The Effectiveness of Aerial Videography to Characterize Lakeshore Condition

Alberta Conservation Association

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EXECUTIVE SUMMARY

The Riparian Habitat Assessment Project (RHAP) developed and tested the ability of low-level videography to describe shoreline conditions in shallow lakes of Alberta, Canada. We compared the spatial resolution and acquisition costs of the video with three other available sources of land cover imagery. To enhance the capacity of the video product we developed a scoresheet for making shoreline health and integrity determinations when the video was viewed by a trained observer. We also compared the video scoresheet assessment criteria with those of three ground based riparian health assessment methods and quantified inter- and intra-observer agreement in shoreline assessments completed using low-level videography. Cost effectiveness of assessments using low-level videography captured from an amphibious trike with that captured from a boat, the ground and a helicopter were also compared. These comparisons showed that low-level videography and the video assessment scoresheet were highly cost effective compared to other modes of assessment. This approach also provided moderately high resolution imagery capable of distinguishing fine to moderate scale changes in shoreline conditions and relatively robust inter- and intra-observer assessment results. Taken together, our data suggest that low-level videography, combined with simple assessment criteria, represents a rapid and cost effective means to assess shoreline conditions.

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We are most indebted to George Walker (Alberta Sustainable Resource Development – Fish and Wildlife) who has been deeply involved in every aspect of project development and delivery. His dedication, resourcefulness, adaptability and patience made him an indispensable leader and a key to this project's success. Without his efforts this project and report would not have been possible.

Review and editing of this report was provided by Stephanie Grossman, Doug Manzer and an anonymous reviewer employed by the Alberta Cooperative Conservation Research Unit.

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1.0 INTRODUCTION

1.1 Project Rationale

Lentic riparian and littoral habitats and the fish and wildlife populations they support are under increasing pressure from human-caused disturbances across North America. These disturbances include physical changes to, or removal of riparian and littoral vegetation and soil, point-source discharges, including nutrient inputs (e.g., sewage inputs) and development of in-lake structures e.g., docks (Scrimgeour and Chambers 2000, Radomski and Goeman 2001). Changes in riparian and littoral habitats resulting from shoreline development have degraded fish spawning, nursery and foraging habitats, reduced thermal and predator cover and generally reduced fish production (Robinson and Tonn 1989, Schindler and Scheuerell 2002, Pratt and Smokorowsk 2003).

Dramatic expansions in the number of lake-front cottages in Alberta since the 1970s have raised serious concerns about the effect human activities are having on lake fish communities in the province. The lack of current and comprehensive information on the status of riparian and littoral areas of entire lakes, and the extent of human disturbance is a formidable obstacle hampering the sustainable management of Alberta lakes.

1.2 Project History

In 1997 the Alberta Conservation Association (ACA) identified that a rapid and cost effective method to quantify and qualify “whole lake” riparian habitats and human-caused activities influencing riparian and littoral zones did not exist. The desired spatial scale (e.g., shoreline of entire lake) made ground-based collection of this information cost and time prohibitive. Although unmeasured, it was generally felt a lower precision, lower cost measurement method that generated coarse information at larger spatial scales would provide resource managers with sufficient information to make good management decisions regarding riparian areas.

Initial activities to develop this methodology were completed in 1997 through the ACA Northeast Business Unit Lake Inventory Project. As part of this project, trials were performed between May and July 1997 to document shoreline areas at priority lakes using a standard VHS video camera taken from a slow moving boat. Our intent was to complete whole lake assessments of riparian and littoral areas using a rapid and cost-effective method. The use of video provides many benefits including opportunities to: i) re-assess riparian and littoral characteristics using different habitat criteria and ii) quantify observer bias on these lakeshore classifications. Video footage can also capture baseline conditions that can be used to evaluate spatial and temporal changes in littoral and riparian conditions. These efforts are ultimately linked to a broader effort to conserve lake ecosystems, including the education of lakeside occupants and agencies whose mandates include shoreline conservation.

Our preliminary evaluations showed that videography obtained from a boat (i.e., at water level) was of limited value because it did not provide sufficient height to quantify the spatial extent of riparian and littoral areas due to low depth perspective. This approach was also problematic due to varying water depths of near-shore water habitats that make travel at consistent distances from shore (required in order to provide a comparable perspective throughout) difficult to maintain. Similarly, shoreline views were obstructed when emergent macrophyte biomass was high as is the case in the majority of Alberta's mesotrophic and eutrophic lakes.

An aerial videography trial was subsequently performed at Lac La Nonne, Alberta in late July 1997. A commercial videography company was retained to capture approximately one mile of shoreline using VHS video (i.e., an oblique angle shot from 30 to 180 m above the lake surface) using their proprietorial video equipment mounted on a Robinson R22 helicopter. Project staff were not present on the helicopter when video footage was captured. Although the video captured during the trial was likely adequate to make the desired assessments, the cost to deliver this one-mile of video in 1997 was $1,500.00. While cost efficiencies could be realized if this method was used on a larger scale, it was decided that this method would likely be too costly and alternative methods were evaluated. In addition, the absence of ACA staff on the flight to contribute verbal comments along with the videography during flight was also deemed to be a shortcoming of this method.

In August and October, 1997 aerial videography trials were performed at Vincent and Sandy Lakes (approximately 200 km NE and 50 km NW of Edmonton, Alberta respectively), using a Buckeye "Powered Parachute", Ultralight Aircraft. This aircraft is inexpensive to run (approximately $10-15/hr plus fuel and lubricants), is capable of low velocity flights (48 kph) and can fly at the desired altitudes of $\leq$ 60 m with greater safety than conventional helicopters. However, it cannot be flown in winds exceeding 24 kph, and like most helicopters, has no ability to take off and land from water, a desired project delivery element required for functionality and safety. Obtaining stable videography when wind velocity exceeded 24 kph posed problems regardless of aircraft type used. Therefore, video capture is usually performed during the calmest parts of the day; in north-central Alberta that typically occurs in early morning and late evening. These periods also provide a balance between light, shadow and real color depth, which can assist in the determination and differentiation of ground features seen on the video.

In 2000, the ACA, in partnership with Alberta Sustainable Resource Development – Fish and Wildlife (ASRD-FW), initiated the Riparian Habitat Assessment Project (RHAP) to i) develop and apply a cost effective low-level aerial video capture method, ii) develop a scoresheet to make riparian management area health and integrity assessments from the video by a trained observer, and iii) export this information to conservation agencies, groups and interested individuals to generate awareness of riparian health values and where those values and shoreline health are affected by human activities. The desired outcome being community delivered, on-the-ground riparian conservation and protection activities.

1.3 Delineating riparian zones and the riparian management area

A commonly understood definition of riparian area does not exist. Lee and Smyth (2003) report that:

> "Currently, the most widely accepted definition is based on a probabilistic delineation. Areas closer to the water's edge are more likely to be riparian."

> "Typically, the definition for riparian areas varies according to its intended use in research or management."

An example of a research definition of a riparian area is found in Armantrout (1998):

> "(1) Of, pertaining to, situated or dwelling on the margin of a river or other water body. (2) Also applies to banks on water bodies where sufficient soil moisture support the growth of mesic vegetation that require moderate amount of moisture."

Prichard et al. (2003) provides another research-based definition but expands the term to riparian-wetland area and includes a conceptual management boundary:

> "An area that is saturated or inundated at a frequency and duration sufficient to produce vegetation typically adapted for life in saturated soil conditions. It is also the transitional area between permanently saturated wetland and upland areas often referred to as a riparian area. This transition area has vegetation or physical characteristics reflective of permanent surface or subsurface water influence. Wetlands and wetland transitions are usually managed as a unit."

The riparian area, when used to describe management activities within that zone, has been referred to as the "Riparian Management Area (RMA)." Like riparian area, this definition also varies depending upon the intended use (i.e., management activity). Lee and Smyth (2003) states:

> "The primary difficulty in defining riparian areas for management is clearly translating the changes in multiple functions, structures and biota along the gradient, i.e., ecotone, from aquatic to terrestrial upland into administrative boundaries."

This observation is supported by Hoiberg et. al. (2003):

> "Delineation of riparian area widths is a politically charged issue, as is the determination of acceptable levels of management within the areas. Guidelines for RMA widths and intensity of management often lack scientific support."

One example of how RMA has been used by management agencies to describe their activities within the riparian area is found in the 2001 Southwest Oregon State Forests Management Plan (Oregon Department of Forestry 2001):

> "Riparian Management Areas will be established immediately adjacent to waterways for the purpose of protecting aquatic and riparian resources, and maintaining the functions and ecological process of the waterways."

This term also appears in the Forest Practices Code of British Columbia [Canada] Act, Operational Planning Regulation, and provides a multi-level regulatory description of the RMA:

> "….an area, of width determined in accordance with Part 10 of the regulation, that is adjacent to a stream, wetland or lake with a riparian class of L2, L3 or L4 and, consists of a riparian management zone and, depending on the riparian class of the stream, wetland or lake, a riparian reserve zone."

Although a generally accepted and concise definition of riparian and RMA is not available, there is general agreement that both areas include aquatic and terrestrial components. When management activities target these components within the riparian area, the resulting RMA length and width will vary depending upon the intended management goals for those components. The RHAP uses this understanding of RMA as the basis for collection and assessment of aerial videography in support of fish, wildlife and shoreline habitat conservation and protection activities in Alberta. It also uses a modification of the concept reported in Lee and Smyth (2003) that: "Areas closer to the water's edge are more likely to be riparian" to read: Areas closer to the water's edge are more likely to be RMAs.

Considering that "management" activities (e.g., assessment of fish spawning and colonial nesting bird status and condition, addressing human-caused removal of emergent macrophytes) within the RMA typically extend into the water, for the purpose of this project we broadened the definition of RMA to include offshore areas with emergent macrophytes. Therefore, the RMA is bounded by the offshore extent of emergent macrophytes visible, up slope to the edge of permanent treed vegetation as shown in Figure 1.

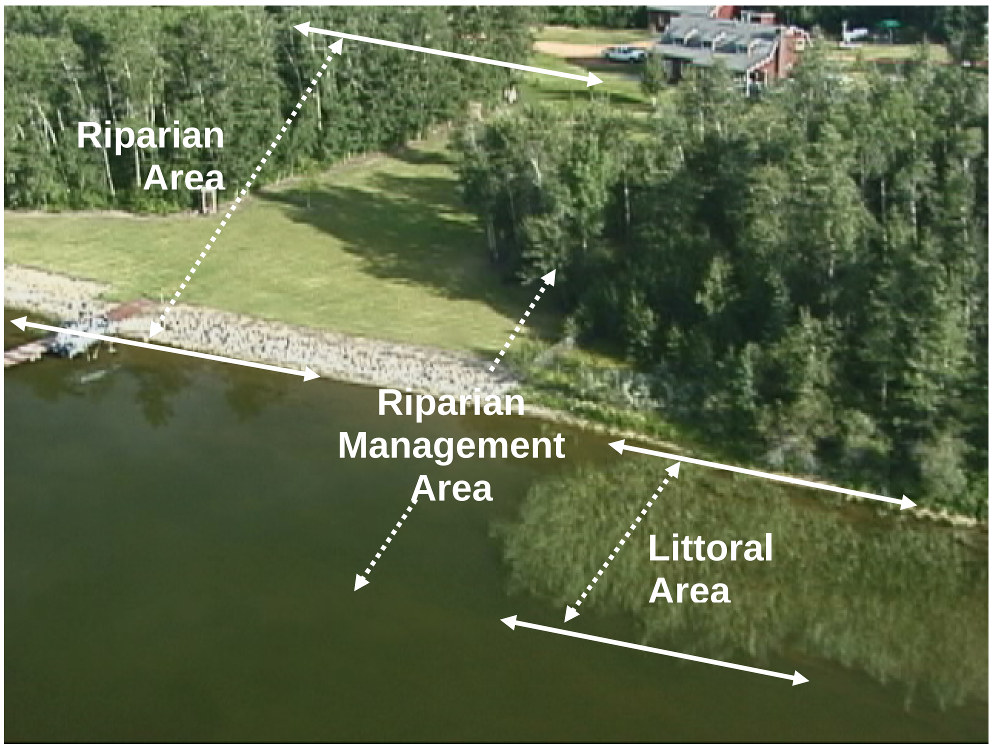

Figure 1. Shoreline area showing the approximate location of the riparian, littoral riparian management areas (RMA). The width of these areas varies between lakes. Aerial videography focuses on the land-water interface area (i.e., RMA shown running through center of picture). The RMA can include the entire riparian and littoral areas at some lakes, depending upon the amount of treed vegetation blocking the camera's view of the land surface and if the littoral area extends offshore beyond the cameras view.

1.4 Describing riparian health and integrity

A detailed treatise on the concepts of health and integrity, and their application, is provided by Scrimgeour and Wicklum (1996). For this project we will use their definition of health, i.e., "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."

1.5 Project objectives

To achieve the first primary objective described in section 1.2, we: i) developed, tested and delivered a low-flight aerial videography system to capture this data from priority lakes in north-central Alberta, and, ii) evaluated the products generated by this remote sensing system as to their effectiveness and comparability to other assessment methods. To achieve the second primary objective we: i) developed a scoresheet for determination of riparian health and integrity of RMAs displayed on the video and compared that scoresheet to other ground-based scoresheets. We also described the cost efficiency of using the RHAP scoresheet with video captured from boat, helicopter, ultralight aircraft and ground-based assessment using the Cows and Fish sheet.

2.0 STUDY AREA

Field work was completed at 16 lakes in central Alberta (Figure 2). The majority (10 of 16) of study lakes are located solely within the Low Boreal Mixedwood ecoregion whereas two lakes were located within both the Low Boreal Mixedwood and either the Mid Boreal Mixedwood or Aspen Parkland ecoregions. One lake was located solely within the Lower Boreal Cordilleran and one within the Mid Boreal Mixedwood ecoregions (Table 1).

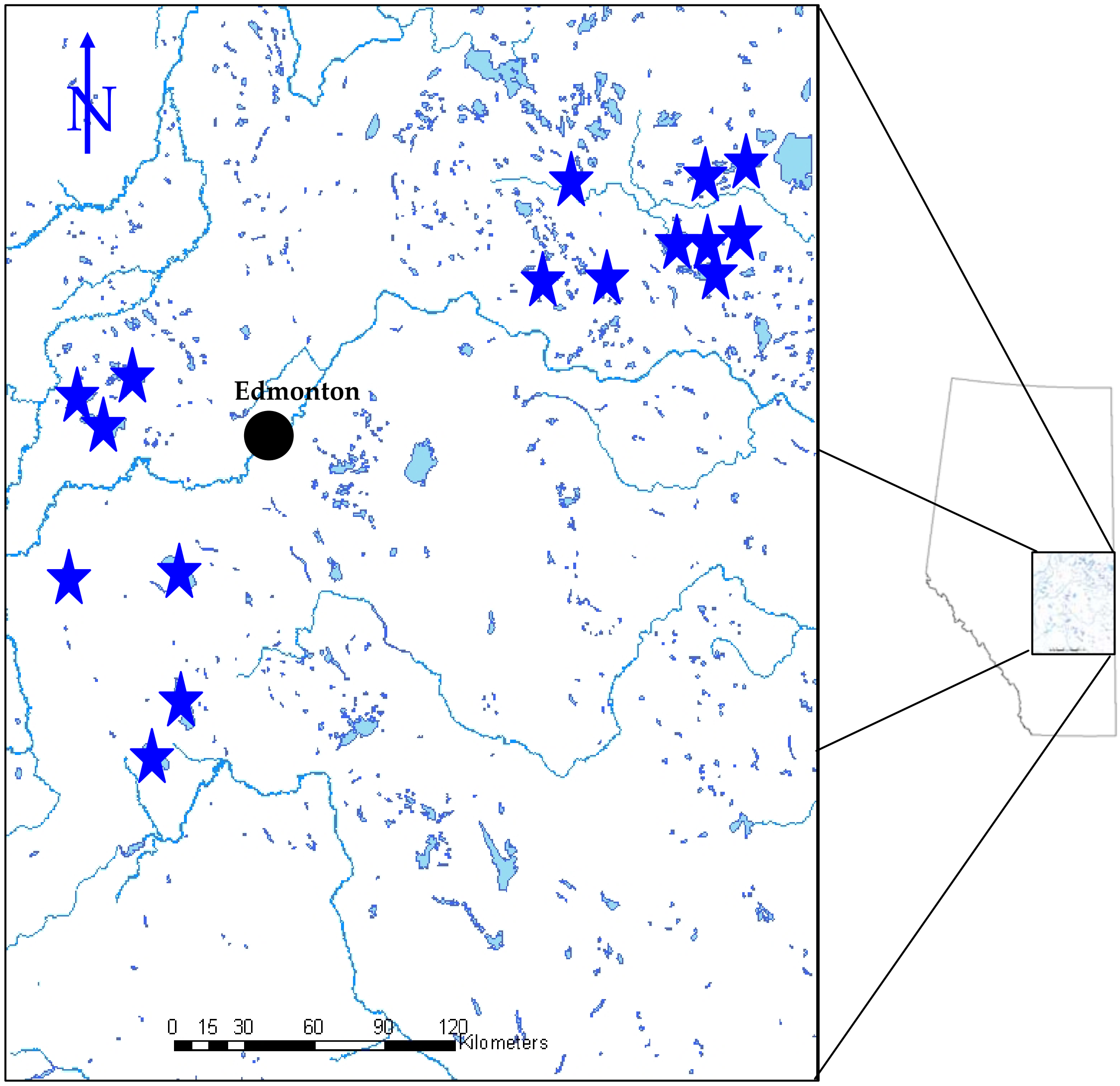

Figure 2. Location of the 16 study lakes in central Alberta, Canada. Blue stars highlight the locations of the study lakes and the inset shows the relative location of the lakes within the province of Alberta.

Table 1. Ecoregion types and selected lake and drainage area attributes of the 16 study lakes in Alberta. Information on ecoregions was derived from Strong and Legatt (1992), whereas information on lake and drainage areas was derived from Mitchell and Prepas (1990). Drainage areas do not include lake areas. LBR – Low Boreal Mixedwood, LBC – Lower Boreal Cordilleran, LBM – Low Boreal Mixedwood, AP – Aspen Parkland, MBM – Mid Boreal Mixedwood.

Lake	Ecoregional representation	Drainage Area (km^2)	Lake surface area (km^2)	Shoreline length (km)	Maximum depth (m)	Mean Depth (m)
Bonnie	LBM	49.6	3.77	18.7	6.1	3.1
Buck	LBC	233	25.4	32.8	12.2	6.2
Charlotte	LBM	384	64.1	50	10.7	6.6
Ethel	LBM	542	4.9	11.0	30.0	6.6
Fork	LBM	-	-	-	-	-
Gull	LBM, AP	206	80.6	58.0	8.0	5.4
Hilda	LBM	-	-	-	-	-
Isle	MBM	246	23.0	41.1	7.5	4.1
Jessie	LBM	-	-	-	-	-
Lac Ste. Anne	LBM, MBM	619	54.5	63.6	9.0	4.8
Moose	LBM	755	40.8	64.1	19.8	5.6
Muriel	LBM	384	64.1	50	10.7	6.6
Pigeon	LBM	187	96.7	46	9.1	6.2
Sylvan	LBM, AP	102	42.8	36	18.3	9.6
Vincent	LBM	-	-	-	-	-
Wabamun	MBM	259	81.8	57.3	11	6.3

2.1 Forest cover and soils

The Low Boreal Mixedwood is a transition between the Aspen Parkland and Mid Boreal Mixedwood ecoregion with Orthic Gray luvisols predominant (Strong and Legatt 1992). Forest communities are dominated by aspen (*Populus* spp.) on moderately well- to well-drained Gray luvisols and Eutric brunisols, while an aspen, balsam poplar (*Populus balsamifera*) complex typically occurs on imperfectly drained Gray luvisols and Gleysols. Black spruce (*Picea mariana*) occurs predominantly on poorly drained sites.

Upland sites in the Mid Boreal Mixedwood are dominated by trembling aspen (*Populus tremuloides*) and balsam poplar with black spruce, willow (*Salix* spp.) and sedge (Cyperaceae) dominant on poorly drained depressions and in lowland sites. Climax species of white spruce (*Picea glauca*) and balsam fir (*Abies balsamea*) are seldom dominant due to the frequent occurrence of fires. Soils in reference sites are dominated by Gray luvisols and Eutric brunisols.

The Lower Boreal-Cordilleran is an ecotone between boreal and cordilleran climatic conditions and reflects the transition from deciduous boreal to coniferous cordilleran vegetation. Lodgepole pine (*Pinus contorta*) is the dominant species on well drained Gray luvisols while trembling aspen, balsam poplar, paper birch (*Betula papyrifera*), lodgepole pine, white spruce, black spruce and balsam fir predominate on moderately well-drained sites. Poorly drained sites are dominated by black spruce whereas a black spruce, white spruce and lodgepole pine complex is found on imperfectly drained sites.

The Aspen grassland ecoregion is a climatic and ecological transition zone between the boreal forest and grassland (Strong and Legatt 1992) and is defined by the mixture of native grassland and deciduous plant communities found in Chernozemic soils. Grassland-dominated areas are characterized by rough fescue (*Festuca campestris*) with aspen clones, located on well- to moderately well-drained black and dark brown chernozems. Aspen dominated areas are found on moderately well-drained black and dark brown chernozems. Much of the Aspen-grassland ecoregion is comprised of undulating or hummocky terrain.

2.2 Air temperature and precipitation

Within these ecoregions, mean summer temperatures are lowest in the Lower Boreal Cordilleran (12.8 ^{o}C) and highest in the Aspen Parkland (14.4^{o}C) (Table 2). During the winter months, mean winter temperatures are lowest in the Mid Boreal Mixedwood (-13.2^{o}C) and highest in the Lower Boreal Cordilleran (-7.8 ^{o}C; Table 2). However, extreme winter temperatures can fall to -30^{o}C in all ecoregions (Strong and Legatt 1992). The majority (60.5% to 63.6%) of precipitation in the Low Boreal Mixedwood, Mid Boreal Mixedwood, Lower Boreal Cordilleran and Aspen parkland ecoregions falls during the summer (May through August) and annual precipitation is highest in the Lower Boreal Cordilleran, relative to Aspen Parkland, Mid Boreal Mixedwood and Lower Boreal Cordilleran ecoregions (Strong and Legatt 1992, Table 2).

2.3 Lake and drainage basin morphometrics

The majority (eight of 16) of study lakes are moderately large, for Alberta standards, and range between 40.8 and 96.7 km^2 (Table 1). Two of the four remaining lakes range in size from 23 to 25.4 km^2, whereas the remaining two lakes are small (< 5 km^2). All lakes are moderately deep (range of maximum depths = 6.1 to 30 m), mesotrophic to eutrophic and ice-covered between December and May.

Table 2. Summary of summer and winter air temperatures (°C) and annual precipitation (mm) in the Low Boreal Mixedwood, Mid Boreal Mixedwood, Lower Boreal Cordilleran and Aspen Parkland ecoregions, Alberta. Summer = May through August, Winter = November through February. Information derived from Strong and Legatt (1992).

Variable	Low Boreal Mixedwood	Mid Boreal Mixedwood	Lower Boreal Cordilleran	Aspen Parkland
Air temperatures (°C)				
Summer				
Mean	13.8	13.5	12.8	14.4
Mean minimum	7.0	7.3	6.9	7.7
Mean maximum	20.4	19.6	18.3	20.9
Winter				
Mean winter	-10.5	-13.2	-7.8	-8.7
Mean minimum	-15.8	-18.6	-14.3	-14.0
Mean maximum	-5.3	-7.7	-2.1	-3.7
Precipitation (mm)				
Summer	235	240	295	259
Winter	61	64	60	53
Annual	380	397	464	412

2.4 Lake shore development

While not quantified, anthropogenic activities are thought to alter the shorelines and littoral vegetation of 10 to 80% of the study lakes. Activities most often seen include cutting, cultivation or removal of native vegetation and the deposition of sand, rock and soil. These activities are often associated with the establishment of cottages and the development of beaches, shoreline retaining walls, lawns and related trees and shrubs, decks, docks and storage buildings.

3.0 MATERIALS AND METHODS

3.1 Assessing the ability of low level aerial videography to characterize riparian management areas

3.1.1 Low level videography protocols and the SeaWing ultralight

We evaluated the ability to define RMAs captured using videography equipment from the SeaWing trike, an amphibious ultralight aircraft (Figure 3). The ultralight is a relatively simple aircraft to operate and provides an inexpensive and safe video platform required for real-color hand-held video capture using the SONY DCR-TRV 900 digital video camera. Geo-referencing of the video was achieved by linking a Red Hen Systems, VMS200 Video mapping unit ("red box") to the camera. The Red Hen System captures a Global Positioning System (GPS) spatial coordinate (i.e., latitude and longitude) at one second intervals on the cameras left audio track. The GPS location and time is referenced to that same time on the video by using the videos "universal time code", thereby synchronizing the video image with the GPS location of the ultralight. The right audio track is available to capture verbal comments from the pilot and camera person through the onboard intercom system. The camera and VMS system is shown in review mode in Figure 4. Flight and filming configuration is shown in Figure 5 and a sample image extracted from the video is shown in Figure 6.

Figure 3. The SeaWing Amphibious weight-shift ultralight aircraft used to gather aerial videography on lentic riparian areas.

Figure 4. The Sony digital video camera and Red Hen Systems Global Positioning Systems mapping used to record and geo-reference aerial videography.

Figure 5. Video capture configuration during aerial videography. Pilot is shown on the right and videographer on the left.

Figure 6. An image captured using low-level aerial videography showing shoreline area converted from forest to a mixture of grass and large cobble materials. The image was taken at an approximate height of 50 m while the SeaWing ultralight was located about 100 m from the lake shore. Note the location of a dock in the foreground and a cottage in the background.

Test flights were conducted between May 2000 and October 2001 at Vincent and Moose lakes to determine the best combination of flight direction, altitude and camera zoom settings required to capture the RMA.

3.1.2 Defining the spatial resolution and acquisition costs of low-level videography and comparisons with three other methods

From a video imaging perspective, spatial resolution has been described as the area on the ground that an imaging system, such as a satellite sensor, can distinguish. There are many measures of spatial resolution. One of the most common measures is the Instantaneous Field of View (IFOV), which is defined as an area on the ground that is viewed by the instrument (e.g., satellite, video or still camera) from a given altitude at any given time (Association for Geographic Information 1999). However, spatial resolution does not refer to the smallest object that can be detected (i.e., presence or absence), rather the smallest item that, without other information, can be identified from the image (NASA 1999). The spatial resolution (IFOV) of the true color aerial videography captured by RHAP has not been directly measured but can likely approach 15 cm, based on observations of common objects of known size, (e.g., lumber planks in docks, cottage lot width from survey plans, length of known boat types) captured on the video. This level of spatial resolution, obtained from the low-level videography protocol, is capable of defining many important characteristics of the RMA.

We determined the ability of imagery from three frequently used remote sensing image sources (i.e., aerial photography, Indian Resource Sensing System satellite imagery [IRSS] and IKONOs satellite imagery) to provide adequate resolution to complete riparian assessment by comparing their advertised spatial resolution (IFOV) with that of the aerial videography. We also performed a comparison of costs (per square km) to acquire frequently used imagery, i.e., Indian Resource System Satellite, IKONOS satellite, air photography and aerial videography for a hypothetical lake. Determination was made of minimum imagery order sizes and if the images could be geo-referenced, a key requirement for RHAP so it can use Geographical Information System (GIS) software (Red Hen Systems Mediamapper and ESRIs ArcView/ArcGIS) to process data.

3.2 Applying RHAP scoresheet to low level aerial videography

Defining ecosystem health and integrity continues to be a contentious issue (Karr 1991, Steedman 1994, Scrimgeour and Wicklum 1996) and descriptions of riparian and littoral areas can be evaluated using a multitude of attributes indicative of ecosystems health or ecosystem integrity, depending upon the study questions being addressed. In the present study, we have predominantly used videography as the basis from which assessments of ecological integrity of riparian areas are performed. To support this approach we developed the Aerial Videography – RMA - Health and Integrity Assessment Scorecard for Lakes provided in Appendix 7.1. This scorecard uses a generalization of the ecosystem health and integrity approach discussed by Scrimgeour and Wicklum (1996).

3.3 Comparison of criteria to assess lentic riparian management areas

We compared rapid bioassessment criteria used by RHAP to quantify riparian condition with three sets of rapid bioassessment criteria for standing water bodies: i) Lentic standard checklist (USDI, United States Department of the Interior 2003) (Appendix 7.2), ii) Riparian function checklist for lakes (BCMF, British Columbia Ministry of Forests 1999) (Appendix 7.3), and iii) Alberta lentic wetland health assessment survey (ABCF, Alberta Cows and Fish Program 2003) (Appendix 7.4). Our primary objective was to compare and contrast criteria used with the RHAP with those used in other rapid bioassessment methods.

Quantifying riparian condition is typically achieved by trained observers providing answers to a suite of questions provided on field score-sheets. While we attempted to complete comparisons of riparian habitat criteria within rapid bioassessment approaches, our preliminary observations suggested that moderate differences in the types and numbers of questions within field score-sheets existed among the four sets of criteria. For example, criteria used by the United States Department of the Interior are based predominantly on providing answers to moderate numbers of questions related to the quantification of vegetative and hydrological characteristics of riparian zones (7 and 9 questions, respectively). In contrast, criteria used by the British Columbia Ministry of Forests rely on fewer questions related to vegetative and hydrological characteristics of riparian zones (6 and 1 questions, respectively). Thus, to allow comparisons among the four sets of rapid bioassessment criteria, we initially identified those criteria related to: i) vegetation, ii) physical and chemical, and iii) hydrological attributes of riparian zones. Within each of these categories, we also defined the number and types of questions related to each of these three categories and whether the questions were relatively complex (Table 3).

The USDI, BCMF and ABCF score-sheets focus on the riparian and riparian-wetland area. Being ground-based approaches, the protocols can include descriptions of these habitat types. In contrast, our RHAP videography approach cannot consistently capture the riparian and riparian-wetland area but can consistently capture and assess the RMA.

Table 3. Riparian health and integrity score-sheet question categories, sub-categories and key elements used to evaluate riparian condition at lakes.

Criteria category	Component	Description
Vegetation	Vigor	Growth and ability to withstand wind and water events, stabilize soils, filter sediment and pollutants and source of woody debris.
	Diversity	Preferred and invasive species categories, species age-classes and indicators of hydric soils.
	Density and distribution	All species, specific species, species categories and preferred species.
	Disturbance	Natural (e.g., browsing) or human-caused.
Physical and Chemical	Erosion and deposition	Soil loss, nutrient, organic matter, pollution and sediment input.
	Soils and physical cover	Water retention, shoreline protection e.g., rock, bare ground, hummocking.
	Disturbance	Natural or human-caused alteration of vegetation or physical attributes.
	Wildlife species	Species diversity
Hydrology	Water	Surface and sub-surface level and fluctuation, inflow, outflow, soil saturation, frost, natural or human-caused disturbance.

3.4 Determining the effectiveness of RHAP videography scoresheet to describe riparian habitat health and integrity

Mausel et al. (1992) described the growing use of aerial videography as an assessment tool in the field of biological resource management, including its use in the classification of riparian vegetation, quantification of fish habitat and assessment of aquatic habitats. Since 1992, scientific literature describing the use of multi-spectral aerial videography for documentation of riparian vegetation has increased (Redd et. al. 1994, Malthus and George 1997, Everitt et al. 1999, Jakubauskas et. al 2002). In comparison, we failed to find literature dealing with use of aerial video and a rapid bio-assessment method (e.g., scoresheet) to quantify health and integrity of the riparian zone adjacent to standing waters. Pritchard (1999) described a method using aerial photographs to assess the function of stream riparian/wetland areas, but this method focused on streams and has not been applied to standing water bodies.

3.5 Inter and intra-observer variance in riparian health and integrity assessments

Understanding the extent that biological assessments differ within (i.e., intra-observer variance) and among observers (inter-observer variance) is an important consideration when evaluating the effectiveness of monitoring programs (e.g., Nerbonne and Vondracek 2003). Using our low-level videography methods and the Aerial Videography – RMA - Health and Integrity Assessment Scorecard for Lakes, we quantified both within and among variance in RMA classifications using videography captured from the three lakes in 2002.

We quantified intra-observer (i.e., within observer) variance in riparian assessments by comparing assessments of Bonnie, Lac Ste. Anne and Sylvan Lakes by a trained observer completed on 26 August 2003 and again on 28 August 2003. In contrast, we quantified inter-observer (i.e., between observers) variance in riparian assessments by comparing the average of the two inter-observer assessments of the three lakes with a single assessment completed by a second trained observer on 9 September 2003.

The small sample size (N=3) precluded use of standard statistical analysis to quantify variance in intra- and inter-observer classifications. A qualitative analysis was performed by comparing: i) distances (km) and ii) percentage of shorelines of each lake classified into each the three riparian classes (1 = healthy, 2 = moderately impaired, 3 = highly impaired).

3.6 Comparison of cost efficiencies between health and integrity assessment delivery methods

We compared the projected costs of assessing riparian zones using our low-level videography approach with the costs of riparian assessments completed from the ground (i.e., a ground-based approach), from a boat and from a helicopter. For these comparisons we estimated the costs of obtaining low-level aerial videography with videography captured from a boat and a helicopter, using RHAP's most recent videography score-sheet (i.e., 19 August 2003) to make the assessments. Because ground–based videography does not provide an adequate perspective (i.e., cannot capture the entire riparian or RMA), we compared the costs of obtaining assessments from our low-level videography with that obtained by applying the ground-based Alberta Cows and Fish "Lentic Wetland Health Assessment (Survey) Score-sheet" (June 13, 2003 version, Cows and Fish Program 2003). To identify major cost components, we estimated total costs by adding costs related to: i) labour (salary, benefits [calculated as 18% of salary] and expenses), ii) capital equipment costs (calculated by assuming a 10-year amortization period), and iii) equipment costs (i.e., equipment maintenance, rental and insurance).

Because our approach was to estimate costs rather than completing assessment of the same lake using all four approaches, we derived cost estimates for each method (low level videography, ground-based, boat and helicopter) by estimating costs to complete an assessment of a hypothetical lake. This hypothetical lake was identified as having a shoreline length of 39 km, partitioned into three equal types of shoreline development and vegetation cover typical of that observed in north-central Alberta (i.e., comprised of native vegetation, agricultural use [e.g., haying and grazing] and cottage development). The native and agricultural shorelines were assessed using 0.5 km reaches or polygons (26 polygons total per category) while the cottage shoreline was assessed using 30 m polygons. The widths of these lots (i.e., polygons) were based on the estimated average lot width recorded on survey plans for Vincent Lake, Alberta, Canada. Vincent Lake is a representative lake, with cottage development and lot sizes that are similar across many lakes in north-central Alberta.

4.0 RESULTS

4.1 Ability of low-level aerial videography to characterize riparian management areas

4.1.1 Low level videography protocols and the SeaWing ultralight

Flights completed between May and October in 2000 and 2001 indicated that the highest quality RMA videography was obtained when the ultralight aircraft was flown at approximately 56 to 72 kph in a counter clockwise fashion, at a height of approximately 46 m with the camera pointed forward, 45 degrees right and 45 degrees down (i.e., forward-right-down oblique angle). Taken together, this provided the best balance between aircraft height, filming angle, field of view and camera zoom capabilities (i.e., decreased zoom coincides with increased stability of the video footage). GPS flight line information obtained from left audio track and subsequent assessment information derived from the videography were mapped as individual GIS data layers using the Red Hen Systems Media-mapper (GIS) software. Audio annotations captured on the right audio track provided additional context for viewed images thereby improving assessment efficiency and confidence. GIS layers were exported to ESRI ArcView software and included with other standard GIS data layers (e.g., Indian Resource Satellite Imagery). Captured information was used to generate data outputs, including Microsoft Excel spreadsheets and graphs (*.xls, *.dbf), ESRI-based layers (*.shp) and maps (*.jpg).

4.1.2 Spatial resolution and acquisition costs of low-level videography and comparisons with three other methods

Our evaluations indicate that the approximate 15-cm spatial resolution provided by low-level aerial video (Figure 7) provides sufficient detail to accurately and dependably assess riparian conditions, and in terms of resolution and costs, is superior to current imagery obtained from IKONOS, IRS and aerial photography. While our graphical assessment of imagery from IKONOS, IRS and aerial photography (Figure 8) shows that these methods are also capable of quantifying some riparian condition differences, their lower spatial resolution and image colour can make descriptions of riparian conditions problematic. For example, the 1-m spatial resolution from IKONOS imagery provides insufficient target separation to achieve dependable assessment ability and accuracy to assess riparian conditions (Figure 8). However, the 1-m spatial resolution and false color imagery is sufficient to assess emergent macrophyte density, distribution and change assessments (Arzandeh and Wang 2003).

Figure 7. An image extracted from aerial videography captured at Sylvan Lake on 24 July 2002. The video was taken at an approximate height of 40 m while the SeaWing ultralight was located about 50 m from the lake shore. The propeller (silver object at end of arrow) located on the outboard motor on the boat shown in the lower right area of the image is visible when standard videography play-back methods are applied.

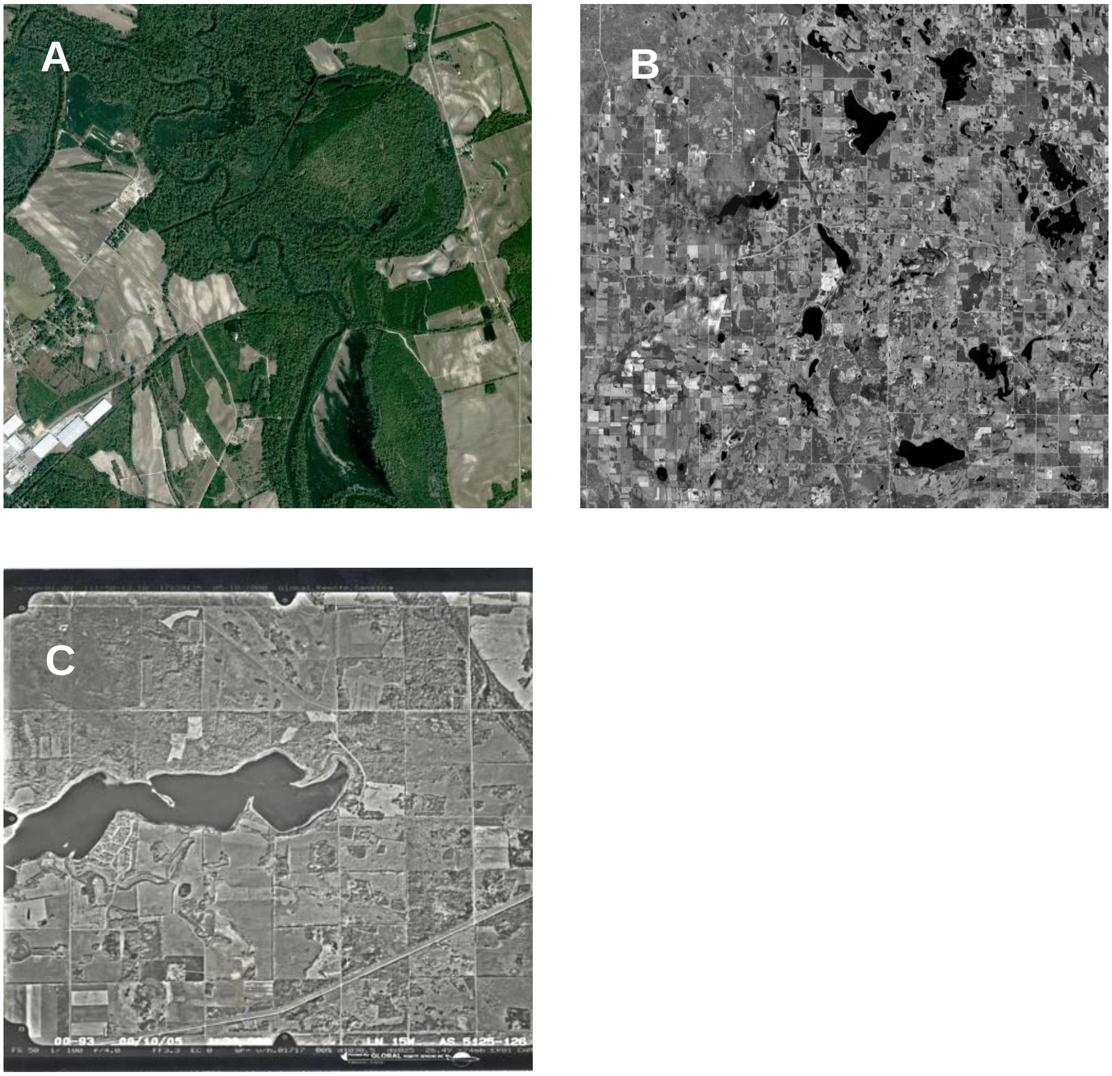

Figure 8. Examples of imagery from IKONOS satellite (A - A true colour image of the Tarboro County area of North Carolina, USA, October, 1999), Indian Remote Sensing satellite (B - black and white image of the St. Paul County area of Alberta, Canada, 1998), and aerial photography (C - 1:30,000 scale black and white airphoto of Bonnie Lake in the County of St. Paul, Alberta Canada, May 10, 2000).

In contrast, imagery from the Indian remote Sensing has an estimated spatial resolution of 3 m and while this allows assessments of riparian conditions, at least, at moderately coarse scales, it does preclude assessments at fine scales (Figure 8). The spatial resolution (15 cm) resulting from enhancements of standard scale aerial photography

(Figure 8) can provide sufficient resolution to assess riparian conditions but the absence of color makes differentiation of vegetation and certain ground cover types difficult. Lastly, the vertical perspective offered from aerial photography and satellite imagery also reduces the accuracy of assessment through loss of depth perspective compared to the oblique angle provided by the video.

Our analyses also showed marked differences in the cost to acquire imagery among the four protocols (Table 4). When standardized to acquire the same area, the costs to acquire a 1 km^2 image using low-level videography protocols was at least 101 and 102 times lower than that from aerial photography and Indian Remote Sensing Satellite, respectively and 1438 times less expensive than the costs of securing IKONOS imagery. While we did not provide cost estimates to complete a special aerial photography flight over a desired target area, we assumed that these costs would exceed the cost of existing stock photography. Special orders to obtain satellite imagery are not required as image capture for IRS is repeated every 4 days and every 3 days for IKONOS. The four imagery types compared can all be geo-referenced for use in a GIS environment.

Table 4. Comparison of costs (Canadian funds) to acquire imagery to assess riparian conditions. A) Photosat Information Ltd., B) Information from Infoterra Limited, C) Alberta Government Airphoto Services, D) Standard 25 cm^2 aerial photography (1:30,000 scale). Image coverage is ≈ 4 km^2, when enlarged to maximum (12x) coverage is ≈ 3.5 km^2, E) Video capture field of view of 0.2 km x 65 kph capture speed = 13 km^2 hr. Tape capacity is 1 hr x 13 km^2/hr = 720 sq km^2/hr, F) Enlargement cost: depends on physical size of enlargements and range from output sizes of 25 cm^2 ($28.00) to 100 cm^2 ($125.00), G) $60 hr/ 720 km^2 hr = $0.08 / km^2.

	IRSS (A)[1]	IKONOS (B)[1]	Aerial Photography (C)[2]	Low-level videography
Best spatial resolution (Instantaneous field of view)	1 m	1 m	15 cm	15 cm
Image colour format	black and white only	black and white or color	black and white only	Color
Size of single image (km^2)	576	100	3.5 (D)	720 (E)
Estimated cost / km^2	$ 5.21	$115.00	$8.12 - $36. 23 (F)	$ 0.08 (G)
Minimum order size (km^2)	576	100	No minimum	No minimum

[1]Based on prices on 21 August 2003
[2]Based on prices on 25 August 2003

4.2 Applying RHAP scoresheet to low-level aerial videography

When the scorecard is applied to low altitude (< 60 m) aerial videography the result is a rapid, "coarse-filter" assessment of the integrity of the RMA based on individual polygons, which can be summarized to describe attributes of both health and integrity of entire lakes. If a "fine-filter" assessment is desired then a ground-based method would be required.

4.3 Comparison of criteria to assess lentic riparian zones

4.3.1 Criteria types

Our comparisons showed that the types of criteria and the related questions within each of the score-sheets used to quantify riparian conditions in our RHAP program include many of the same components used by United States Department of the Interior, British Columbia Ministry of Forests and the Alberta Cows and Fish Program (Table 5). In general, all four approaches recognize that riparian areas adjacent to standing water bodies (lakes) are profoundly influenced by hydrological conditions that affect soil conditions and the plant and animal communities that these habitats support. For comparative purposes, we divided questions into three broad categories of: i) vegetation, ii) physical and chemical and iii) hydrological (Table 5). In general, the number of questions and thus, detail of the assessment within the USDI score-sheet is at least twice that within the BCMF, ABCF and RHAP score-sheets. All four field score-sheets (without supporting information) are provided in Appendices 7.1 through 7.4.

Table 5. Comparison of the number of questions within the three categories of criteria used by the United States Department of Interior (USDI), British Columbia Ministry of Forests (BCMF), Alberta Cows and Fish Program (ABCF) and the Riparian Habitat Assessment Program (RHAP) to assess riparian condition. Numbers within parentheses identify the specific questions within each of the four score-sheets.

Criteria category and component	Number of questions within each score-sheet			
Vegetation	USDI	BCMF	ABCF	RHAP
Vigor Growth and ability to withstand wind and water events, stabilize soils, filter sediment and pollutants, and source of woody debris.	4 (11, 12, 13, 15)	4 (2, 4, 6, 8)	0	0
Diversity Preferred and invasive species categories, species age-classes and indicators of hydric soils.	3 (8, 9, 10)	1 (3)	1 (4)	1 (2)
Density and distribution All species, specific species, species categories and preferred species.	0	0	3 (1, 2, 3)	3 (1, 3, 4)
Disturbance Natural or human caused, e.g., browsing.	0	1 (5)	1 (5)	0
Physical & Chemical				
Erosion and deposition Soil loss; nutrient, organic matter, pollution and sediment input.	2 (16, 19)	3 (10, 12, 13)	0	0
Soils and physical cover Water retention, shoreline protection e.g., rock, bare ground, hummocking.	3 (17, 18, 20)	2 (9, 11)	0	0
Disturbance Natural or human caused alteration of vegetation or physical attributes.	0	0	3 (6, 7, 8)	3 (5, 6, 7)
Wildlife species diversity	0	1 (7)	0	0
Hydrology				
Water Surface and sub-surface, level and fluctuation, inflow, outflow, soil saturation, frost, natural or human caused.	9 (1 thru 7, 14, 17)	1 (1)	1 (1)	1 (1)

4.3.2 *Comparisons of the importance of the three criteria types*

Vegetation

Our comparisons showed that about one-third of all questions within both the USDI (7 of 23) and BCMF (5 of 13) score-sheets were related to vegetation cover, whereas about half of those within the ABCF (5 of 9) and our RHAP (4 of 8) focus on vegetative attributes. In absolute terms, the USDI included the most questions (N = 7) related to vegetation cover relative to all other score-sheets (BCMF: N=6; ABCF: N=5; RHAP: N=4; Table 5). The RHAP score-sheet's emphasis on the assessment of vegetative elements associated with shoreline health and integrity stems from its shared heritage with the ABCF approach as well as the unique ability of this approach to characterize vegetation cover.

Physical and chemical

All four assessment approaches include considerations of the physical and chemical conditions within riparian zones (Table 5). In relative terms, the number of questions related to physical and chemical attributes of riparian zones ranged between 22% to 46% and was highest for BCMF (6 of 13 questions = 46%) and our RHAP (3 of 8 = 38%), compared with that used in the ABCF (3 of 9 = 33%) and USDI (5 of 23 = 22%) score-sheets. In absolute terms, the BCMF (N=6) and the USDI (N=5) score-sheets included more questions related to physical and chemical attributes compared to ABCF (N=3) and our RHAP protocols (N=3) (Table 5).

Hydrology

Each of the four bioassessment score-sheets also includes consideration of hydrological attributes within riparian zones. The score-sheet used by the USDI places its major focus (9 of 20 questions, Table 5) on hydrological-related assessment questions, whereas the BCMF, ABCF and RHAP score-sheets each contained one question in this category. In relative terms, hydrology related questions ranged from 13% to 45% of the score-sheets, with the highest being USDI (9 of 20 questions = 45%) followed by RHAP (1 of 8 questions = 13%), ABCF (1 of 10 questions = 10%) and BCMF (1 of 13 questions = 8%). A representative health and integrity assessment result using the RHAP score-sheet and aerial videography is graphically shown in Figure 9 (Sylvan Lake 2002).

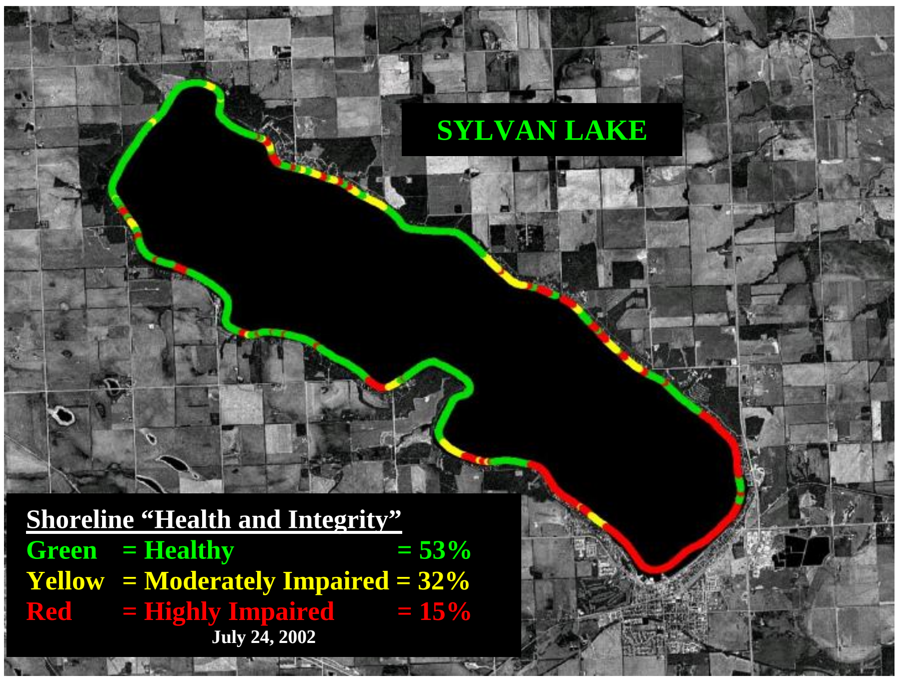

Figure 9. Graphical representation of the status of riparian zones of Sylvan Lake. The assessment was based on results of applying our riparian criteria to lowlevel videography obtained in 2002. Note that the majority of riparian areas in the southeast region of the lake are highly impaired, whereas areas in the northwest region are largely healthy.

4.3.3 *Complexity of the criteria and supporting information*

While we consider all four approaches (USDI, BCMF, ABCF and RHAP) to be rapid bioassessment approaches, the level of information required to complete the score-sheet varies. In relative terms, the USDI protocol is the most complex, where the observers are required to have a high level of knowledge and the final assessment is derived from an assessment team rather than a single interpretation. The BCMF score-sheet was rated medium in complexity as questions still require good assessor knowledge but are less complex than those within the USDI score-sheet. The ABCF method rates as medium-low complexity as the questions can be answered following only minimal instruction. In contrast, our RHAP scorecard, by design, is the least complex of those assessed. This low complexity arises from both the low number of questions and the minimal amount of information that is required to provide answers to questions within the score-sheet. Three of the four approaches are associated with moderate to high amounts of supporting information required to understand the objectives of each assessment and on which to make reliable and consistent evaluations. In contrast, the amount of supporting information for our RHAP score-sheet is low.

Although the relative complexity of questions within the four score-sheets vary across the assessment methods, the broad categories (i.e., vegetation, physical and chemical, and hydrology) used to report their findings are very similar. For instance, output from the USDI approach rates riparian conditions within one of four broad categories of: i) properly functioning, ii) at risk, iii) non-functioning or, iv) unknown. These ratings are determined when the assessor, in this case, the assessment team, provides binary responses (i.e., yes or no) to questions within the score-sheet. The BCMF protocol uses a similar approach (binary responses), but tabulates the number of "yes" answers and expresses that as a percent of the total score. The percent score is then used to categorize the assessed area into one of three categories: i) properly functioning (>79% of questions were yes), ii) at risk (20% to 79% were yes), and iii) non-functional (< 20% were yes). The ABCF uses a weighted total score where each question has four possible answers that are associated with a different weighting score ranging from 0 to 12. Maximum scores vary between questions (3 to 12) to indicate the relative importance (weight) each question has on the entire assessment. The tabulated score is related to the maximum available score and expressed as a percent. The percent scores are then used to categorize the assessed area into one of three categories: i) properly functioning (healthy, score of 80 – 100%), ii) functional at risk (healthy, but with problems, score of 60 – 79%), and iii) nonfunctional (unhealthy, score of < 60%). We consider that this method is advantageous compared to the USDI and the BCMF methods because it produces a weighted quantitative score.

Because we derived the RHAP score-sheet, in part, from the ABCF program it also uses a similar weighted score method, where each question has up to four possible answers with each answer having a different score ranging from 0 to 3, some, in half point increments. Maximum scores vary between questions (0 to 3) and indicate the relative importance (weight) of each question to the assessment score. Our results are reported in a similar manner to the ABCF method, whereby a score is assigned to one of three categories to define general riparian health and integrity as: i) healthy (score of 9.5 or more), ii) moderately impaired (7.0 to 9.0), and iii) highly impaired (6.5 or less).

Lastly, while all four score-sheets allow the trained observer to quantify a diversity of riparian attributes, they also allow the user to exclude some questions, for example, when a site does not have the potential to grow large trees. Therefore, the BCMF, ABCF and RHAP final scores are relative to the total available score (i.e., total of questions answered).

4.4 Determining the effectiveness of RHAP videography scoresheet to describe riparian habitat health and integrity

Riparian Management Area Health and Integrity (RMA-H&I) assessments derived from remote sensing products (e.g., aerial videography) can rapidly provide generalized RMA-H&I information at large spatial scales (e.g., whole lake). Ground-based RMA-H&I assessment methods (e.g., Cows and Fish Program's "Lentic Wetland Health Assessment (Survey) Form" (Appendix 7.4) can arguably provide more detailed RMA-H&I information than that generated through the use of remote sensing products. However, ground-based methods cannot rapidly and cost effectively quantify and qualify "whole lake" riparian habitats. To achieve the best balance between precision and scale RHAP used and adapted questions from the Cows and Fish Programs "Lentic Wetland Health Assessment (Survey) Form" to develop the RHAP Aerial Videography scoresheet (Appendix 7.1).

4.5 Inter and intra-observer variance in riparian health and integrity assessments

Our analyses indicated minimal differences in the repeated classification of riparian zones by the single trained observer into the three habitat classes (Table 6). In fact, differences in the total length of shorelines classified as healthy, moderately impaired and highly impaired differed between 0.0 and 0.7 km in absolute terms (Table 6) and by 0.0 to 3.2% in relative terms (Figure 10).

Table 6. Within-observer variance in distance (km) of riparian zones of Bonnie Lake, Lac Ste. Anne and Sylvan Lake, Alberta classified as healthy, moderately impaired and highly impaired. Variances in classifications were based on a repeated classification by a single observer (i.e., Time 1 versus Time 2) of videography obtained from the each lake in 2002.

Riparian Classification	Bonnie Lake			Lac Ste. Anne			Sylvan Lake		
	Time 1	Time 2	Diff	Time 1	Time 2	Diff	Time 1	Time 2	Diff
Unimpaired	14.0	14.6	0.6	33.7	33.0	-0.7	18.7	18.4	-0.3
Moderately impaired	3.0	2.4	-0.6	6.4	6.4	0.00	2.5	2.2	-0.3
Highly impaired	1.7	1.7	0.00	23.5	24.2	0.7	14.8	15.4	0.6
Shoreline distances	18.7	18.7	0.00	63.60	63.60	0.00	36.0	36.0	0.00

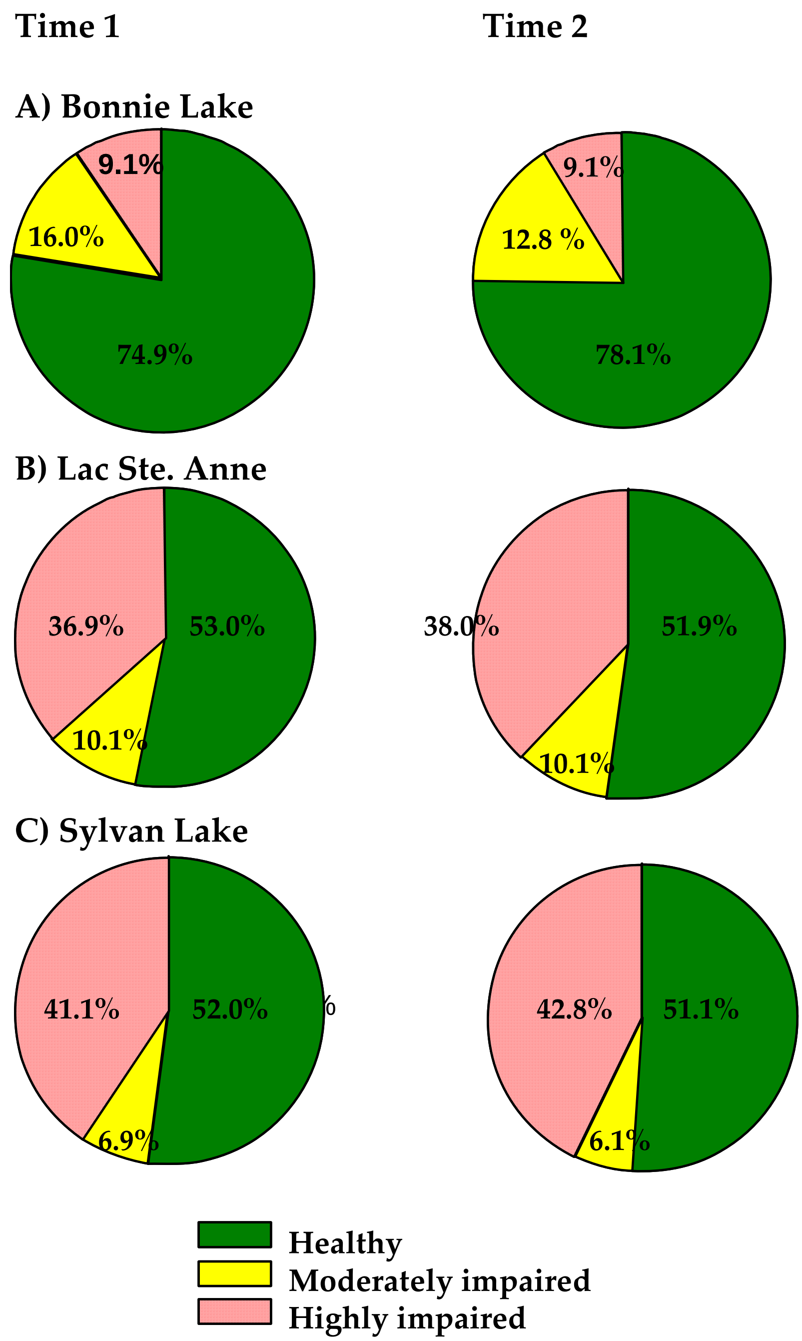

Figure 10. Percent of riparian zones of Bonnie Lake (A), Lac Ste. Anne (B), and Sylvan Lake (C) classified as unimpaired, moderately impaired and highly impaired by a single observer in 2002 (i.e., Time 1 and 2).

Our analyses also showed minimal differences between the two trained observers in the classification of riparian zones into the three habitat classes (Table 7). In fact, differences in the total length of shorelines classified as healthy, moderately impaired and highly impaired differed between 0.3 to 8.3 km in absolute terms (Table 7) and by 1.5 to 7.8% in relative terms (Figure 13).

These results suggest that the Aerial Videography Scoresheet can derive consistent and comparable RMA-H&I values from low-level aerial videography. However, additional data should be collected to supply sufficient sample size for statistical evaluation.

Table 7. Between-observer variance in distances (km) of riparian zones of Bonnie, Lac Ste. Anne and Sylvan lakes, Alberta classified as unimpaired, moderately impaired and highly impaired. Variances in classification were based on two trained observers (i.e., Observer 1 versus Observer 2) classifying videography obtained from each lake in 2002.

Riparian classification	Bonnie Lake			Lac Ste. Anne			Sylvan Lake		
	Obs. 1	Obs. 2	Diff	Obs. 1	Obs. 2	Diff	Obs. 1	Obs. 2	Diff
Unimpaired	14.2	14.5	- 0.3	33.4	38.4	- 5.0	18.5	19.4	- 0.9
Moderately impaired	2.8	1.4	1.4	6.4	9.7	- 3.3	2.4	3.8	- 1.4
Highly impaired	1.7	2.8	- 1.1	23.8	15.5	8.3	15.1	12.8	2.3
Shoreline distances	18.7	18.7	0.0	63.6	63.6	0.0	36.0	36.0	0.0

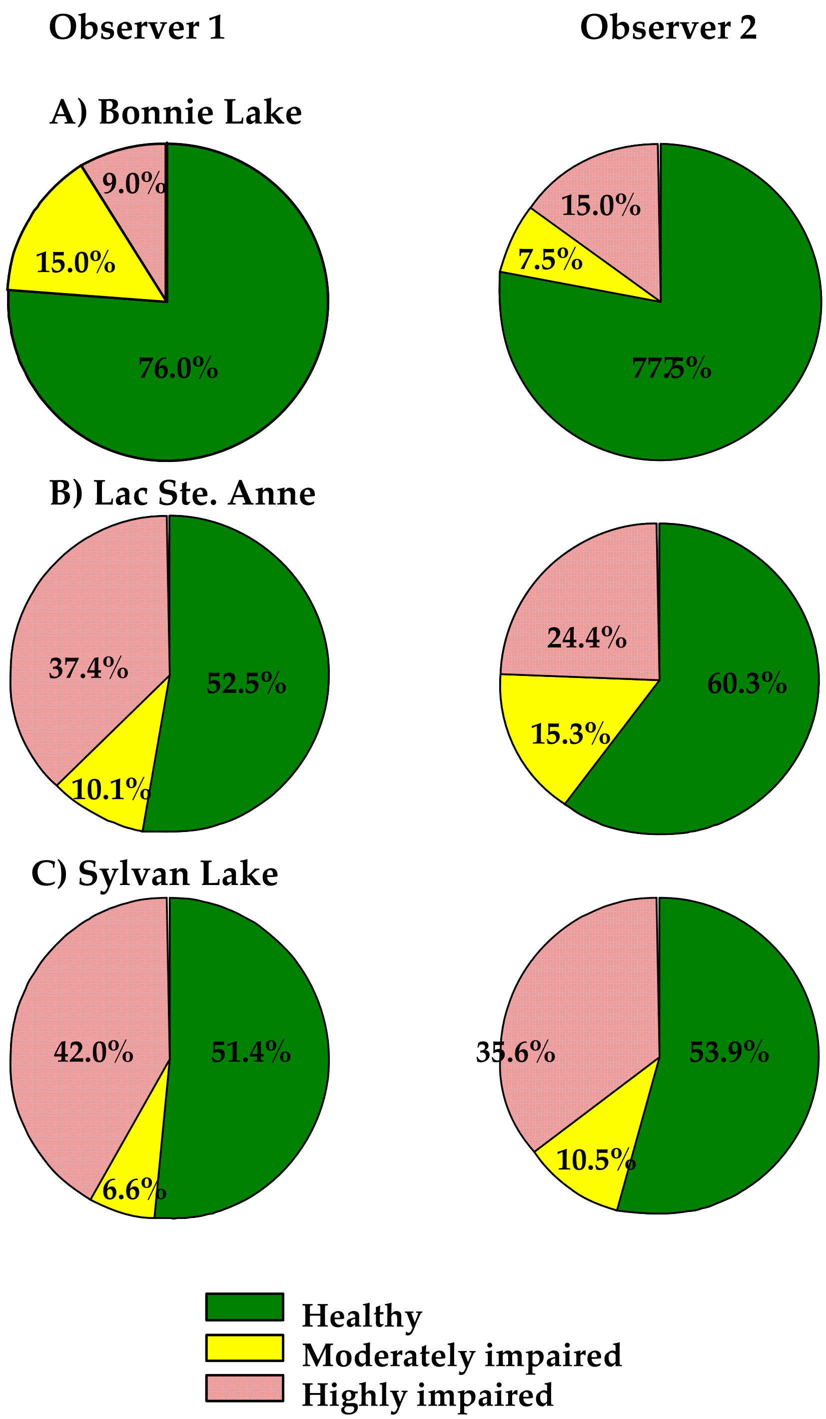

Figure 11. Percent of riparian zones of Bonnie Lake (A), Lac Ste. Anne (B), and Sylvan Lake (C) classified as unimpaired, moderately impaired and highly impaired by two observers in 2002 (i.e., Observer 1 and 2).

4.6 Comparison of cost efficiencies between health and integrity assessment delivery methods

Our analyses showed that low-level videography obtained using the ultralight aircraft was the most cost effective method to assess riparian health and integrity and required a total of only 9.5 hrs, including travel time and time to collect and process data (Table 8). In contrast, the helicopter-based method required approximately 1.2 times more time (i.e., 2 additional hours), but when data acquisition and processing time are considered the helicopter method's efficiency equals the ultralight-based method. The use of a helicopter at low air velocities (i.e., 55 to 65 kph) and altitudes (50 to 75 m above water level), however, raises safety concerns because it does not provide a safe margin of error in the event of an engine failure. Use of the ultralight aircraft, however, provides a greater level of safety following an engine failure as it is capable of gliding substantial distances and can safely complete landings on the water surface.

In comparison, the boat-based method requires about 14 hrs (1.5 times) more time to complete the assessment than the ultralight aircraft method. The boat-based video approach is also problematic due to varying water depths adjacent to the shoreline, which preclude consistent offshore boat travel distances and, as a result, the visual perspective for assessments of riparian habitat.

The ground based-method needed an estimated 259 hrs (27 times) more than the ultralight aircraft method to complete the assessment as it uses administrative boundaries (e.g., cottage lot, quarter section) to set the size of its assessment polygons. This is problematic when applied to shoreline cottages that can number in the hundreds around developed lakes in north-central Alberta. When the ground-based method is used to assess larger shoreline polygons (e.g., native and agricultural lands) its assessment time is reduced dramatically (26 hrs) but remained 4 to 14 times greater than those of the other methods.

Table 8. Number of polygons per land cover type and estimated time for capturing and processing data per polygon for riparian health and integrity assessment of hypothetical lake using four methods. Additional details: a – length of native and agricultural polygons is 0.5 km and cottage lots 30 m; b – polygons are assessed based on administrative boundaries (e.g., cottage lot width, quarter section); c - assumes a 4-hour return-trip (vehicle) from base of operations to lake; d - completed during field component of ground method; e - processing of assessment data into assessment results, f - video is assessed based on changes in shoreline health and integrity score (i.e., biological polygons) not administrative boundaries. Time estimates described are to complete the entire category (e.g., all 26 polygons in the boat – field category would be assessed in approximately 5 hours); g – 2-hour helicopter return-trip from base of operations to lake.

	Hypothetical Shoreline Composition			
	Native	Agriculture	Cottage lots	Total
Shoreline (km)	13	13	13	39
Number of Polygons (a)	26	26	433	485
Ground Method (Hrs) (b)				
Travel (c)				4.0
Data Collection	26.0	26.0	216.5	268.5
Data Processing (d)(e)	0.0	0.0	0.0	0.0
Totals	26.0	26.0	216.5	268.5
Video Method – Boat (Hrs) (f)				
Travel (c)				4.0
Data Collection	5.00	5.00	5.00	15.0
Data Processing	1.50	1.50	1.50	4.5
Totals	6.50	6.50	6.50	23.5
Video Method – Helicopter (Hrs) (f)				
Travel (c)(g)				6.0
Data Collection	0.3	0.3	0.3	1.0
Data Processing	1.5	1.5	1.5	4.5
Totals	1.8	1.8	1.8	11.5
Video Method – Ultralight (Hrs) (f)				
Travel(c)				4.0
Data Collection	0.3	0.3	0.3	1.0
Data Processing	1.5	1.5	1.5	4.5
Totals	1.83	1.83	1.83	9.5

Variation in the total cost to assess riparian conditions among the four methods was strongly influenced by the amount of time required to complete the lake assessment compared to other cost components (Appendix 7.5). The relationship between increased total time costs and assessment times results from increased costs in labour, capital total costs and overall costs to assess riparian zones (i.e., expressed as dollars per kilometer) among the four assessment methods (Figure 12). Labour and capital costs associated with the helicopter method are captured as rental fees and identified as one component of "other" costs and accounts for the disproportionately high cost of the helicopter method compared to the other methods within the category of "other costs" (Figure 12).

Difference in the comparative cost efficiencies among the four methods are apparent when the costs of the three categories are combined. Based on this analysis, the cost to assess riparian conditions of the hypothetical lake using the ultralight (lake assessment cost=$683) was approximately 2.3 times less than that using the boat (lake assessment cost = $1,579), and 4.8 times (lake assessment cost = $3,270) and 27.4 (lake assessment cost = $18,722) less expensive than using the helicopter and ground-based methods, respectively.

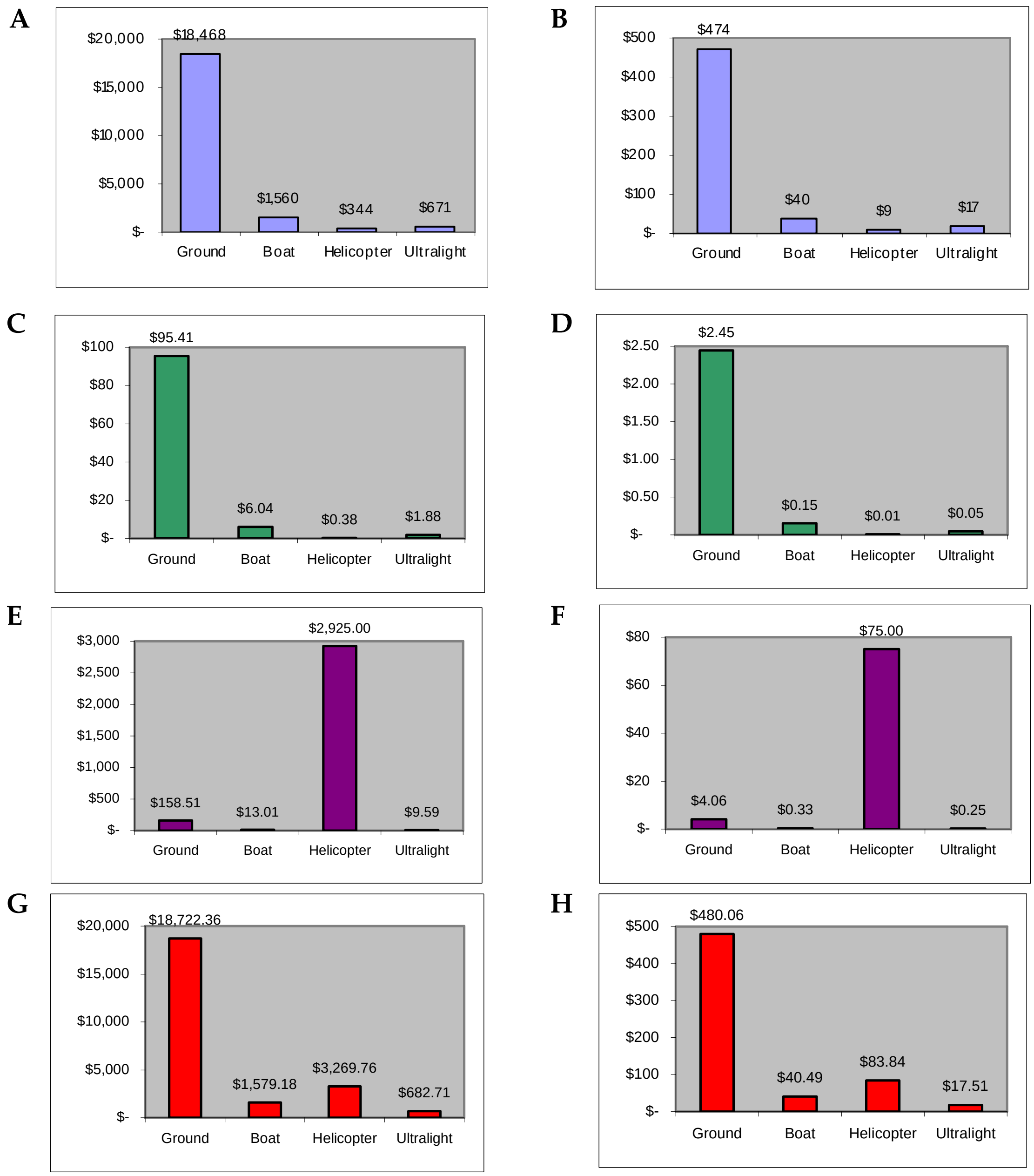

Figure 12. Total labour costs (wages and expenses) (A) and labour cost per km (B); total capital costs (C) and capital cost per km (D), amortized over 10 years; total other costs (E) and other cost per km (F) (maintenance, rental and insurance); all costs (G) and all costs per km (H) to deliver a riparian health and integrity assessment of a 39 km theoretical lake. Lake shoreline is partitioned into three 13 km shoreline cover types: i) native (26 polygons, 0.5 km each), ii) agricultural (26 polygons, 0.5 km each), and iii) cottage development (433 polygons, 30 m each).

5. 0 INTERPRETATIONS

Our results indicate that the low-level aerial videography method generates a cost effective and superior remote sensing (visual) product compared with other approaches. The images from this low-level videography can provide adequate resolution to complete rapid, repeatable and defendable assessments of riparian conditions. This information provides the ability to define riparian health and integrity at a broad scale to direct and focus riparian conservation and protection activities through enhanced education and awareness, stimulation of conservation partnerships (e.g., lakeshore communities) and the development of reclamation and remediation initiatives at priority lakes in Alberta.

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7.0 APPENDICES

7.1 Aerial Videography Lentic Health and Integrity Score-sheet (Riparian Habitat Assessment Project, 2003)

AERIAL VIDEOGRAPHY[1] - LENTIC RIPARIAN MANAGEMENT AREA
HEALTH AND INTEGRITY ASSESSMENT SCORECARD [2, 3]

August 11, 2003
Draft for discussion purpose only, not for distribution.

Riparian areas have been described as pertaining to, situated or dwelling on the margin of a river or other water body. This term also describes banks on water bodies where sufficient soil moisture supports the growth of mesic vegetation that requires a moderate amount of moisture (Armantrout 1998). The term riparian-wetland area has been used to describe an area that is saturated or inundated at a frequency and duration sufficient to produce vegetation typically adapted for life in saturated soil conditions. It is also the transitional area between permanently saturated wetlands and upland areas often referred to as a riparian area (Prichard 2003). The upland boundary of riparian-wetland areas is sometimes easily determined by abrupt changes in the landform and/or vegetation, but proper determination often depends on experienced interpretation of more subtle features (Cows and Fish 2003). In north-central Alberta this landform break is often associated with a change in vegetation from lower woody shrubs to taller deciduous or coniferous trees. This break can also correspond to the waterbodies full supply level (i.e., high water mark).

This scorecard, when applied to low altitude aerial videography (< 200 ft) of the riparian/riparian-wetland area, provides a rapid method to produce rapid, "coarse filter" assessment of the integrity or health of the riparian/riparian-wetland area and the role human activity plays in the results. This information can be used to direct conservation activities at those human activities negatively impacting the health or integrity of these areas. The extent of negative "human-caused" impact in lentic riparian/riparian-wetland has been observed as increasing, or being more concentrated, closer to the waters edge. Historically, management activities (e.g., preservation, enforcement and rehabilitation, etc.) designed to address these negative impacts have been focused within this RMA. The ability for the aerial video to capture the entire riparian/riparian-wetland area from all types of lakes is problematic. However, it is currently felt it can consistently capture the RMA the priority target area for conservation activities.

<u>Assessment Questions and Scoring.</u>

1. 85% or more of the polygon area is covered with vegetation of any kind? (Polygon area does not include area covered by water).
   Yes____ (2 points) **No_____** (0 points)

2. Cattails and bulrushes are visibly growing in the littoral zone adjacent to the polygon area? (Identifying immature bulrush and cattail stands may be difficult. On some lakes these species do not grow because of site and/or climate conditions. It is important you know this prior to deciding if their absence is natural or human caused).
   Dense to Medium _____ (1 point), **Medium to Sparse _____** (0.5 points), **None _____** (0 points)

3. Woody plants like willow, birch or poplar cover 15% or more of the polygon area? (In some cases riparian areas do not have the potential for woody plants because of soil chemistry and other factors, i.e., saline and drainage. In some cases woody plants do not meet this threshold because of site and successional reasons).
   Yes____ (1 point) **No_____** (0 points)

4. Within the 15% woody zone, what is the abundance of woody plants? (If the answer to Question 3 is no, this question receives 0 points)
   Dense to Medium ____(1 point) or **Sparse to Medium ____** (0.5 points)

5. 35% or more of the polygon show visual signs of human caused removal or alteration of vegetation? (e.g., includes conversion of native vegetation to lawn grass, mowing, grazing, etc.).
   Yes____ (2 points) **No_____** (0 points)

6. 35% or more of the polygon show visual signs of human-caused physical alterations or exposed soil surface? (e.g., removal of rocks, addition or removal of sand, harrowing beaches, retaining walls, boat houses, decks, patios, walking or ATV trails, cattle activity, etc.)
   Yes____ (3 points) **No_____** (0 points)

7. What picture does most of the polygon look like?
   Picture A? ____ (1 point) **Combination of A and B?____** (0.5 points) **Picture B?____** (0 points)

8. Does the lake have human caused water withdrawal (e.g., cottage, municipal, industrial, etc) or filling? (e.g., dams, weirs, drainage channel outflow) (This is a background question supported by the aerial videography but requiring local input or knowledge to answer).
   None ___ (2 points) **Minor**___ (1.0 points) **Moderate to Extreme**___ (0 points)

Total possible points = **13 .**

Actual points (sum from questions above) = _____.

Summary of Question Scorecard

If the score is **9.5 or more** it is likely the RMA is **healthy**.

If the score is **7.0 to 9.0** it is likely the RMA is **moderately impaired**.

If the score is **6.5 or less** it is likely the RMA is **highly impaired**.

[1] Aerial videography developed by Blake Mills, Alberta Conservation Association and George Walker, Alberta Sustainable Resource Development, Fish & Wildlife Division.

[2] Prepared by Gerry Ehlert, Blake Mills, Wayne Nelson and George Walker of the Vincent Lake Working Group.

[3] This Score Card was adapted from the Alberta Lentic Wetland Health Assessment Survey, Cows and Fish, 2003.

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7.2 Lentic Standard Checklist (U.S. Dept. of the Interior, Bureau of Land Management, 2003).

Lentic Standard Checklist

Name of Riparian-Wetland Area:____________________

Date:__________ Area/Segment ID: ____________ Acres:__________

ID Team Observers: ____________________

Yes	No	N/A	HYDROLOGY
			1) Riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events
			2) Fluctuation of water levels is not excessive
			3) Riparian-wetland area is enlarging or has achieved potential extent
			4) Upland watershed is not contributing to riparian-wetland degradation
			5) Water quality is sufficient to support riparian-wetland plants
			6) Natural surface or subsurface flow patterns are not altered by disturbance (i.e., hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)
			7) Structure accommodates safe passage of flows (e.g., no headcut affecting dam or spillway)

Yes	No	N/A	VEGETATION
			8) There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
			9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)
			10) Species present indicate maintenance of riparian-wetland soil moisture characteristics
			11) Vegetation is comprised of those plants or plant communities that have root masses capable of withstanding wind events, wave flow events, or overland flows (e.g., storm events, snowmelt)
			12) Riparian-wetland plants exhibit high vigor
			13) Adequate riparian-wetland vegetative cover is present to protect shoreline/soil surface and dissipate energy during high wind and wave events or overland flows
			14) Frost or abnormal hydrologic heaving is not present
			15) Favorable microsite condition (i.e., woody material, water temperature, etc.) is maintained by adjacent site characteristics

Yes	No	N/A	EROSION/DEPOSITION
			16) Accumulation of chemicals affecting plant productivity/composition is not apparent
			17) Saturation of soils (i.e., ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils
			18) Underlying geologic structure/soil material/permafrost is capable of restricting water percolation
			19) Riparian-wetland is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)
			20) Islands and shoreline characteristics (i.e., rocks, coarse and/or large woody material) are adequate to dissipate wind and wave event energies

Summary Determination

Functional Rating:

Proper Functioning Condition _________
Functional—At Risk _________
Nonfunctional _________
Unknown _________

Trend for Functional—At Risk:

Upward _____
Downward _____
Not Apparent _____

Are factors contributing to unacceptable conditions outside the control of the manager?

Yes ___
No ___

If yes, what are those factors?

___ Dewatering ___ Mining activities ___ Watershed condition
___ Dredging activities ___ Road encroachment ___ Land ownership
___ Other (specify)____________________________________

Rationale For Rating:

7.3 Riparian Function Checklist (British Columbia Ministry of Forests, Forest Practices Branch, 1999.

Lakes, Ponds and Wetlands
Riparian Function Checklist

<table>
<tr><td colspan="4">Range Unit: Range Agreement Holder:
Range Agreement Number:</td></tr>
<tr><td colspan="4">UTM Coordinates::</td></tr>
<tr><td colspan="4">Name of Riparian-Wetland Area: BEC Subzone:</td></tr>
<tr><td colspan="4">Date: Segment ID:</td></tr>
<tr><td colspan="4">Classification of Lake or Pond:</td></tr>
<tr><td colspan="4">Type of Wetland (< 2m depth): Marsh (beaver ponded; fresh water; saline; closed basin);
Swamp; Bog; Fen; Shrub-carr</td></tr>
<tr><td colspan="4">Observers:</td></tr>
<tr><td>Yes</td><td>No</td><td>N/A</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Hydrologic</td></tr>
<tr><td></td><td></td><td></td><td>Water levels have remained unchanged over time (willow fringe or willow skeletons).</td></tr>
<tr><td></td><td></td><td></td><td>Biotic/Vegetation</td></tr>
<tr><td></td><td></td><td></td><td>The plant community is showing good vigour and maintenance of riparian soil moisture characteristics.</td></tr>
<tr><td></td><td></td><td></td><td>Diversity and structure of the riparian and emergent vegetation has been maintained.</td></tr>
<tr><td></td><td></td><td></td><td>The plant community is adequate to filter sediments and pollutants.</td></tr>
<tr><td></td><td></td><td></td><td>Occurrences of trampling, rubbing or browsing are uncommon.</td></tr>
<tr><td></td><td></td><td></td><td>Adequate vegetation cover is present to protect banks.</td></tr>
<tr><td></td><td></td><td></td><td>A diversity of vertebrate and invertebrate life is evident.</td></tr>
<tr><td></td><td></td><td></td><td>The riparian plant community is an adequate source of large woody debris, both now and for the foreseeable future.</td></tr>
<tr><td></td><td></td><td></td><td>Erosion/Deposition</td></tr>
<tr><td></td><td></td><td></td><td>Bank shearing, soil compaction, and bare ground are uncommon.</td></tr>
<tr><td></td><td></td><td></td><td>Soil erosion and deposition in the wetland and riparian area are within natural levels.</td></tr>
<tr><td></td><td></td><td></td><td>Hummocks are rounded and completely vegetated.</td></tr>
<tr><td></td><td></td><td></td><td>Nutrient Inputs and Water Quality</td></tr>
<tr><td></td><td></td><td></td><td>Nutrient levels are normal (there is a lack of algae mats and organism die-offs and there is a good aquatic species diversity).</td></tr>
<tr><td></td><td></td><td></td><td>Inputs of fine organic matter are appropriate (leaves, small branches and twigs).</td></tr>
</table>

Check one

PFC ____

At risk ____

Non-functional ____

Notes:
Is the desired plant community present (diversity - - species comp., age classes, structure, form)?

Soils types and textures?

Are the riparian soils subjected to prolonged saturation and anaerobic conditions?

Is this wetland part of a beaver controlled riparian system?

7.4 Lentic Wetland Survey Score-sheet (Alberta Cows and Fish Program, 2003.)

ALBERTA LENTIC WETLAND SURVEY FIELD SCORE SHEET

1. Vegetative Cover of the Polygon. **Score:** _______

6 = More than 95% of the polygon area is covered by live plant growth.
4 = 85% to 95% of the polygon area is covered by live plant growth.
2 = 75% to 85% of the polygon area is covered by live plant growth.
0 = Less than 75% of the polygon area is covered by live plant growth.

2a. Total Canopy Cover of Invasive Plant Species (Weeds). **Score:** _______

3 = No invasive plant species on the site.
2 = Invasive plants present with total canopy cover less than 1 percent of the polygon area.
1 = Invasive plants present with total canopy cover between 1 and 15 percent of the polygon area.
0 = Invasive plants present with total canopy cover more than 15 percent of the polygon area.

2b. Density/Distribution Pattern of Invasive Plant Species. **Score:** _______

3 = No invasive plant species (weeds) on the site.
2 = Invasive plants present with density/distribution in categories 1, 2, or 3.
1 = Invasive plants present with density/distribution in categories 4, 5, 6, or 7.
0 = Invasive plants present with density/distribution in categories 8, or higher.

3. Disturbance-Caused Undesirable Herbaceous Species. **Score:** _______

3 = Less than 5% of the site covered by disturbance-caused undesirable herbaceous species.
2 = 5% to 25% of the site covered by disturbance-caused undesirable herbaceous species.
1 = 25% to 45% of the site covered by disturbance-caused undesirable herbaceous species.
0 = More than 45% of the site covered by disturbance-caused undesirable herbaceous species.

4. Preferred Tree and Shrub Establishment and Regeneration. **Score:** _______

(If site lacks potential for woody species, replace both Actual and Possible Scores with NA.)
6 = More than 15% of the total canopy cover of preferred trees/shrubs are seedlings and saplings.
4 = 5% to 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
2 = Less than 5% of the total canopy cover of preferred tree/shrubs are seedlings and saplings.
0 = Preferred tree/shrub seedlings or saplings absent.

5. Utilization of Preferred Trees and Shrubs. **Score:** _______

(If site lacks potential for woody species, replace both Actual and Possible Scores with NA.)
3 = None (0% to 5% of available second year and older leaders of preferred species are browsed).
2 = Light (5% to 25% of available second year and older leaders of preferred species are browsed).
1 = Moderate (25% to 50% of available second year and older leaders of preferred species are browsed).
0 = Heavy (More than 50% of available second year and older leaders of preferred species are browsed).

6. Human Alteration of Polygon Vegetation. **Score:** _______

6 = Less than 5% of polygon vegetation is altered by human activity.
4 = 5% to 15% of polygon vegetation is altered by human activity.
2 = 15% to 35% of polygon vegetation is altered by human activity.
0 = 35% or more of polygon vegetation is altered by human activity.

7. Human Alteration of Polygon Physical Site. **Score:** _______

12 = Less than 5% of the polygon is physically altered by human activity.
8 = 5% to 15% of the polygon is physically altered by human activity.
4 = 15% to 35% of the polygon is physically altered by human activity.
0 = 35% or more of the polygon is physically altered by human activity.

8. Human-Caused Bare Ground. **Score:** _______

6 = Less than 1% of the polygon is human-caused bare ground.
4 = 1% to 5% of the polygon is human-caused bare ground.
2 = 5% to 15% of the polygon is human-caused bare ground.
0 = 15% or more of the polygon is human-caused bare ground.

9. Degree of Artificial Withdrawal or Raising of Water Level. **Score:** _______

9 = The waterbody is Not Subjected to artificial water level change.
6 = The degree of artificial water level change is Minor.
3 = The degree of artificial water level change is Moderate.
0 = The degree of artificial water level change is Extreme.

10. Comments and Observations.

ADDITIONAL MANAGEMENT CONCERNS (OPTIONAL)

11. Overflow Structure Stability. **Score:** _______

(If the water body is not human constructed nor structurally altered, and lacks an overflow structure, replace both Actual and Possible Scores with NA.)
6 = The overflow structure is made of concrete, pipe, or armoured rock and appears stable.
4 = The overflow structure is unprotected or is made of other material, but still appears stable.
2 = The overflow structure is made of concrete, pipe, or armoured rock, but appears unstable.
0 = The overflow structure is unprotected or is made of other material and appears unstable.

12. Shoreline Rock Volume and Size.

12a. Shoreline Rock Volume. Rate the shoreline rock volume as the highest appropriate category: **Score:**_______

3 = More than 40% of shoreline volume is rocks at least 2.5 inches.
2 = 20% to 40% of shoreline volume is rock at least 2.5 inches.
1 = 10% to 20% of shoreline volume is rock at least 2.5 inches.
0 = Less than 10% of shoreline volume is rocks at least 2.5 inches.

12b. Shoreline Bank Rock Size. Rate the shoreline rock size for the polygon as the highest category: **Score:**_______

3 = At least 50% of rocks present are boulders and large cobbles (>5 inch).
2 = 50% of rocks present are small cobbles and larger (>2.5 inches).
1 = At least 50% of rocks present are coarse gravels and larger (>0.6 inches).
0 = Less than 50% of rocks present are coarse gravels and larger (>0.6 inches).

13. Vegetative Use by Animals. Use the categories below to score the amount of utilization. **Score:**_______

3 = 0 to 25% available forage taken.
2 = 26 to 50% available forage taken.
1 = 51 to 75% available forage taken.
0 = 76 to 100% available forage taken.

14. Susceptibility of Parent Material to Erosion. **Score:**_______

3 = Not susceptible to erosion (well armoured).
2 = Slightly susceptible to erosion (moderately armoured).
1 = Moderately susceptible to erosion.
0 = Extremely susceptible to erosion.

15. Percent of Shoreline Accessible to Livestock. **Percent:**______

16. Percent of Tree and Shrub Cover in the Polygon that is Dead and/or Decadent. **Percent:**______

17. Polygon Trend. Select one: Improving, Degrading, Static, or Status Unknown **Trend:**___________________

18. Break Down the Polygon Area into the Land Uses Listed (must total to approx. 100%):

No land use apparent:__________
Turf grass (lawn): __________
Tame pasture (grazing): __________
Native pasture (grazing): __________
Recreation (ATV paths, campsites, etc.): __________
Development (buildings, corrals, paved lots, etc.): __________
Tilled cropping: __________
Perennial forage (e.g., alfalfa hayland): __________
Roads: __________
Logging: __________
Mining: __________
Railroads: __________
Other: __________

Description of Other Usage Noted:____

____

____

19. Break Down the Area Adjacent to the Polygon Into the Land Uses Listed (must total to approx. 100%):

No land use apparent:__________
Turf grass (lawn): __________
Tame pasture (grazing): __________
Native pasture (grazing): __________
Recreation (ATV paths, campsites, etc.): __________
Development (buildings, corrals, paved lots, etc.): __________
Tilled cropping: __________
Perennial forage (e.g., alfalfa hayland): __________
Roads: __________
Logging: __________
Mining: __________
Railroads: __________
Other: __________

Description of Other Usage Noted:____

____

____

Calculating the Lentic Health Score

To arrive at the overall site health rating, the scores are totalled for all the factors, and that total is divided by the possible perfect score total. A sample score sheet is shown below.

Vegetation Factors		**Actual Pts**	**Possible Pts**
1. Vegetative Cover of Polygon		6	6
2a. Total Canopy Cover of Invasive Plant Species		1	3
2b. Density/Distribution Pattern of Invasive Plant Species		1	3
3. Disturbance-Caused Undesirable Herbaceous Species		2	3
4. Preferred Tree and Shrub Establishment and Regeneration		2	6
5. Utilization of Preferred Trees and Shrubs		2	3
6. Human Alteration of Polygon Vegetation		4	6
	Vegetative Score:	18	30
Soil/Hydrology Factors			
7. Human Alteration of Polygon Physical Site		8	12
8. Human-Caused Bare Ground		2	6
9. Degree of Artificial Withdrawal of Water		9	9
	Soil/Hydrology Score:	19	27
	TOTAL SCORE:	**37**	**57**

Rating = (Total Actual) / (Total Possible) X 100%

Rating = (37) / (57) X 100% = 65%

Rating Category: 80-100% = Proper Functioning Condition (Healthy)
60-79% = Functional At Risk (Healthy, but with Problems)
Less than 60% = Nonfunctional (Unhealthy)

The manager should realize that a less than perfect score is not necessarily cause for concern. An area rated at 80% is still considered to be functioning properly. At the same time, ratings of individual factors can be useful in detecting strengths or weaknesses of a site. A low score on any factor warrants management focus. For example, the sample score sheet shown above has low scores for invasive plant species, tree and shrub regeneration, and bare ground (items 2, 4, and 8). These are factors in which a management change might result in improvement on a subsequent assessment.

7.5. Comparison summary of time (travel, data collection and processing) and cost (wages, travel, capital and other) estimates for riparian health and integrity assessment of hypothetical lake using the four assessment collection protocols. Additional details: a - amortized over 10 yrs, 21.5 days/month, 7.5 hrs/day; b, c & e - based on two employees; d - based on one employee; f & g - ground survey would use either boat or quad; h - ground and boat; i - ultralight.

			Assessment Delivery Method			
			Ground	Boat	Helicopter	Ultralight
	Time (hrs)	Travel	4.0	4.0	6.0	4.0
		Collect Data	268.5	15.0	1.0	1.0
		Process Data	0.0	4.5	4.5	4.5
		Total	268.5	23.5	11.5	9.5
		Estimated	Unit Costs x Total Assessment Delivery Method Hours			
	Item & Unit Rate	Unit Cost	Ground	Boat	Helicopter	Ultralight
	Wages ($/hr)	$ 24.50	$ 13,156.5 (b)	$ 1,151.50 (c)	$ 232.73 (d)	$ 465.45 (e)
Travel	Gas ($/litre)	$ 0.70	$ 43.61	$ 41.30	$ 35.00	$ 52.48
	Food ($/day)	$ 30.00	$ 2,180.00	$ 152.00	$ 20.00	$ 39.99
	Lodging ($/day)	$ 85.00	$ 3,088.33	$ 215.33	$ 56.66	$ 113.31
Capital Costs (a)	Vehicle ($/day)	$ 1.55	$ 56.32	$ 3.93	N/A	$ 1.03
	Boat ($/hr)	$ 0.21	$ 7.52 (f)	$ 0.42	N/A	N/A
	Quad ($/hr)	$ 0.41	$ 14.68 (g)	N/A	N/A	N/A
	Ultralight ($/hr)	$ 1.55	N/A	N/A	N/A	$ 0.21
	VMS 200 ($/hr)	$ 0.34	N/A	$ 0.88	$ 0.25	$ 0.25
	Handheld GPS ($/hr)	$ 0.13	$ 4.65	$ 0.34	N/A	$ 0.10
	Utility Trailer - covered ($/hr)	$ 0.25	N/A	N/A	N/A	$ 0.17
	Utility Trailer - uncovered ($/hr)	$ 0.13	$ 4.72	N/A	N/A	N/A
	Video Camera ($/hr)	$ 0.18	N/A	$ 0.47	$ 0.13	$ 0.13
	Still Camera ($/hr)	$ 0.21	$ 7.52	N/A	N/A	N/A
Other	Equipment Maintenance ($/hr)	$ 0.52 (h) $ 0.93 (I)	$ 139.62	$ 12.22	N/A	$ 8.83
	Helicopter Rental ($/hr)	$ 800.00	N/A	N/A	$ 2,925.00	N/A
	Vehicle Insurance ($/hr)	$ 0.31	$ 11.26	$ 0.79	N/A	$ 0.21
	Boat and Quad Insurance ($/hr)	$ 0.21	$ 7.63	N/A	N/A	N/A
	Flying Insurance ($/hr)	$ 0.83	N/A	N/A	N/A	$ 0.55
		Total Estimate =	$ 18,722.36	$ 1,579.18	$ 3,269.76	$ 682.71

The Alberta Conservation Association acknowledges the following partner for their generous support of this project