lakes and wetlands	2005, 2006	15	55	30	62.5	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
NCC	2	na	One river	2006	na	na	na	70	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
SRD (grazing lands)	175	na	Various	2006-2010	na	na	na	79.0	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data

Table A-6 continued. Riparian health assessments conducted to date in the South Saskatchewan River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
BOW											
ACA	7	na	7 hydro features (7 sites)	2004	0.0	28.6	71.4	45	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
AENV	14	na	Bow (4 reaches) + 10 tributaries	2006	na	na	na	na	na	Low-Level Videography	Alberta Environment (2010); Riemersma & Andrews (2007)
AENV/Golder	7	na	1 river (7 reaches)	2002	0	80	20	61	Healthy, but with problems	Best Judgement Panel	Golder Associates Ltd. (2003)
ARHMS (C&F)	36	28	Nose, West Nose	2000	13.9	44.4	41.7	58.2	Unhealthy	ARHMS-Riparian Health Assessment	Hull & Halawell (2009)
ARHMS (C&F)	8	5.2	Nose, West Nose	2009	12.5	62.5	25.0	63.8	Healthy, but with problems	ARHMS-Riparian Health Assessment	Hull and Halawell (2009)
ARHMS (C&F)	37	27	Waiparous, Johnson, Meadow, Lost Knife, Four Mile, Aura	2010	83.8	16.2	0.0	88.0	Healthy	ARHMS-Riparian Health Assessment	Hallawell et al. (2011)
ARHMS (C&F)	33	na	Elbow River, plus tributaries	2007	72.7	24.2	3.0	83.5	Healthy	ARHMS-Riparian Health Assessment	Hallawell et al. (2008)
ARHMS (C&F)	18	na	Jumpinpound Creek	2007	38.9	61.1	0.0	77.8	Healthy, but with problems	ARHMS-Riparian Health Assessment	Jumpingpound Creek Watershed Partnership (2009)
ARHMS (C&F)	21	40	Bow (10 reaches)	2003	28.6	47.6	23.8	67.4	Healthy, but with problems	ARHMS-Riparian Health Assessment	ARHMS – Cows & Fish (2005); Alberta Environment (2007)
City of Calgary	41	na	West Nose Creek creek (41 sites)	2003	na	na	na	na	na	Benchmark photography	Riemersma & Andrews (2007)
City of Calgary	456	230	Bow, Elbow, Nose Creek, West Nose Creek streambanks	2010	--	--	--	--	--	Streambank assessment	City of Calgary data
City of Calgary	36	na	Bow and Elbow Rivers	2009	0	33	67	53.3	Unhealthy	ARHMS-Riparian Health Assessment	City of Calgary data

Table A-6 continued. Riparian health assessments conducted to date in the South Saskatchewan River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
City of Calgary	59	na	Bow, Elbow, Nose, West Nose	2007-2010	5.1	52.5	42.4	56.2	Unhealthy	ARHMS-Riparian Health Assessment	City of Calgary data
NCC	7	na	6 hydro features (7 sites)	2002, 2003	14.3	85.7	0.0	72.3	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
NCC	12	na	8 hydro features (12 sites)	2005, 2006	50.0	33.3	16.7	74.2	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
SRD (grazing lands)	115	na	various	2006-2010	na	na	na	77.1	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data
OLDMAN											
AENV	4	na	4 creeks	2006	na	na	na	na	na	Low-Level Videography	Alberta Environment (2010); Riemersma & Andrews (2007)
AENV/Golder	18	na	4 rivers (18 reaches)	2002	11.1	61.1	27.8	62.5	Healthy, but with problems	Best Judgement Panel	Golder Associates Ltd. (2003)
ARD	3	na	Indianfarm Creek (3 reaches)	2007, 2012	na	na	na	25	Unhealthy	ARHMS-Riparian Health Assessment	ARD Unpublished data
ARD	3	na	Indianfarm Creek (3 reaches/43 transects)	2007-2012 (sub-set of transects re-assessed every year)	na	na	na	na	na	Field assessment (before and after measurement)	ARD Unpublished data
ARHMS (C&F)	46	61.6	Oldman (10 reaches), Tributeries: Waterton, Belly, St. Mary	2001, 2004	10.9	52.2	37.0	59.2	Unhealthy	ARHMS-Riparian Health Assessment	ARHMS – Cows & Fish (2005); Alberta Environment (2007)
ARHMS (C&F)	400	na	Various	1997-2006	15	55	30	na	na	ARHMS-Riparian Health Assessment	Petry & Palechek (2010) but citing C&F work so duplicated from above
Lethbridge Community College	4	na	1 creek (4 sites)	1998	na	na	na	na	na	Fish habitat manual - stream stability and % bank vegetation	Riemersma & Andrews (2007)

Table A-6 continued. Riparian health assessments conducted to date in the South Saskatchewan River basin.

Organization	# of sites	Length (km)	Name/Type of feature	Year(s)	H [%]	HwP [%]	UH [%]	Avg. Score	Health Status	Tool Used for Assessment	Reference
Lethbridge Community College	4	na	1 creek (4 sites)	2004	na	na	na	na	na	Fish habitat manual - stream stability and % bank vegetation	Riemersma & Andrews (2007)
NCC	160	na	Many different hydro features	2002-2006	21.3	46.3	32.5	62.9	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
SRD (grazing lands)	147	na	Various	2006-2010	na	na	na	71.0	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data
S.SASK (main)											
AENV/Golder	2	na	1 river (2 reaches)	2002	0	100	0	70	Healthy, but with problems	Best Judgement Panel	Golder Associates Ltd. (2003)
ARHMS (C&F)	8	12.83	South Saskatchewan (2 reaches)	2000, 2003	0	37.5	62.5	48.1	Unhealthy	ARHMS-Riparian Health Assessment	ARHMS – Cows & Fish (2005); Alberta Environment (2007)
AXYS	1	na	1 river	2006	na	na	na	65	Healthy, but with problems	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
NCC	23	na	14 rivers	2002-2006	4.3	60.9	34.8	58.7	Unhealthy	ARHMS-Riparian Health Assessment	Riemersma & Andrews (2007)
SRD (grazing lands)	34	na	na	2006-2010	na	na	na	77.3	Healthy, but with problems	ARHMS-Riparian Health Assessment	SRD unpublished data