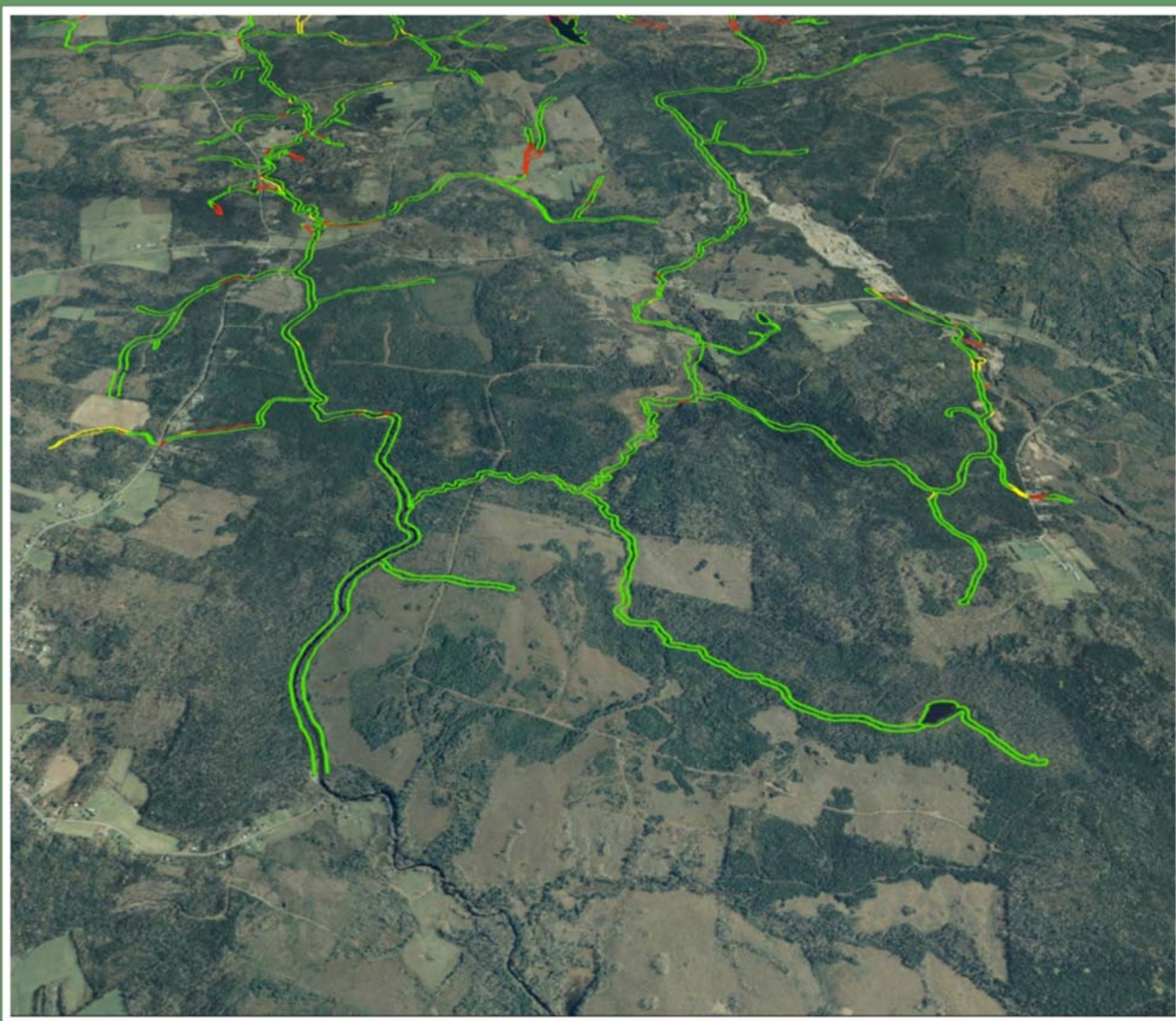
Riparian Health Assessment Training and Analysis Report for the Nova Scotia Federation of Agriculture



Prepared by the
Applied Geomatics Research Group
March 2009

Nova Scotia Federation of Agriculture

Canada

AGRG Applied Geomatics Research Group

Acknowledgements

The authors of this report would like to extend sincere appreciation to the following people and departments for the assistance that they provided and the contributions that they made to this project …

Workshop Presenters

- Sean Basquill and Reg Newell (Nova Scotia Department of Natural Resources)
- Levi Cliché (Clean Annapolis River Project)
- William Jones (ADI Limited)
- Bill Livingstone and Jeff Wentzell, (Annapolis Valley Campus, NSCC)

Workshop Assistance

- Henry, Shelley, Tom, and Wanda (NSFA) for their help in announcing the workshop and registering participants
- Darren MacKinnon, Bruce Hicks, and Tim Mooney (Centre of Geographic Sciences, NSCC) for their assistance during the delivery of the workshop in Lawrencetown
- Karen Reinhardt for her help as a lab assistant on Day 2 of the Workshop

Data Providers

- Nova Scotia Geomatics Centre for access to the provincial base mapping data layers
- Nova Scotia Department of Natural Resources for access to the provincial forest inventory data layer
- Nova Scotia Department of Agriculture for access to the Riparian Health Assessment (RHA) survey results for the Upper Cornwallis River Watershed

Riparian Health Assessment
Training and Analysis Report
for the
Nova Scotia Federation of Agriculture
by the
Applied Geomatics Research Group

March 2009

Contents

Introduction

Background

In the fall of 2008 the Applied Geomatics Research Group (AGRG) began discussing specific project opportunities with the Nova Scotia Federation of Agriculture (NSFA). In December 2008 the AGRG submitted a proposal to the NSFA entitled, Riparian Health Assessment (RHA) Analyses and Training. The proposal was formally accepted in early January 2009 and project work continued until completion in March 2009.

Project Objectives

The goal of this project was to conduct both an investigation into the development of a RHA screening-level strategy and training to help promote an improved understanding of riparian health and function to the Nova Scotia agriculture sector. The two accepted objectives were to:

i) investigate the development of a strategy for conducting a screening-level assessment of riparian health; given that the use of the RHA tool is time-consuming and labour-intensive, there is interest in determining the value of using remotely-sensed data to help identify impacts that have occurred in riparian areas; this type of assessment would be different than what is possible from using the RHA tool, but it could lead to a more efficient technique for delineating the areas where the RHA tool should be employed;

ii) provide training focused on the importance and use of data collected during riparian health assessments of agricultural landscapes and small watersheds; some training on the consistent use of the riparian health assessment tool has already occurred and has resulted in the need for training on what to do with data collected; training will emphasize the importance of interpreting RHA data using mapping software tools and other readily available datasets that help to describe watershed related characteristics.

In summary, the objectives of the project are designed to provide support for:

- Empowering multi-stakeholder processes for landscape management;
- Building the landscape management capacity of stakeholders;
- Providing a basis for environmental and agricultural policies for more effective landscape planning.

Training

The NSFA has been actively engaged in projects concerning watersheds and riparian health assessments. They have, for example, employed the Nova Scotia Riparian Health Assessment (NS RHA) Tool, to conduct a RHA in the St. Andrews Watershed. The NS RHA Tool is an implementation of the Cows & Fish program. This is a GPS-based tool that allows users to assess riparian areas by way of a series of questions. Appendix II provides a listing of the questions and responses employed by the tool. NSFA, and other organizations and government departments, have been promoting this tool and training individuals in its use.

The training delivered as part of this project did not set out to train individuals in the use of this Tool, but instead to provide training focused on the type of data that is collected when using the Tool and how it can be used within a geomatics context. Geomatics is a term that encompasses the technology and application of computer-based mapping tools that include: Global Positioning Systems (GPS), Geographic Information Systems (GIS), and Remote Sensing (RS).

On March 12-13, 2009 the AGRG conducted a two-day training workshop focused on the use of geomatics tools for riparian health assessments. Thirty participants registered for the first day and 24 registered for the second day (see Appendix I for a registrant list). The workshop was advertised for just over a week, and yet 30 people signed up. This is a good indication of the level of interest that exists in riparian health issues.

Day 1 Workshop Presentations

The first day consisted of a series of presentations and discussions dealing with the importance of riparian health assessments (RHA's) in agricultural landscapes and small watersheds, and the use of geomatics tools and spatial data to better understand the impacts taking place on the landscape.

The day began with Sean Basquill, Nova Scotia Department of Natural Resources, delivering a presentation entitled, *Riparian Areas and Their Ecological Significance*. Basquill provided a definition of riparian areas and discussed their ecological importance. It was a great presentation to start with and one that outlined the reasons for caring about riparian health issues.

Next, Levi Cliche, Clean Annapolis River Project, provided a perspective from a community group that is providing a leadership role when it comes to working with land owners. Cliche's presentation, *Riparian Zone Enhancement and Protection in the Annapolis River Watershed*, illustrated the kind of restoration projects that CARP has been involved with and in so doing provided a real sense of the type of work that needs to be done to improve riparian health.

Fortunately, Reg Newell, Nova Scotia Department of Natural Resources, was able to attend the workshop. Newell was a member of the Coordinating Committee during the development of the NS RHA Tool, and he delivered the presentation entitled, *The GPS-Based NS Riparian Health Assessment Tool*. The presentation outlined the 13 questions that the Tool addresses and Newell provided a real-world application perspective based on projects that he has been involved with.

Rod Metcalf, the person responsible for the software development of the Tool, was also present and provided valuable design and implementation input throughout the day.

Bill Livingstone, AGRG-NSCC, then provided an overview of a current project that the AGRG is leading with his talk, *FYI: Overview of AGRG's Watershed Quality Assessment Project*. The project involves the development and implementation of tools for environmental assessment of watershed quality. This presentation was designed to provide workshop participants with a few of some of the other assessment tools that are being used in water quality and watershed work.

After lunch, David Colville, AGRG-NSCC, presented, *Introducing the Use of GIS for Visualizing and Interpreting Riparian Data*. The objective of this presentation was to provide an overview of some of the ways that Geographic Information Systems (GIS) can be used in conjunction with RHA data. Workshop participants were given a sense of what the exercises designed for Day 2 would deal with.

William Jones, ADI Limited, then delivered a presentation entitled, *High Resolution Satellite Image Data for Riparian Mapping*. Jones provided great background on the remote sensing and available image data sets. He then focused on illustrating how remote sensing has been applied in the Upper Cornwallis River Watershed to assess the riparian areas that exist there. More on this is available in the Analyses section of this report.

A wrap-up session entitled, *Moving Forward with Riparian Health Assessments: What's Next?,* was led by Jeff Wentzell, NSCC. Wentzell began by listing a number of questions that could be used by the audience as means of stimulating a discussion on riparian health issues. He then opened the floor and led a discussion. He recorded participant's questions/comments and collated them into a Wrap-Up Session Report (see below).

Overall the day was designed to address riparian health issues and emphasize how geomatics tools (i.e., GPS, GIS, and RS) can be useful in the collection, interpretation, and communication of these issues. It is felt that this was achieved.

All of the presentations had been previously collected from the authors and they were packaged, printed, bound, and provided to workshop participants at the beginning of the day (these have been submitted to the NSFA under separate cover). The feedback received from participants indicated that they enjoyed the presentations and felt that they were worthwhile and valuable. Much appreciation was voiced for the hardcopy version of the presentations.

Wrap-Up Session Report

Prepared by: Jeff Wentzell, NSCC

The Wrap-Up Session for the Riparian Health Assessment (RHA) Workshop began by presenting a series of questions for the group to discuss. The questions presented were:

1) Is RHA information valuable to collect?
2) What should we do with it?
3) Who is using NS RHA tool? (Other tools?)
4) What are the barriers to implementing RHA?
5) What is the value of GIS/RS?
6) Pros & Cons of implementing GIS/RS?
7) How do we collect & manage RHA data?
8) How do we share RHA data? Should we?
9) Who is responsible for the data?
10) Other questions/comments?

Once these questions were presented, a general discussion took place. The following points were captured:

A) Training

The recognized need for training on the NS RHA Tool for both individuals and organizations was discussed. Discussion around what the technical requirements for an individual to do a RHA with the tool took place. It was pointed out that currently there is a two-day training session, but there are no plans for taking the NS RHA tool training to the community. Questions and points made:

- If an organization wants to implement NS RHA – how does this happen?
- Who is available to conduct RHA training?
- There is a need for the creation of a NS RHA Tool for Dummies Guide
- More needs to be done to solidify a common methodology for data collection including how to collect and the timing of the collection
- Creation of an on-line support site to continue the interaction with trainers and the other participants (e.g. AGRG Moodle Site) was suggested
- Forums and Listserves for RHA activities were also suggested

B) Technical – GPS/GIS/RS

There were issues discussed around the collection of data – features on the landscape can be a barrier to collecting data, including obstructions in the riparian areas.

- What can go wrong in the field?
    - Satellite coverage
    - Failure of batteries
    - Terrain

C) Data Collection

- Essential to document the RHA process with photos
- Who wants to do an RHA?
    - Farmers
        - It was suggested this needs to be part of the EFP process
    - Watershed groups
    - Individual property owners
    - Government Agencies
- Do we need to develop guidelines for RHA?

D) Approach to RHA

There was discussion as to how the NS RHA tool can be utilized within a GIS environment. The cost of walking all streams in NS is no doubt cost prohibitive. Is the NS RHA tool a screening level tool versus a localized assessment? Can we create a screening level tool in a GIS with the current sources of spatial data to identify potential areas that need localized assessments?

E) General Comments

- How does RHA fit within a watershed management plan?
- Are farmers contributing to riparian health
    - Need to be proactive
    - What are the solutions to identified problems?
- The issue of sharing data and implementing the RHA tool need further discussion so there is a common solution and a reduction in the duplication of effort.
- How do groups partner for RHA and community engagement?
- What is the Federation's role in RHA?
- What is the provincial government's role in RHA? Does Geonova have a potential role in the spatial data component?

RHA is a snapshot in time! There was discussion into the issues of methodology, timing, comparison of results, and the spatial / temporal components of conducting an RHA.

This workshop was a great opportunity to have a discussion with approximately three dozen individuals who are concerned and interested in riparian health issues. These notes recorded during the Wrap-Up Session are provided to the NSFA for their information. It is clear from the discussions that took place that there is interest and opportunities to continue to pursuit riparian health assessment initiatives.

Day 2 Workshop Lab Exercises

The second day of the workshop focused on presentations and hands-on exercises which explored the RHA data being collected and how ESRI's GIS software can be used to visualize and interpret these data. Various GIS functionality was explored in order to introduce some of the technical issues associated with the visualization of RHA data. Participants were also introduced to various layers of data that can be used in conjunction with the data collected in the field to aid in the interpretation process.

Workshop Lab Exercises were designed, prepared, and made available to participants (copies were made available to the NSFA under separate cover). The exercises all dealt with the use of GIS and RHA data that was collected during a survey of the St. Andrews Watershed. Four exercises were presented:

(1) *The GIS basics – Introducing the software and the data* provided a starting point for working with the ArcGIS software. This exercise walked participants through the production of their first map that illustrated the RHA data with other spatial layers.

(2) *Riparian health assessment – Working with the data* led participants through the process of exploring the RHA questions/responses and showed how this information could be accessed via maps, tables, and charts. The use of geometric networks for conducting upstream/downstream analyses was also covered.

(3) *Integrating spatial data from other sources* focused mostly on the integration of the RHA data with other spatial data layers such as the NSDNR's Forest Inventory. Participants were shown how simple models could be implemented to assess landcover/landuse impacts on the riparian areas.

(4) *Packaging your own story – Sharing data with others* showed how spatial data sets could be packaged and used in software that is freely available. This exercise also emphasized some of the visualization tools that exist to work with data in a 3D environment.

As the participants worked through the exercises they were encouraged to maintain their results in a specified output directory. At the end of the day participants were each provided with 1GB flash drives. They were then encouraged to copy the exercise workbook and the results that they had created to the flash drives so that they could leave with digital versions of the day's activities.

The participant feedback received at the end of Day 2 was very positive. Participants told us that they enjoyed the presentations and exercises, and many said that they learned a great deal. They appreciated being able to leave with a digital version of the exercises (and their heads full!).

Analyses

This section focuses on the investigation into a screening-level assessment of priority sites for conducting Riparian Health Assessment. This is not an attempt to skip the use of the NS RHA Tool, but instead an attempt to help prioritize where the Tool should be used. This investigation is based on the use of geomatics and existing spatial data sets. That being said, it is recognized that currently available remotely sensed data sets are not capable of answering most of the questions addressed by the NS RHA Tool (see a list of the questions in Appendix II). These questions address issues that are really only acquired by way of on-site assessments. Thus the Tool provides a valuable means of collecting and mapping this level of detailed data.

The NS RHA Tool is employed by walking and assessing the riparian areas within your area of interest. As one walks the area the Tool records the spatial location by way of the onboard GPS unit. At locations where the riparian conditions change you are to stop and respond to a series of questions posed by the Tool. In this way, riparian areas are mapped and the responses to the questions are attached to each area as a set of attributes. With practice, an assessor can collect very detailed information about the vegetation and stream bank condition.

However, this detail comes at quite a cost when you consider the time it takes to walk all the riparian areas associated with the streams, rivers, and lakes within a watershed. As an example, the St. Andrews Watershed has 248km of riparian areas. Assessing an area of this size takes considerable time. And given that the questions address the riparian area at the time it is being assessed, the results are only a snap-shop in time. Weeks, months, or years later and the conditions could easily have changed. Thus an assessor would have to re-walk the areas again to assess them. It is highly unlikely that it would be cost-effective to implement the NS RHA Tool in all the watersheds where an assessment should be carried out. Assessing an area multiple times only exacerbates this point.

It is suggested by the authors of this report that screening-level strategy is needed that would for any area of interest, at any given time, identify the riparian areas that should be prioritized for an onsite assessment. If possible, a screening-level assessment could provide a part of a more cost-effective assessment strategy, and thus allow for more watershed areas to be completed. The screening-level assessment being suggested would rely heavily on existing spatial datasets that can be cost-effectively acquired. Of course, spatial datasets are used as input to geomatics software systems and thus these systems need to be available and accessible (issues that were addressed in the two-day training workshop).

Here in Nova Scotia there are a number of relevant provincial datasets that are available. From base mapping (i.e., streams, lakes, roads, buildings, contours, etc.) to forest and agricultural inventories compiled by the Departments of Natural Resources and Agriculture, respectively. These layers are mapped at a 1:10,000 scale and thereby provide a useful starting point for many projects. Additionally, there are many sources of remotely sensed data (i.e., aerial photos and satellite imagery).

This project has conducted two case studies; the St. Andrews study focuses on a screening-level strategy, while the Upper Cornwallis River study uses RS to extend riparian assessments.

St. Andrews Watershed Case Study

In the summer of 2007 the NSFA commissioned the RHA survey of the St. Andrews Watershed. This led to 248km of riparian areas being walked and mapped. For each riparian section, responses were encoded and a score was derived based on the protocol defined by the NS RHA Tool. Additionally, comments were recorded for all Unhealthy and Healthy with Problems sections, and many of the Healthy sections as well. The inclusion of comments helped tremendously to provide insight into the conditions taking place on the ground. The lack of photographs documenting the conditions observed during the survey is the obvious short-fall of this dataset. Figure 1 illustrates the results of this RHA survey, symbolized by score. The green lines represent the areas found to have a Healthy score (90.1%); yellow lines represent areas that scored as Healthy with Problems (3.3%); and the red lines are those with an Unhealthy score (6.6%).

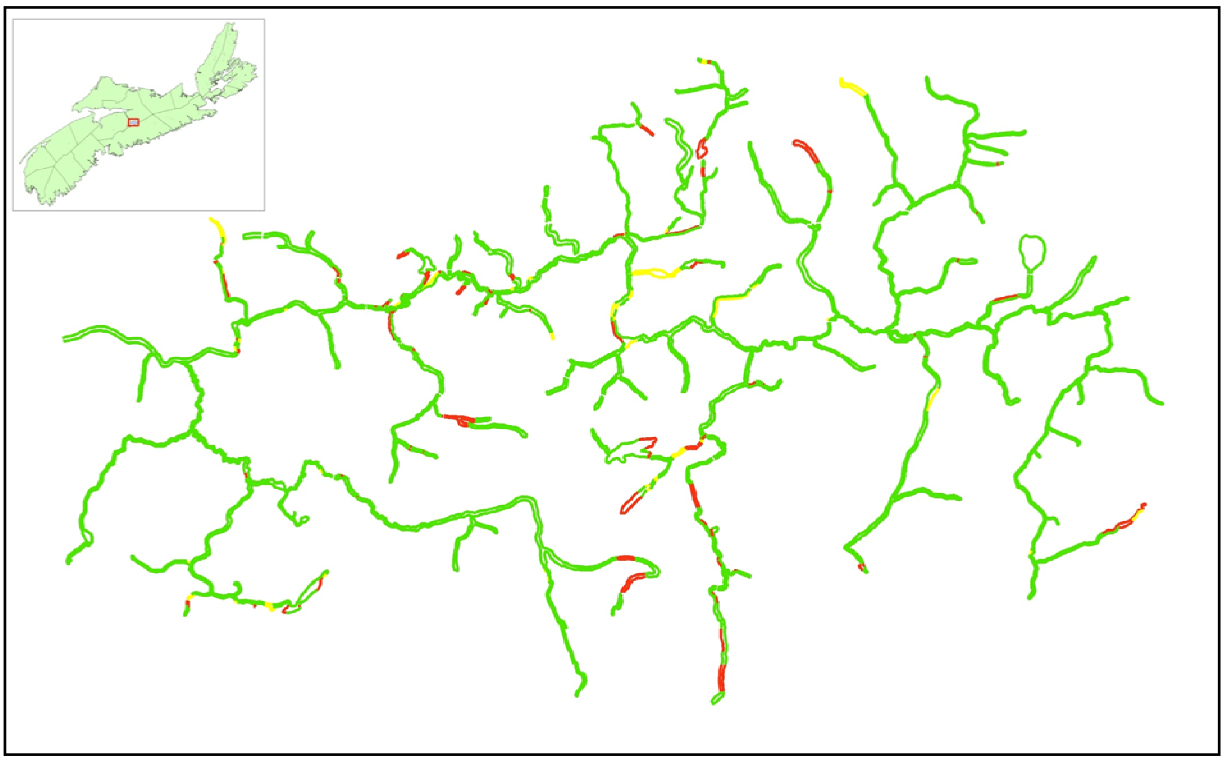


Figure 1: St. Andrews Watershed RHA Symbolized by Score

Figure 2 presents a summary of the RHA areas classified based on the assessor's comments. This clearly shows the total length and the number of occurrences of RHA sections that were found to occur in each of five possible classes. These classes were derived based on the assessor's comments. It is important to note that consistency with the comments can lead to a more informed survey. Forestry was found to be the most detrimental activity in terms of riparian impact, followed by Agriculture and then Human Impact. Without the comments this type of summary information could not be derived from the RHA survey.

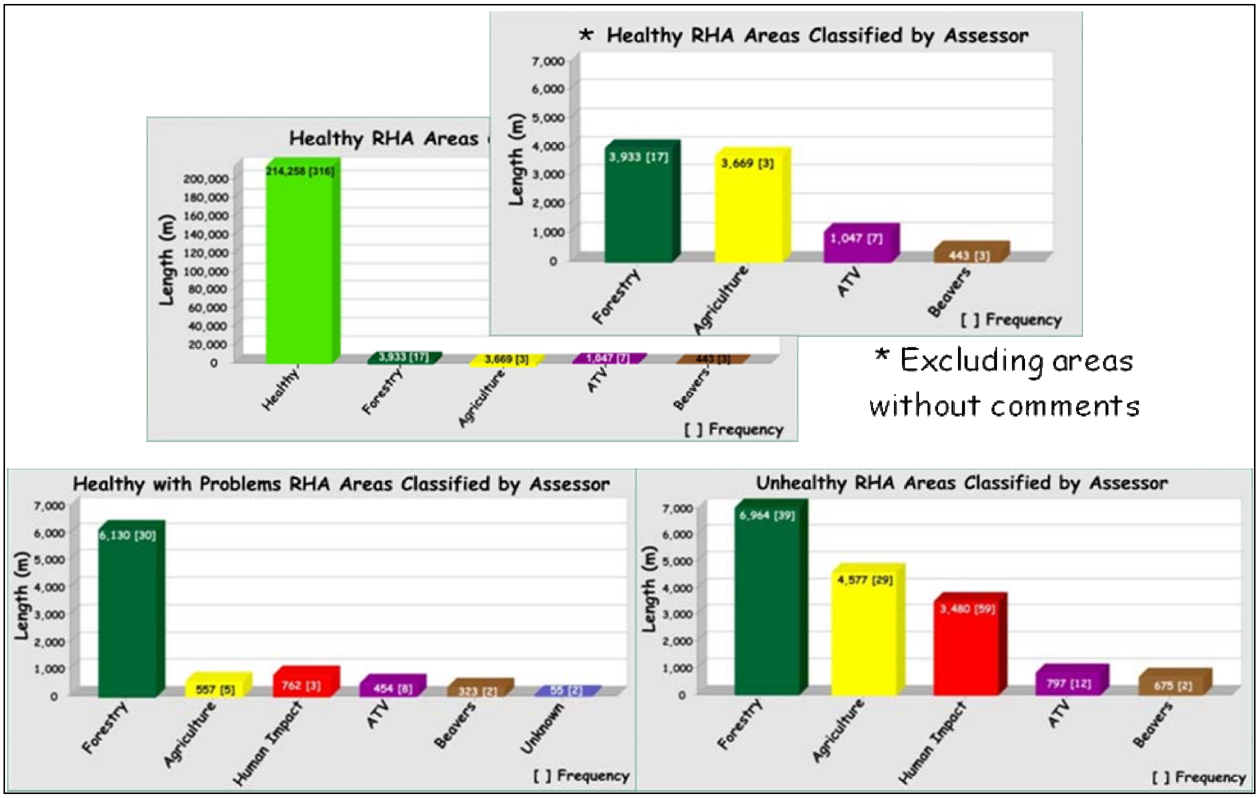


Figure 2: RHA Areas Classified by Assessor's Comments

The above figures are based on information derived solely from the RHA survey. The Forestry class results from forest harvesting activity (i.e., logging). The Agriculture class is based on agricultural activities (i.e., cattle accessing a stream). The Human Impact class includes residential activities (i.e., lawn mowing up to stream edge) and corridor issues (i.e., road crossing a stream). And the ATV and Beaver classes indicate ATV crossings and beaver activity.

From a mapping perspective, and given an interest in defining a screening-level strategy, we are interested in relating these classes to classes that we can derive with existing spatial datasets. Fortunately, the three most dominant classes can be roughly defined with DNR Forest Inventory dataset. The Forestry class may be reflected in what DNR has mapped as clearcut areas. The Agriculture class should fit with the areas that DNR has mapped as agriculture. And the Human Impacts class may connect with what DNR has mapped as urban and corridor areas. To assess these predictions we needed to overlay the RHA areas on a reclassified version of the Forest Inventory. The ATV and Beaver classes cannot be emulated with the Forest Inventory.

However, given that the DNR dataset may not be up-to-date (each county is updated once every ten years), it is important that we update the data wherever we can. Landsat satellite imagery has much to offer in this respect. Landsat is now freely available. It images the same location on the earth every 16 days, and thus as long as there are no clouds the resulting image can be used for update purposes. Clearcuts, the typical harvesting technique in Nova Scotia, can easily be identified with Landsat. Figure 3 shows the results of our update efforts. Figures 4 and 5 present the mapping of the Agriculture (updated with ALIP) and Human Impact classes. Figure 6 shows the resulting updated Forest Inventory data reclassified into Landcover classes.

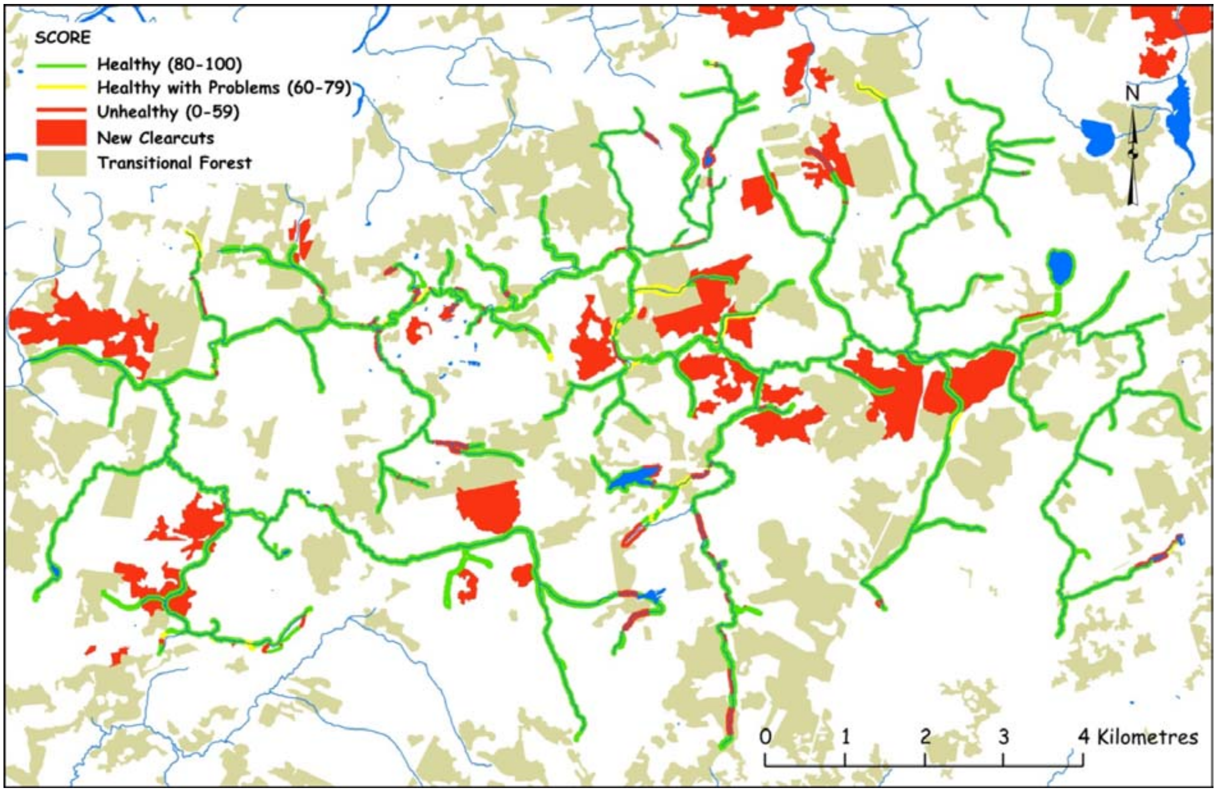


Figure 3: RHA Areas with Landsat Updated (based on a July 2007 image) Transitional Forest Landcover

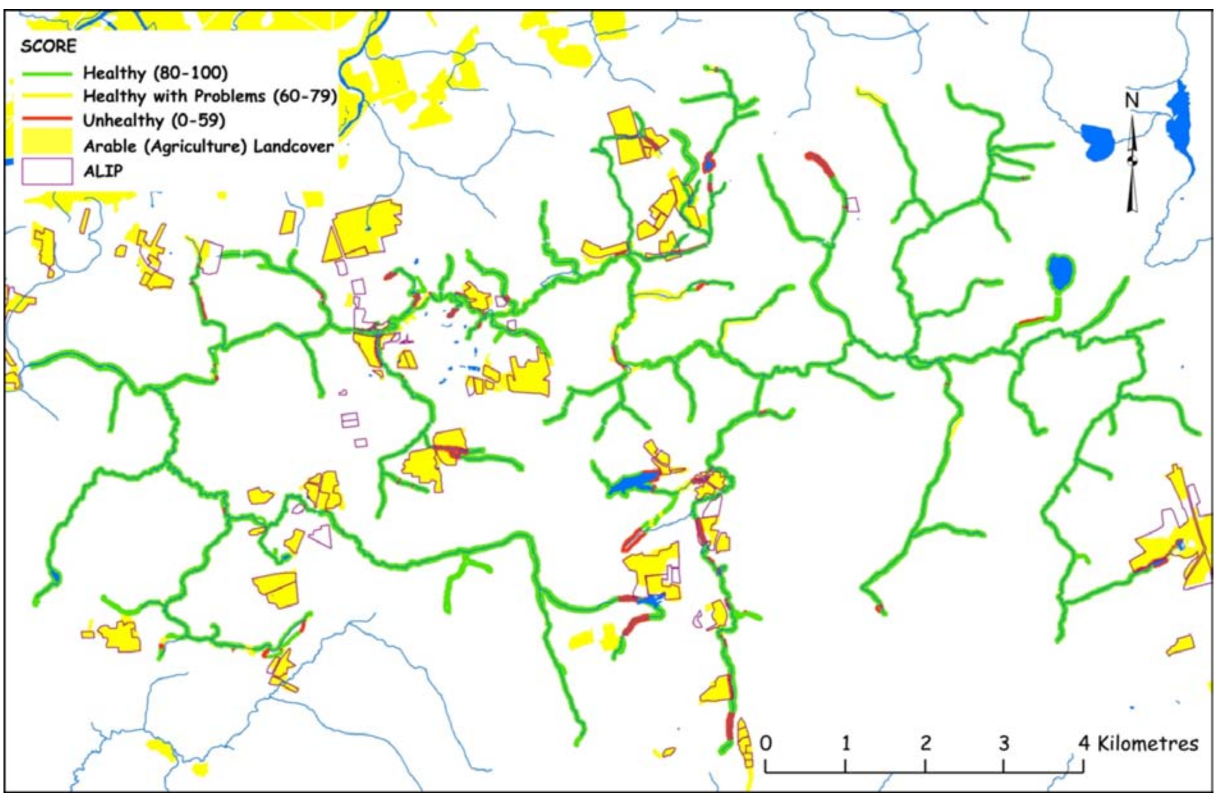


Figure 4: RHA Areas with ALIP Updated Agricultural Landcover

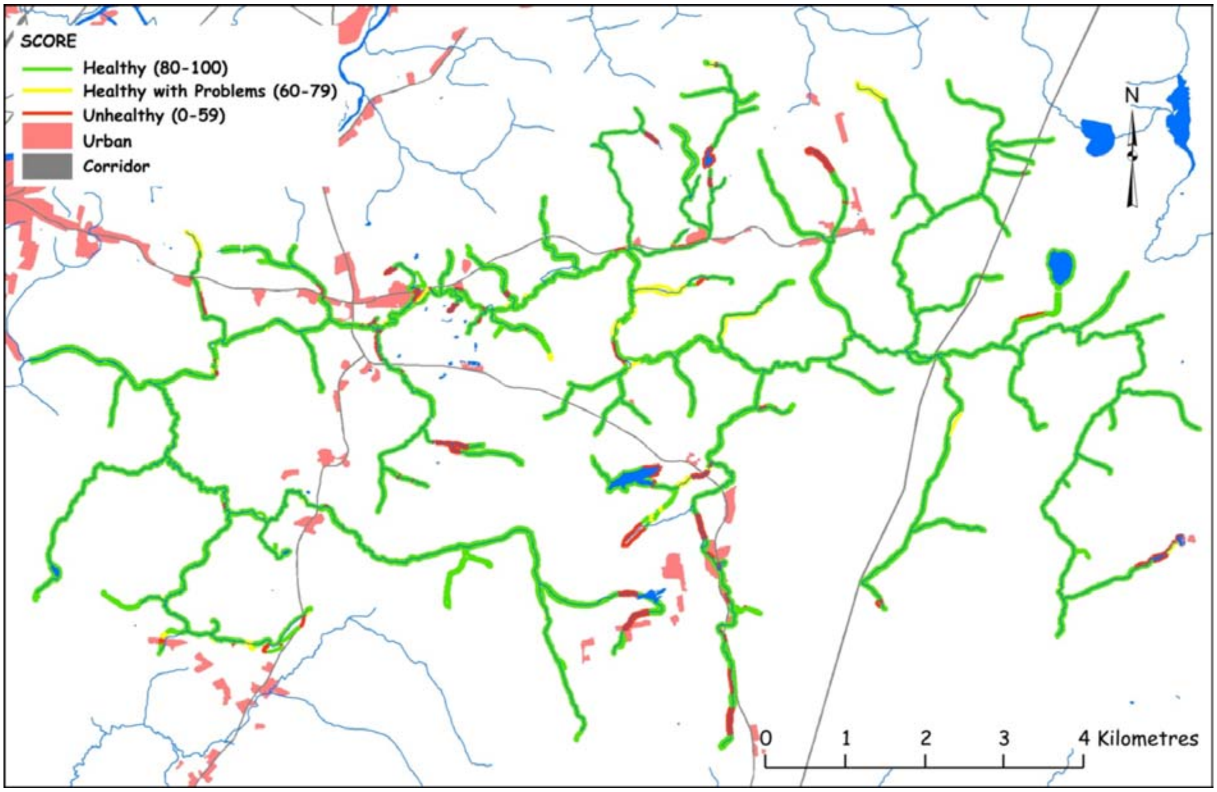


Figure 5: RHA Area with Urban and Corridor Landcover

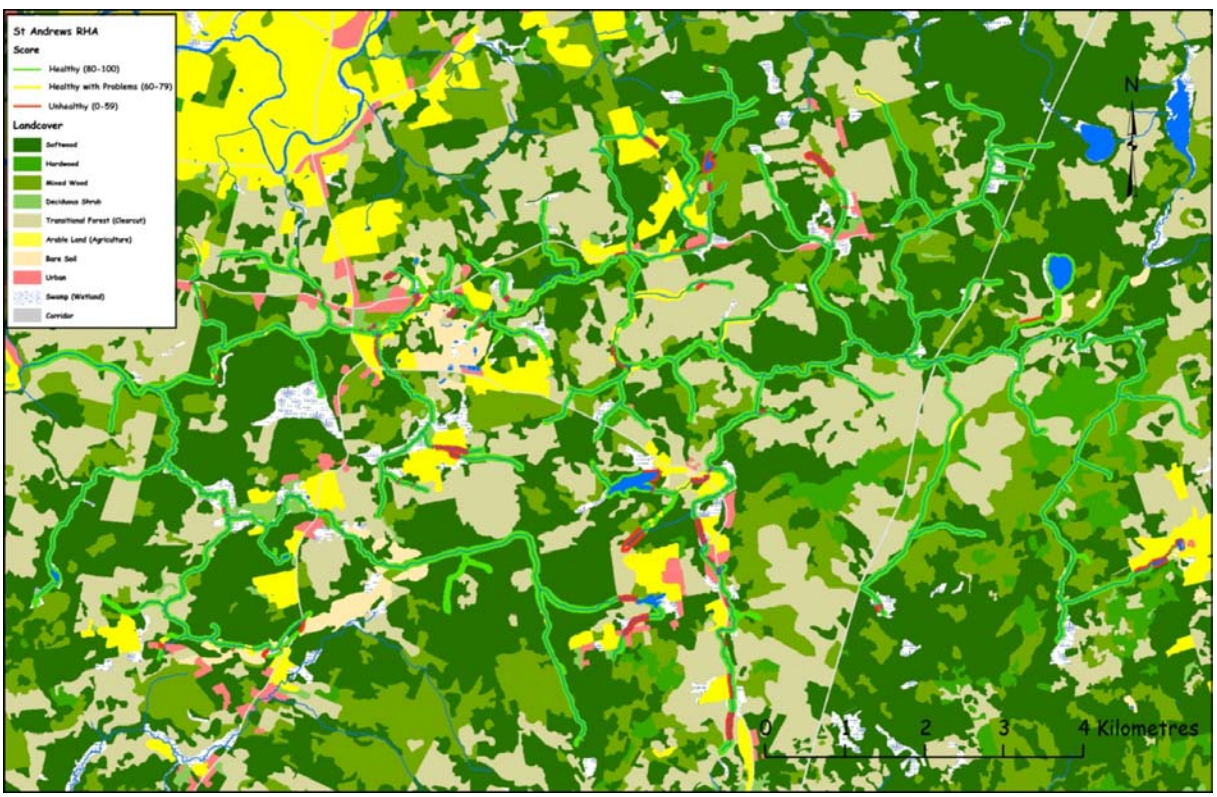


Figure 6: RHA Areas with Updated Landcover

Now, when we use the GIS to intersect the RHA areas with the updated Landcover layer we can then assess the RHA areas based on Landcover. Figure 7 shows the resulting fit. If we had found a good fit between the RHA areas classified as Unhealthy and Healthy with Problems and the "Active" Landcover classes (namely Transitional Forest, Agriculture, Urban, and Corridor) then we could use these "Active" classes to identify areas of concern. However, while many of the troubled RHA areas fell into the "Active" classes, they also fell into other classes as well.

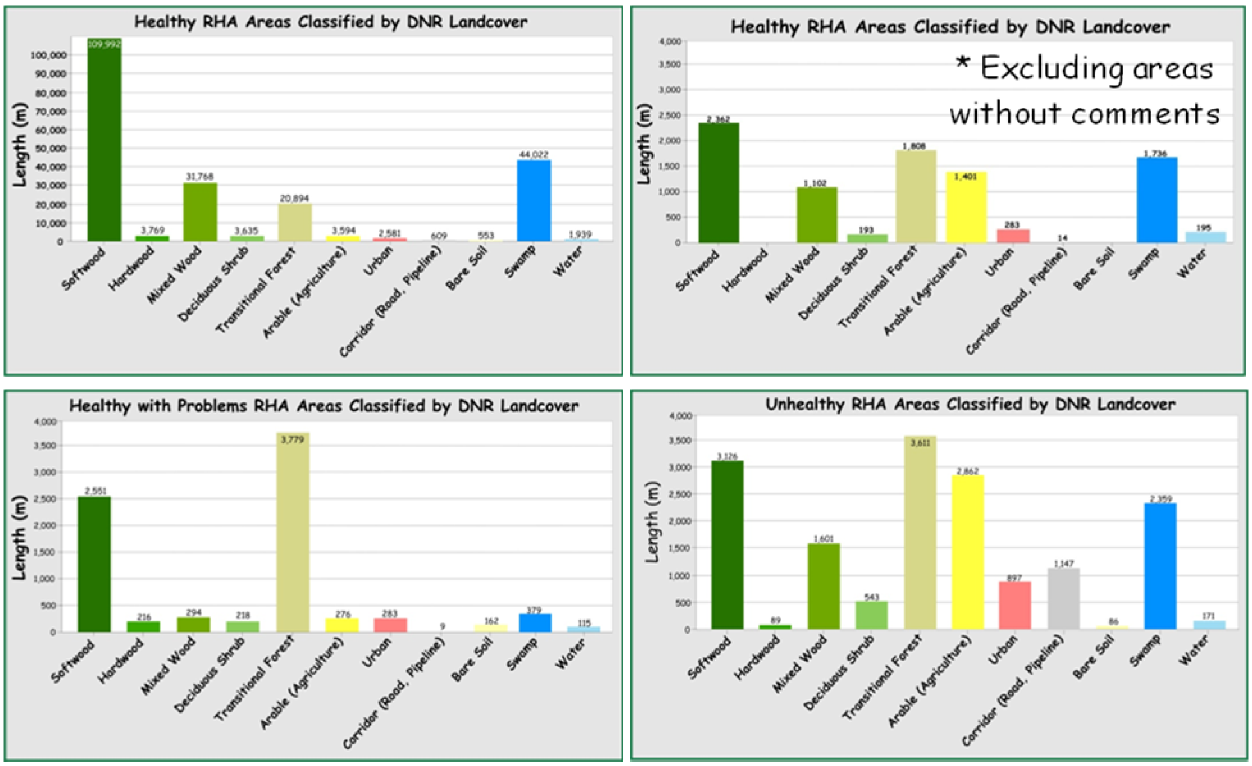


Figure 7: RHA Areas Intersecting Landcover Classes

This indicated the need for a closer look at the results. Figure 8 shows a close-up portion of the RHA areas with the updated Landcover layer. The Unhealthy RHA area shown near the top of the figure illustrates an important example. This RHA area has been classified, in the field, as one area. In the intersection procedure described above, this one area would have been "broken up" as it crossed each Landcover class boundary and attributed to the corresponding class in the Figure 7 graphs. As the assessor's comments indicate, this RHA area is unhealthy due to forest harvesting activity. The RHA does overlap with the Transitional Forest class, but it also overlaps with other classes as well. This is a common place occurrence (other cases can be seen in Figure 8) throughout the RHA dataset. It is related to the scale of Landcover mapping (for example, the DNR Forest Inventory boundaries have a stated accuracy of about 50m).

Next, we calculated the amount of overlap that exists between each of the three RHA classes and the "Active" Landcover classes. We wanted to identify if we could identify a majority of the troubled RHA areas through the use of the "Active" classes. Figure 9 presents the results of this calculation. While there was a very good fit of the Unhealthy and Healthy with Problems classes

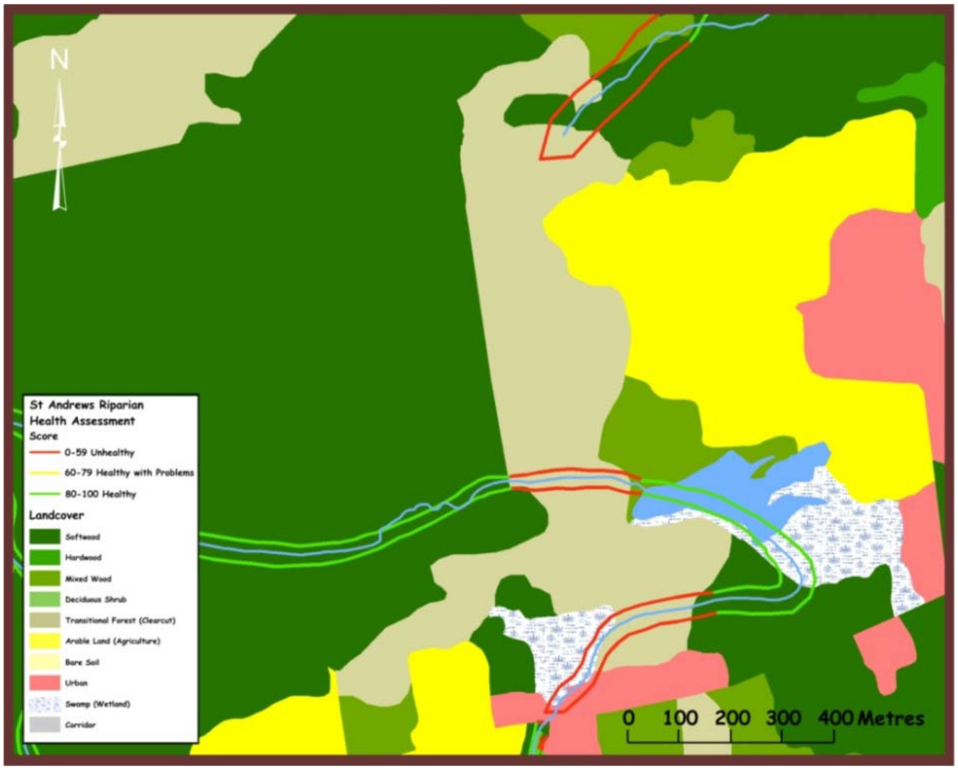


Figure 8: Inset of RHA Areas with Updated Landcover

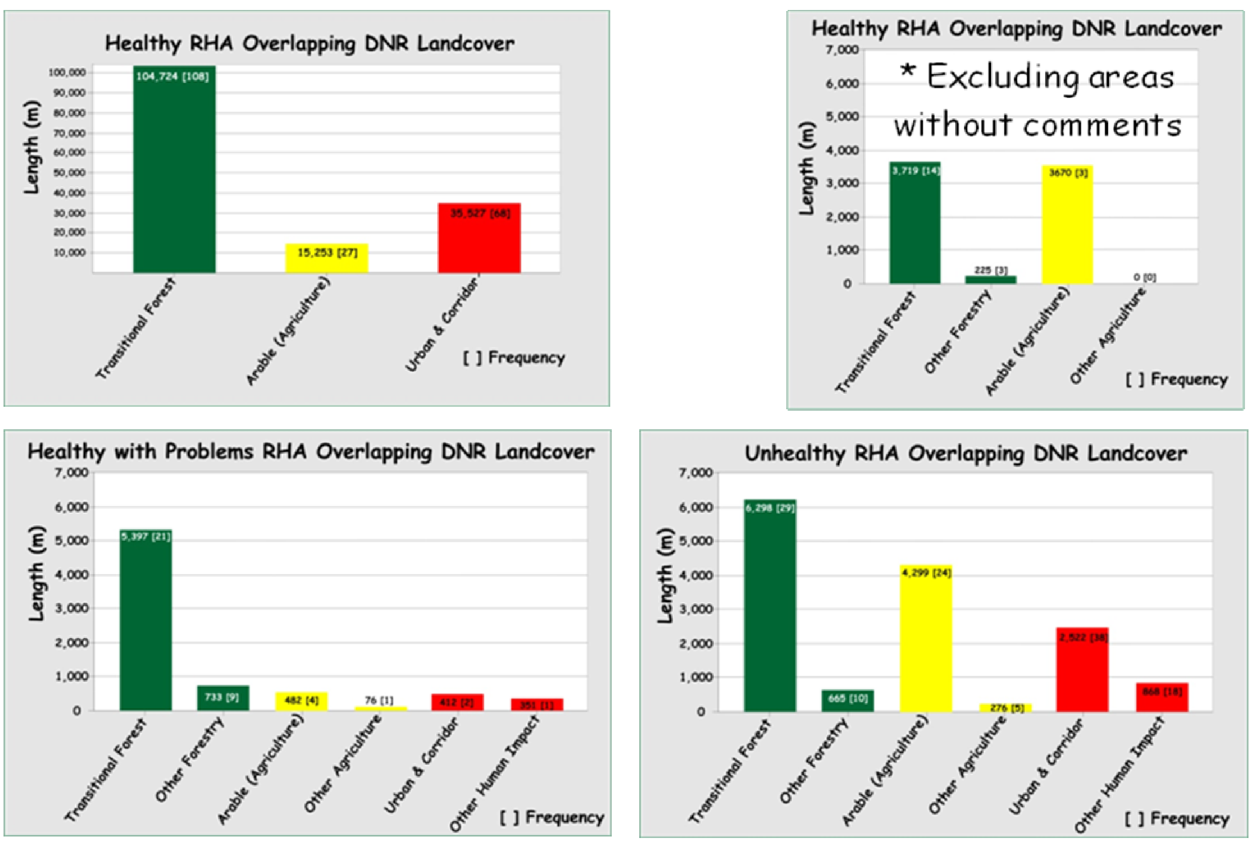


Figure 9: RHA Areas Overlapping "Active" Landcover Classes

and the “Active” Landcover classes, there were also a number of Healthy RHA areas that fell into the “Active” classes. However, it is important to recognize that many of the Healthy RHA areas are long and thus even if only a small portion of a Healthy area overlaps on an “Active” class the entire length is attributed to the class.

The Summary Box of Numbers shown below summarizes the findings of this case study.

Summary Box of Numbers

RHA Lengths in the St. Andrews Watershed …

- Healthy = 223356.5m
- Healthy with Problems = 8281.9m
- Unhealthy = 16491.4m
- Total = 248129.8m (248km)

Intersecting “Active” Landcover Classes:

Healthy	27692m of 223356.5m	(12.4%)
Healthy with Problems	4347m of 8281.9m	(52.5%)
Unhealthy	8651m of 16491.4m	(52.5%)
Total	40690m of 248129.8m	(16.4%)

Overlapping “Active” Landcover Classes:

Healthy	193209.0m of 223356.5m	(86.5%)
Healthy with Problems	6902.2m of 8281.9m	(83.3%)
Unhealthy	14603.2m of 16491.4m	(88.6%)

What this indicates is that an updated “Active” Landcover data layer for the St. Andrews Watershed has been found to provide a very good screening-level assessment. The spatial intersection of a streams data layer with the updated “Active” Landcover layer would identify the areas to prioritize for an RHA survey. Then when in the field conducting the RHA survey the assessor would find that some of the troubled RHA areas would extend out beyond the prioritized areas.

It has been possible to identify 80^{+}% of the troubled areas by conducting this relatively simple procedure with readily available datasets. From the numbers above, 40.69km of prioritized areas (or 16.4% of the total RHA area within the St. Andrews Watershed) would lead to the identification of 88.6% of the Unhealthy areas and 83.3% of the Healthy with Problems areas.

Upper Cornwallis River Watershed Case Study

This case study takes a different approach then that used in the St. Andrews Watershed. Given the lack of complete RHA data (see Figure 10) and a wealth of remotely sensed data for this area, the emphasis of this case study has been on demonstrating the power of RS datasets.

This case study illustrates how remotely sensed datasets can be used in extending riparian health assessments. State-of-the-art satellite imagery is presented and it is shown how these types of imagery (and other datasets i.e., LiDAR) can be used to: acquire detailed, up-to-date descriptions of an area's landcover/landuse; derive and assess the impact of slope on riparian areas; integrate these various spatial components to develop a high-resolution model of the riparian zone. As well, a cost analysis of the remotely sensed data used in this case study is provided.

This Upper Cornwallis River (also referred to as Thomas Brook) Case Study has been completed for the AGRG by William Jones, ADI Limited. Jones's final report is included in this report as Appendix III.

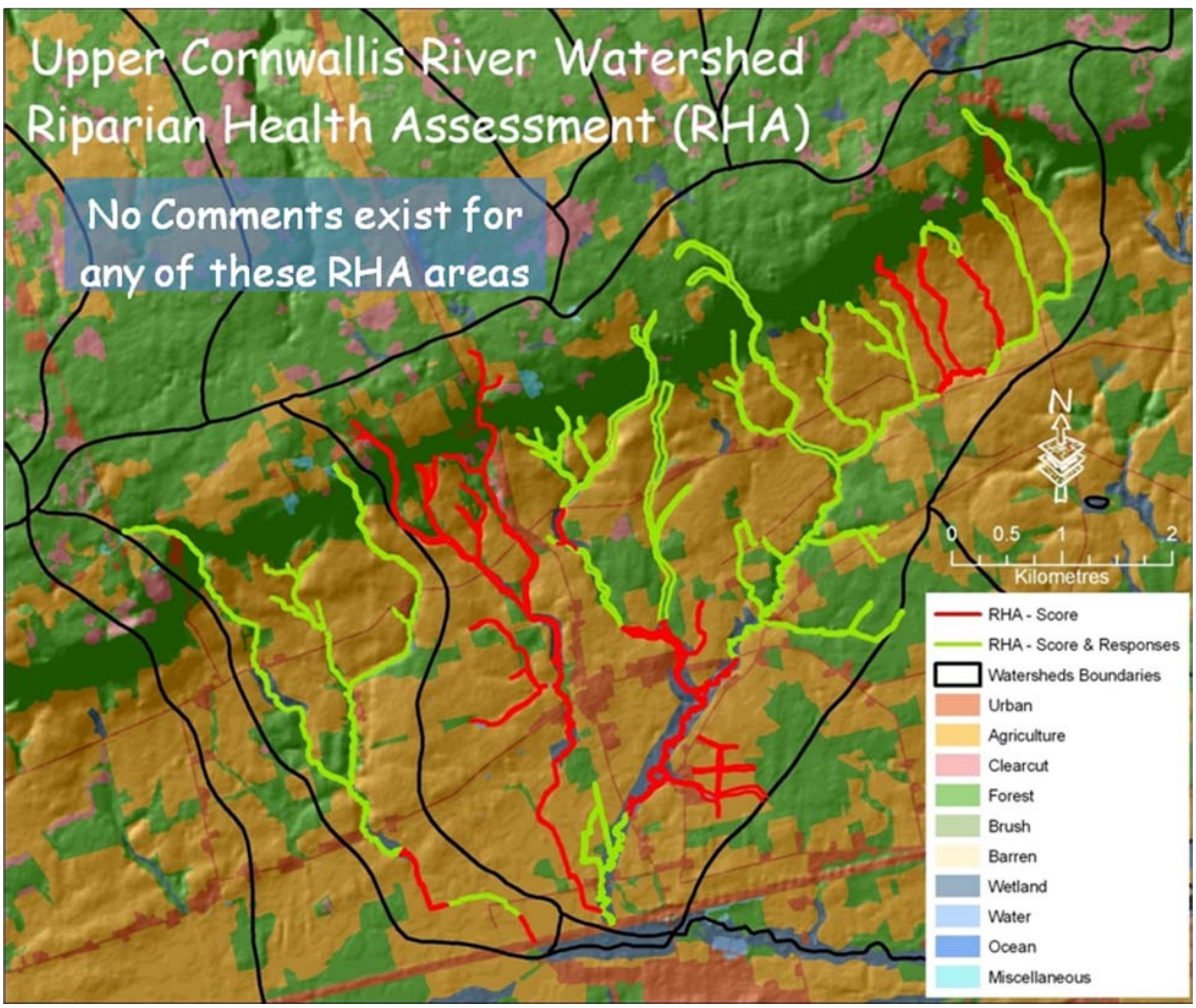


Figure 10: Upper Cornwallis River Watershed RHA

Summary

Training …

After just over one week of notification 30 workshop participants had registered. This indicates a definite interest in riparian health issues.

Based on the discussions that took place on Day 1there is a need for support and further training.

The two-day workshop appears to have been successful and well received by the participants.

Analyses …

The St. Andrews Watershed case study showed that there is good potential for using existing spatial layers to prioritize areas to conduct RHA surveys.

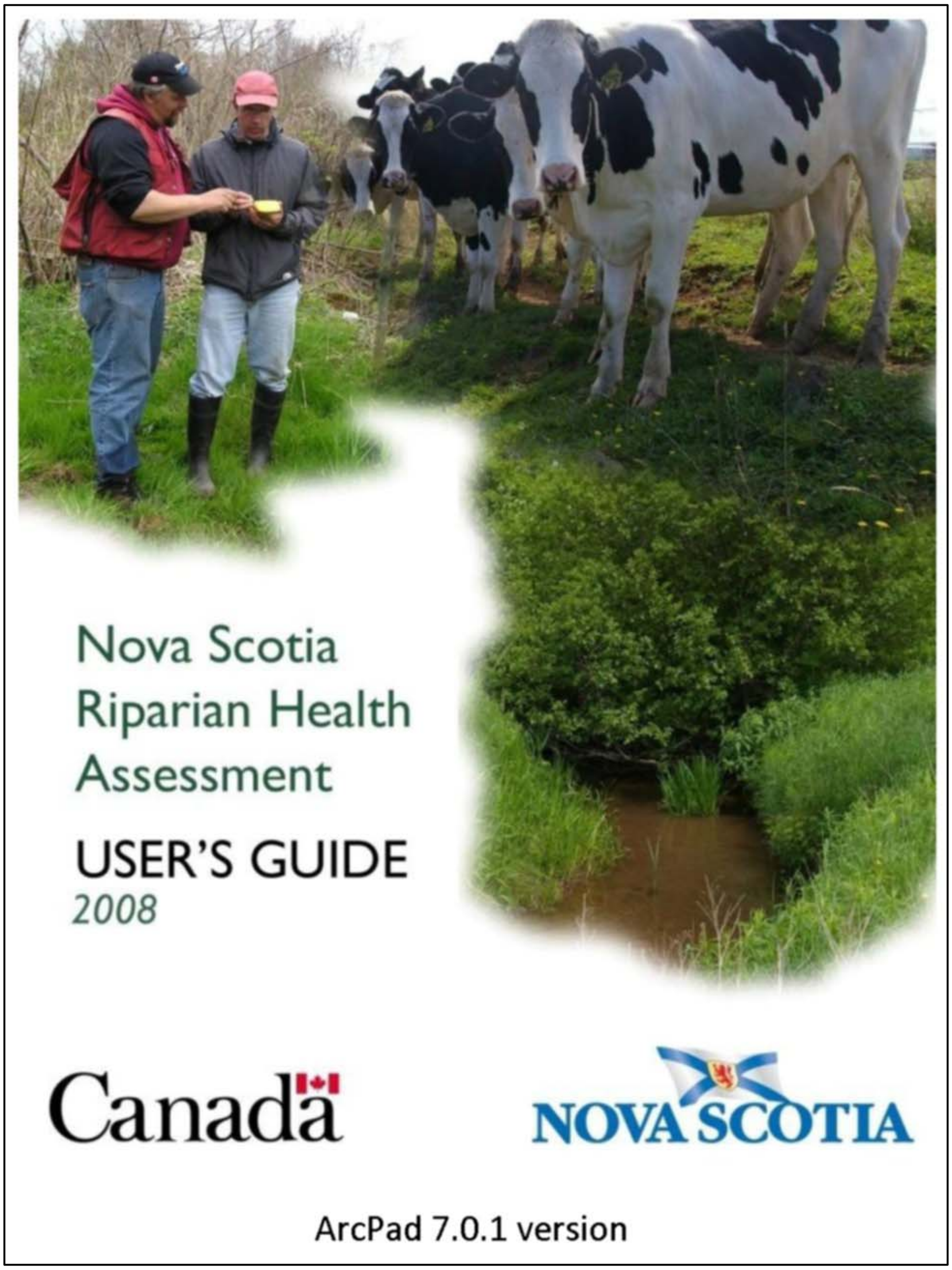
The Upper Cornwallis River Watershed case study focused on illustrating the potential of high-resolution imagery for extending riparian mapping beyond what is possible with the NS RHA Tool.

Appendix I: Workshop Registrants

Workshop Registrants

Name	Address	Organization	e-mail	Phone	Days Attending
Elizabeth MacCormick	P.O. Box 5300, Sydney, NS, Canada, B1P 6L2	Bras d'Or Institute for Ecosystem Research, CBU	Bruce_Hatcher@cbu.ca		2
Norma deSwart			delle.fairclough@ns.sympatico.ca		2
Marlene Clements		Municipality of Kings	mclements@county.kings.ns.ca	902) 690-6126	2
Tom van Oirschot		Environmental Farm Plan	vanoirtr@gov.ns.ca	902-893-6322	2
Matthew Smith	71 Avondale Rd.Newport Landing NS		smithmc@gov.ns.ca	902-757-2382	2
Brad Crewe			crewebc@gov.ns.ca		2
Susan Carbyn	32 Main Street, Kentville, B4N 1J5	Agriculture & Agri-Food Canada	Susan.Carbyn@AGR.GC.CA	902-679-5337	2
Darrell Hingley	PO Box 550 Truro, NS B2N 5E3	Department of Agriculture- Land Protection	hingledd@gov.ns.ca	893-6576	2
Larry Bell	702 Old Sackville Rd., Sackville, NS, B4C 2K3	WATER Research Associates Inc	lbell@water-associates.com	902-252-3385	2
Jim Jotcham	P.O. Box 280, Berwick, NS B0P 1E0	Marbicon Inc.	marbicon@eastlink.ca	902-538-7101	2
Becky Peterson	RR#5 Cardigan, PEI C0A 1G0		boughton@isnhighspeed.ca	902-583-3324	2
Brad McCallum	332 Willow Street, Suite 201, Truro B2N 5A5	NSFA	bmccallum@nsfa-fane.ca	902-893-2293	1st
Jonathan Wort		AgraPoint	j.wort@agrapoint.ca	902-896-0277	1st
Michel Melanson		Yarmouth-Argyle-Barrington-Clare	mmelanson@munargyle.com	902-648-3166	2
Margaret MacDonald	PO Box 232 Mabou NS B0E 1X0	Mabou Harbour Watershed	mmacdona@middlebury.edu	902-945-2945	2
Wendy Rodenhizer	PO Box 10 Mahone Bay NS B0J 2E0	Bluenose Coastal Action Foundation	wendy@coastalaction.org	902-624-9888	2
Amy Weston	581 Stanburne Road Barss Corner NS B0R 1A0	Nova Scotia Salmon Association	amy.weston@ns.sympatico.ca	(902) 644-1276	1st
Raymond Parker	221 Avondale Road, Newport, NS B0N 2A0	Avon Peninsula Watershed Preservation Society	apwps@xplornet.com	(902) 792-0272	2
Rod Metcalf	1256 Highway 12, Kentville,NS B4N 3V8		rodmet@yahoo.ca	(902) 680-6683	2
Britt Roscoe	320 Esplanade, Room 300, Sydney, NS B1P 7B9	CBRM Water Utility	blroscoe@cbrm.ns.ca	(902) 563-5551	2
Erica Versteeg		Environmental Farm Plan	versteel@gov.ns.ca	902-893-6561	1st
Kathryn Bremner		Environmental Farm Plan	bremneka@gov.ns.ca	902-893-6561	2nd
Ken Webb	39 Cox Road, NSAC, Truro, NS B2N 5E3	Agriculture and Agri-Food Canada |	Ken.Webb@AGR.GC.CA	902-893-6724	2
Trevor Graham		Eastern Shore Clam Fishers Association	tracy.graham@eastlink.ca	827-5812	1st
Colin Purcell		Eastern Shore Clam Fishers Association	tracy.graham@eastlink.ca	827-5812	1st
Bill Curry	Box 44, Port Maitland, NS, B0W2V0	TREPA	flyfish@tightlines.ca	649-2428/740-3281	2
Heather Rand		Agriculture & Agri-Food Canada	Heather.Rand@AGR.GC.CA	902-896-3654	1st
Andrew Bishop			p.m.bishop@ns.sympatico.ca	532-0474	1st
Lorelei Langille		Agriculture & Agri-Food Canada		902-896-3654	1st
Sebastian Marquis	PO Box 45071 Sackville, NS B4E 2Z6	Sackville Rivers Association	sackvillerivers@ns.sympatico.ca	865-9238	2
Lloyd Evans	13482 Highway 1 RR#1Wilmot NS B0P 1W0	NSFA	lsevans@ns.sympatico.ca	902-825-4416	1st
Chris Luckhurst		Scotian Gold Cooperative Ltd	chris.luckhurst@scotiangold.com	(902) 679-6003	2nd
Mr. Larry Lutz		Scotian Gold Cooperative Ltd	chris.luckhurst@scotiangold.com	(902) 679-6003	2nd
Reg Newell	136 Exhibition St., Kentville, NS B4N 4E5	Dept Natural Resources - Kentville	newellrb@gov.ns.ca	679-6145	2
Lise Charbonneau			lisechar@hotmail.com		1st

Appendix II: NS RHA Tool Questions and Responses


Nova Scotia
Riparian Health
Assessment

USER'S GUIDE
2008

Canada

NOVA SCOTIA

ArcPad 7.0.1 version

Co-ordinating Committee for the Riparian Health Assessment Project for Nova Scotia:

Nova Scotia Department of Agriculture: Brian MacCulloch
Nova Scotia Department of Natural Resources: Glen Parsons, Reg Newell
Consultants: Rod Metcalf, IT Consultant and Lynne Godlien and Cheryl Phillips, AgraPoint

Riparian Health Assessment Questions …

Q1. How much of the riparian area is covered by vegetation?

6 = More Than 95%
4 = 85% To 95%
2 = 75% To 85%
0 = Less Than 75%

Q2A. How much of the riparian area is covered by weeds (*invasive plant species*)?

3 = No Invasive Species
2 = Less Than 1%
1 = 1% To 15%
0 = More Than 15%

Q2B. What is the density/distribution of the weeds?

3 = None
2 = Class 1-3 (Few)
1 = Class 4-7 (Patches)
0 = Class 8+ (Common)

Q3. How much of the riparian area is covered by disturbance-caused vegetation?

3 = Less Than 5%
2 = 5% to 25%
1 = 25% to 45%
0 = More Than 45%

Q4. Is woody vegetation present and maintaining itself?

6 = More Than 15%
4 = 5% to 15%
2 = Less Than 5%
0 = Tree/Shrub Absent
N/A

Q5. Is woody vegetation being used / suppressed?

3 = None (0% to 5%)
2 = Light (5% to 25%)
1 = Moderate (25% to 50%)
0 = Heavy (More than 50%)
N/A

Q6. How much dead wood is there?

3 = Less Than 5%
2 = 5% to 25%
1 = 25% to 45%
0 = More than 45%
N/A

Q7. Are the streambanks held together with deep-rooted vegetation?

6 = More Than 85%
4 = 65% To 85%
2 = 35% To 65%
0 = Less Than 35%

Q8. How much of the riparian area has bare ground caused by human activity?

6 = Less Than 1%
4 = 1% to 5%
2 = 5% to 15%
0 = More Than 15%

Q9. Have the streambanks been altered by human activity?

6 = Less Than 5%
4 = 5% to 15%
2 = 15% to 35%
0 = More Than 35%

Q10. Is the reach (riparian section) compacted, bumpy or rutted from use?

3 = Less Than 5%
2 = 5% to 15%
1 = 15% to 25%
0 = More than 25%

Q11. Can the stream access its floodplain?

9 = Stage 1a, 1b, 1c
6 = Stage 2
3 = Stage 3
0 = Stage 4a, 4b

PTS	17/57	23/57	29/57	32/57	34/57	37/57	40/57	46/57	52/57
%	**30**	**40**	**51**	**56**	**60**	**65**	**70**	**80**	**91**
	Unhealthy				*Healthy With Problems*			*Healthy*	

Q12. What is the average assessed riparian width?

1 to 5 metres
5 to 10 metres
10 metres plus

Q13. Comments

Appendix III: Riparian Mapping Using Remotely Sensed Data Final Report

Riparian Mapping Using Remotely Sensed Data
Final Report
William Jones, ADI Limited

Introduction

The objective of the project was to investigate the utility of high resolution satellite-based remotely sensed image data and LIDAR Elevation data in the mapping and classification of Riparian Habitat Areas in the Thomas Brook Watershed, Kings County, Nova Scotia. The study site covers 6.9 by 3.8 kilometers and has an area of 2,622 hectares making it approximately 60% of the size of a Provincial 1:10,000 topo map sheet. The Thomas Brook Watershed (Figure 1) is situated on the North Side of the Annapolis Valley and ranges in relief from flat bottomlands and plateaus to steep mountain sides. The watershed drains an area of approximately 2,300 hectares of which 10 % is urban/infrastructure, 60 % is Agriculture, and 30% forested. Agricultural uses include pasture, row crops, grain, and orchards.

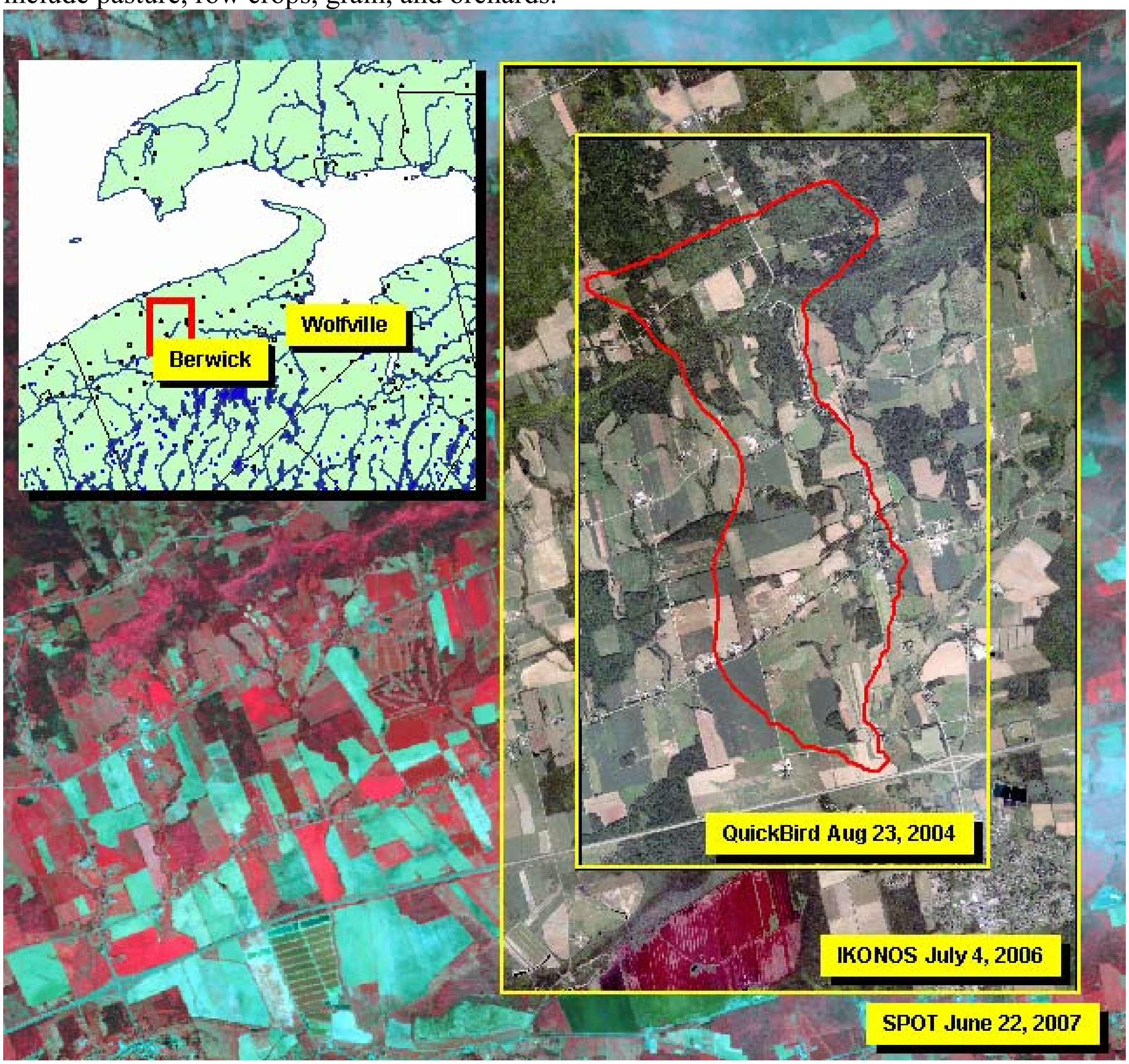


Figure 1: Study Site Location

The Thomas Brook Watershed has been the site of a significant amount of previous work and consequently a number of satellite image and GIS-based data layers were readily available. In the spring of 2008 ADI Limited, under the direction of AGRG, evaluated the use of high resolution satellite image data as a means of updating the provincial ALIP for the NS Federation of Agriculture. A total of eight data sets were used to evaluate the remote mapping of Riparian Health within the Thomas Brook Watershed. A list of these data layers as well as a brief description can be found in **Table 1**.

Table 1: List of Data Layers Used in the Project

Data Set	Type	Date	Resolution
SPOT Multispectral Satellite	Image	June 2, 2007	10 meter Green, Red, Near IR Bands, 20 m SWIR Band
IKONOS Multispectral and Panchromatic	Image	July 4, 2006	4 meter Blue, Green, Red, Near IR Bands, 1 meter Panchromatic Band
QuickBird multispectral and Panchromatic	Image	Aug 23, 2004	2.44 meter Blue, Green, Red, Near IR Bands 0.6 m Panchromatic Band
NSDNR Forest Inventory	Vector	NA	1:20,000 scale
ALIP	Vector	1997	1:20,000 scale
NSGC Topo Base Mapping (roads, watercourses, etc)	Vector	NA	1:10,000 scale
LIDAR Elevation	Grid	NA	2 meter
Riparian Health Classification	Vector	2008	1:2,500 scale

In terms of the satellite image data, quality varies ranging from excellent for the IKONOS and QuickBird **(Figure 2)** images to poor for the SPOT data. The SPOT image data was significantly affected by the presence of cloud shadow and haze. However, despite the presence of these image artifacts, the data provided useful results for comparison with the other two image sources. The SPOT data is potentially one of the most important data sets for this evaluation as it represents a data source that has the lowest cost per area of coverage.

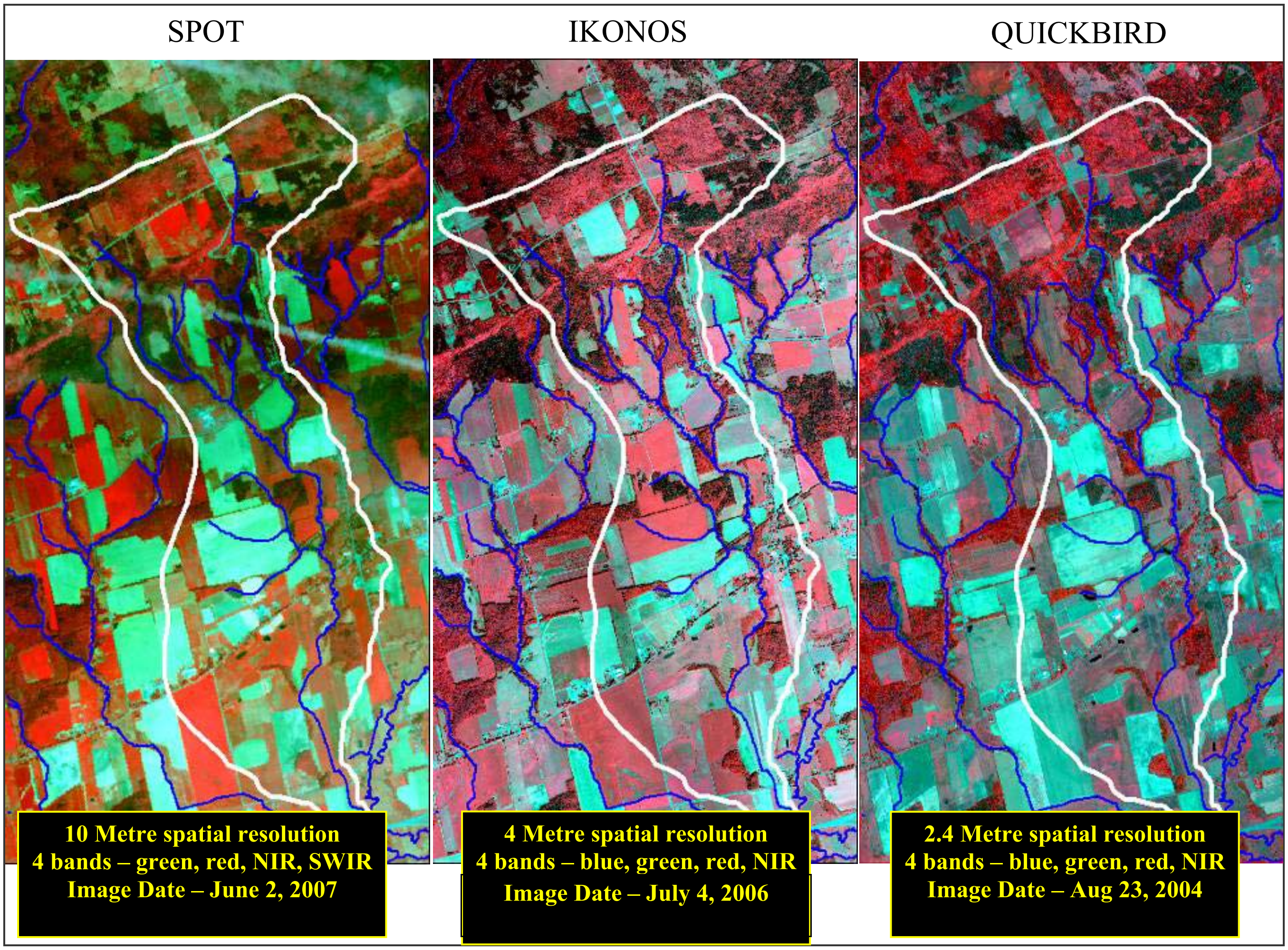


Figure 2. Comparison of QuickBird, IKONOS, and SPOT satellite data for the Thomas Brook area.

Procedure

The provincial RHA approach was evaluated to determine if there was a basis for replication of the system using data extracted from remotely sensed data alone, LIDAR data alone, and both data sets in combination. Unsupervised and supervised classification procedures were used for the automated classification of Riparian Health Areas as defined by the assessment data for the watershed using the QuickBird, IKONOS, SPOT, and LIDAR data. The unsupervised classification procedures were used in an exploratory manner as a means of investigating natural clusters within the data and to assess scene variance relative to class separation. Watercourse buffer zones were generated to limit classification of the satellite and LIDAR data to the riparian zones. An arbitrary buffer distance of 100 meters was used in this project as a means of facilitating demonstration of the utility of the data and is not intended to be representative of a standard buffer size. A digital elevation model with a 2 meter spatial resolution was constructed from the LIDAR elevation grid resulting in the creation of two derivatives; slope and slope aspect in addition to standard elevation. Land use / land cover mapping was generated from the automated classification of the satellite data as a means of defining the nature and extent of activity relative to the riparian areas. Both unsupervised and supervised classifications were employed to produce distinct classes of land use / land cover. The elevation data was evaluated individually and in combination with the satellite data sets. Simple overlay analysis was used to establish areas of potential riparian risk as well as land area associated with this risk. Three dimensional perspective modeling was used to support visual analysis and to facilitate the identification of spatial correlations among the data layers. A PowerPoint presentation outlining project results was presented at the Riparian Workshop held on March 12th and 13th at the Centre for Geographic Sciences.

Results

The current Riparian Health Assessment system as employed by the NS Dept of Agriculture is not explicitly a Riparian Classification / Risk Mapping System but rather a Riparian Health Assessment Guide which is used to provide interested parties with the ability to estimate the relative health of the riparian zone. While remotely sensed data can be used to extract specific characteristics of the Riparian Zone and to classify potential risk there is no direct equivalency between the Riparian Health Areas as defined in the Dept. of Agriculture approach and any approach using remotely sensed data. Consequently an alternative approach is required to fully utilize remotely sensed data for mapping Riparian Health. The mapping of Riparian Health using ground survey techniques can provide highly accurate results but is cost intensive and relatively slow. Remotely sensed data lends itself to systematic mapping and risk assessment designed to provide coverage over large areas or in areas of limited accessibility. The larger the area to be covered lower the cost per unit area.

The fundamental step in the application of a systematic procedure for mapping and classifying riparian zones is the extraction of the boundaries or area of extent. The boundaries of riparian zones are characterized by variability with respect to size and composition. Their definition must be extracted from a number of characteristics such as relief, lithology, hydrology, soil type, land use, and climate. It is this variability that underscores one of the limiting factors of remotely sensed data for the mapping of Riparian Zones and that is the issue of boundary delineation. However, it can be argued that similar difficulty in defining the boundaries of Riparian Zones would be encountered when using ground based survey techniques. The difficulty in establishing riparian boundaries using remotely sensed data in the Thomas Brook Watershed is further compounded by the relatively small size of the watercourses and the watershed itself. Sufficient resolution is not available from satellite platforms to map the paths of the watercourses and consequently the riparian zones. **Figure 3** illustrates the difficulty of mapping watercourses using Quickbird Imagery, the highest resolution satellite data available for this study.

Figure 3. QuickBird pansharpened 1 meter resolution images with provincial watercourses overlain in bottom graphic.

An alternative to defining the riparian zones using remotely sensed data is to utilize available watercourse mapping by applying a buffer along the watercourse. The size of the buffer is a function of watercourse/land characteristics and land use patterns; however, for the purposes of this project a buffer zone of 100 meters was applied to all mapped watercourses **(Figure 4)**. The use of watercourse buffer zones to establish the boundaries of the riparian zone is obviously an arbitrary construct but it does provide a relatively objective means of establishing a discrete boundary around a feature that is not characterized by discrete boundaries.

Figure 4. IKONOS image with watercourses and 100 meter watercourse buffer.

Land use is the critical factor affecting the health of riparian Zones. While unhealthy riparian zones do exist as a result of natural factors the most significant impact by far is from human activity. Land use land cover mapping is required to establish the spatial patterns of activity, the type of activity, and its extent. Land use / land cover maps generated through the classification of the satellite data enables segmentation of the image covering the area of interest into its constituent parts. This facilitates quantification of impact on riparian areas based on land class or land use. For example, the land use / land cover classification in **Figure 5** illustrates that a significant proportion of the land base in the Thomas Brook Watershed is dedicated to agricultural activity. Forestry operations in the area are absent as indicated by the lack of a forest cutover class.

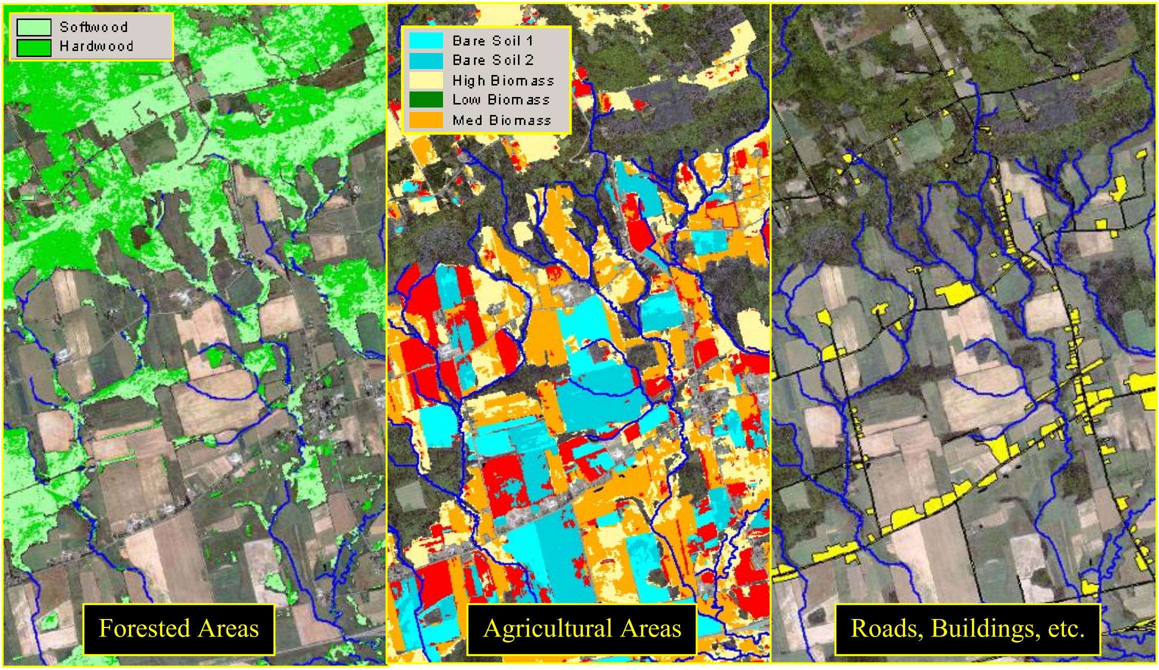


Figure 5. Land use / land cover classification for the Thomas Brook Watershed.

The establishment of riparian zones through the generation of watercourse buffers and the generation of the land use / land cover classification provide an immediate basis for mapping areas of potential risk. Overlaying the watercourses and watercourse buffers (representing the riparian zones) on the agricultural field boundaries as derived from the classification of the Ikonos satellite image data illustrates the agricultural fields that intersect the riparian buffer areas **(Figure 6)**.

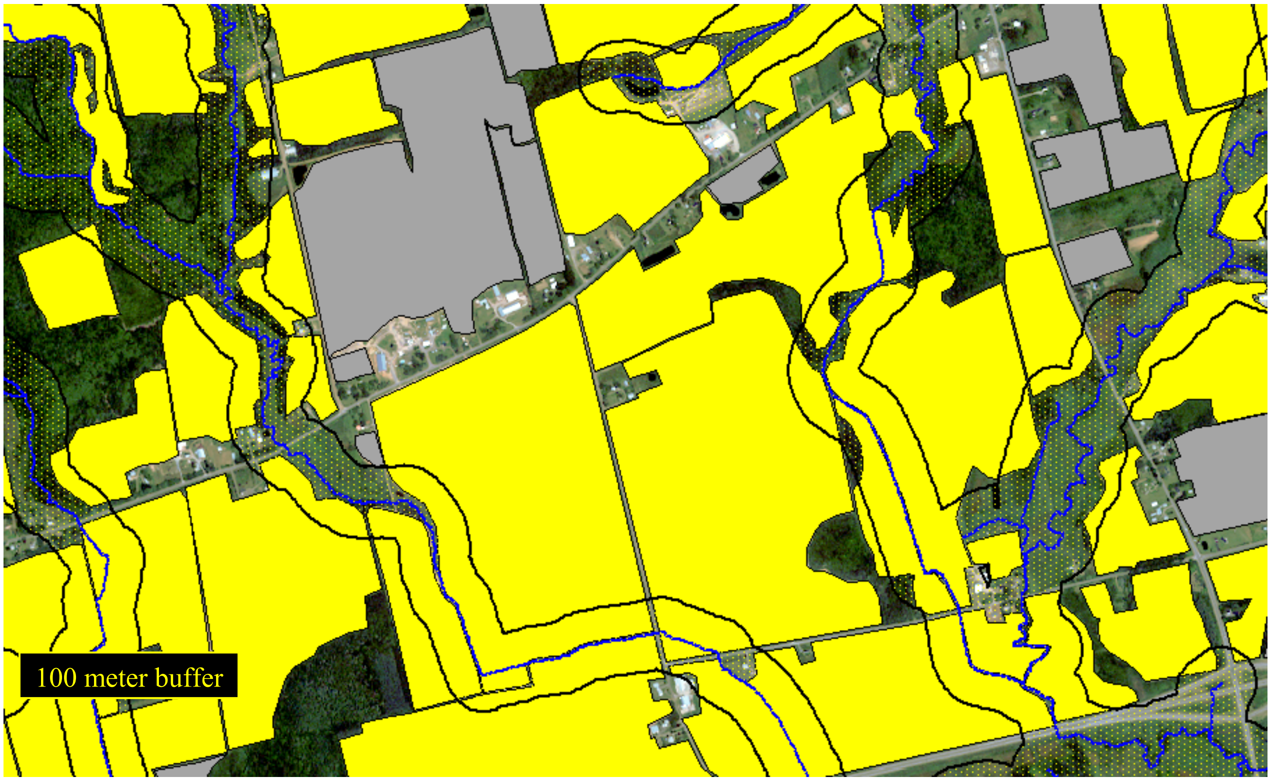


Figure 6. Agricultural fields that intersect the riparian buffer areas.

Using this simple overlay technique the area of agricultural land can be easily calculated. Out of a total of 1276 hectares of agricultural fields 1077 border on a riparian zone. A more accurate estimation of the area of agricultural land intersecting the riparian zones can be seen in **Figure 7**. In this figure only the areas of the agricultural fields that fall within the riparian zone are highlighted. Using this approach the total agricultural area within the riparian zones is calculated to be 813 hectares for a reduction of 264 hectares.

Figure 7. Areas of the agricultural fields that fall within the riparian zone.

A similar overlay approach can be used to map potential risk relating to relief or slope conditions within the riparian zone. An example of this can be seen in **Figure 8**. In this figure all riparian zone areas with a slope of greater than or equal to 12 percent (12 percent slope value selected for illustration purposes) that intersect agricultural fields are highlighted.

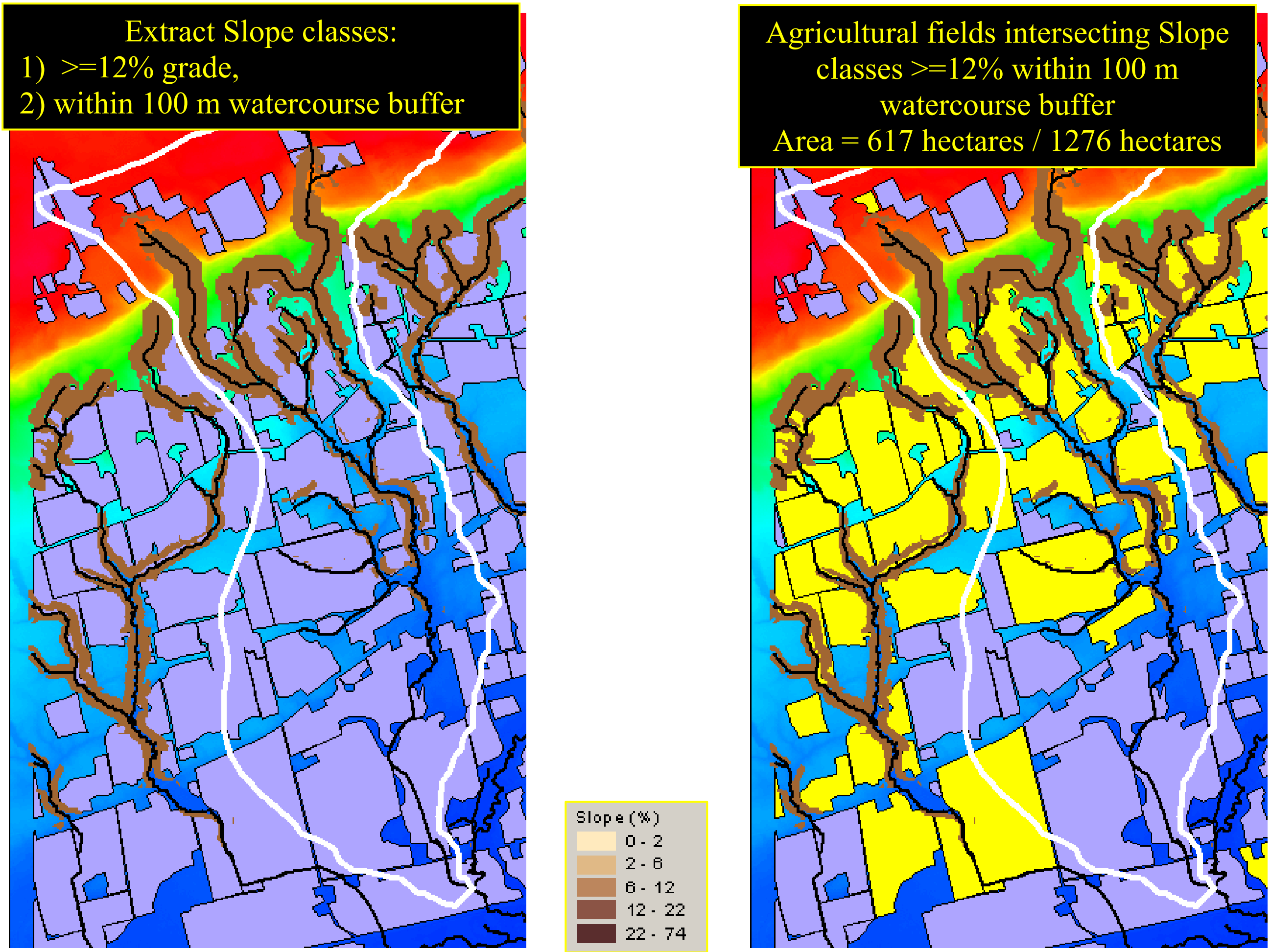


Figure 8. Riparian zone areas with a slope of greater than or equal to 12 percent that intersect agricultural fields.

The area of agricultural fields that intersect this slope range is calculated to be 672 of the total agricultural field area of 1276 hectares. A further refinement illustrating only the areas in agricultural fields within the riparian zones that have a slope of 12 percent or greater can be seen in **Figure 9**. The total area of agricultural fields affected drops to 77 hectares; a significant reduction and a more realistic estimate of potential risk due to slope.

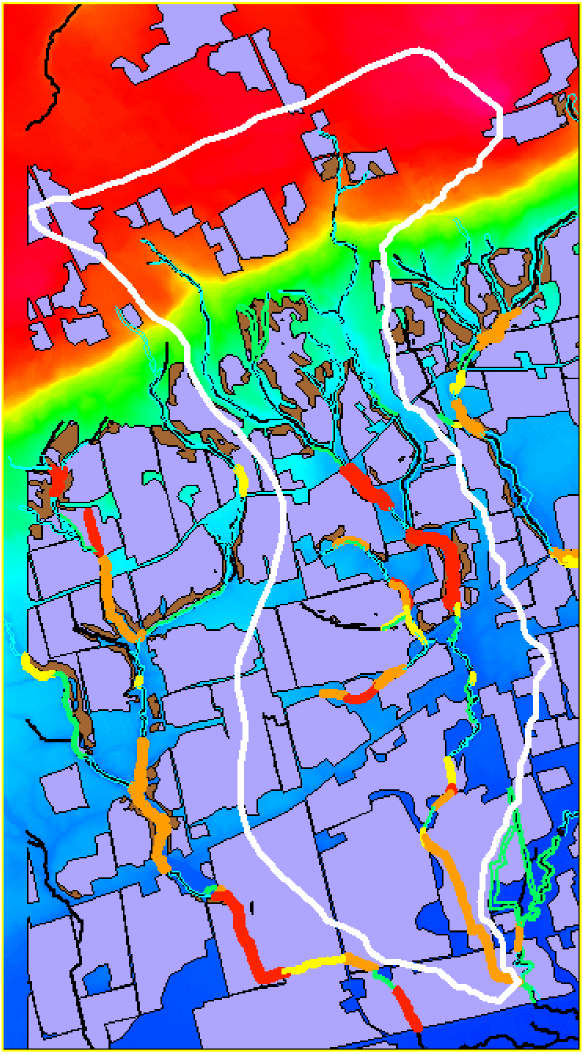


Figure 9. Areas in agricultural fields within the riparian zones that have a slope of 12 percent overlain by provincial RHA classification.

Valuable information for mapping riparian zones and establishing potential risk areas can be extracted from image data and elevation data when processed separately, however, it is the combination of these data layers that results in maximum information content. **Figure 10** illustrates the value of the integration of LIDAR elevation and satellite image data. In this figure contours and the Riparian Health Assessment rankings have been overlain on the satellite image data. Three areas of low risk have been identified. Using elevation data alone, these areas could be interpreted as high slope areas that show a significant riparian risk. Alternatively, the use of image data alone would show these areas to be densely forested and not at risk from any current forest harvesting activity. The combination of both data sources provides support for the low riparian health risk rating. The lack of forest harvesting activity and consequently the abundance of unperturbed vegetation make this a low risk area.

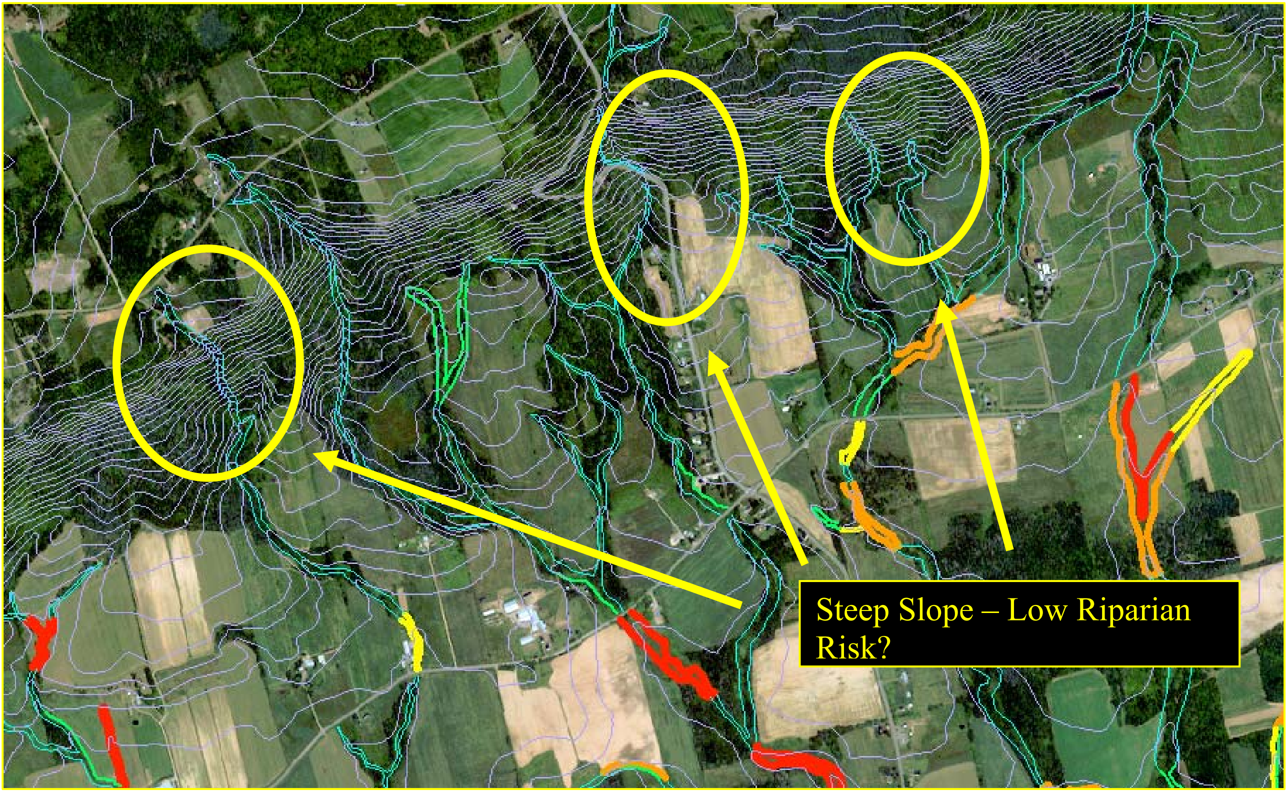


Figure 10. Integration of LIDAR elevation and satellite image data.

One of the key advantages of geomatics technologies lay in the ability to model data in two, three and four dimensions (time series). The use of three dimensional modeling techniques is particularly useful when multiple data layers are present as is the case in riparian mapping. Three dimensional perspective image plots render data in a format that is most compatible with human visual perception. A quick inspection of the three dimensional perspective plot in **Figure 11** provides a rapid appreciation of the topography in the area of interest relative to the riparian health risk ratings and the land use activity.

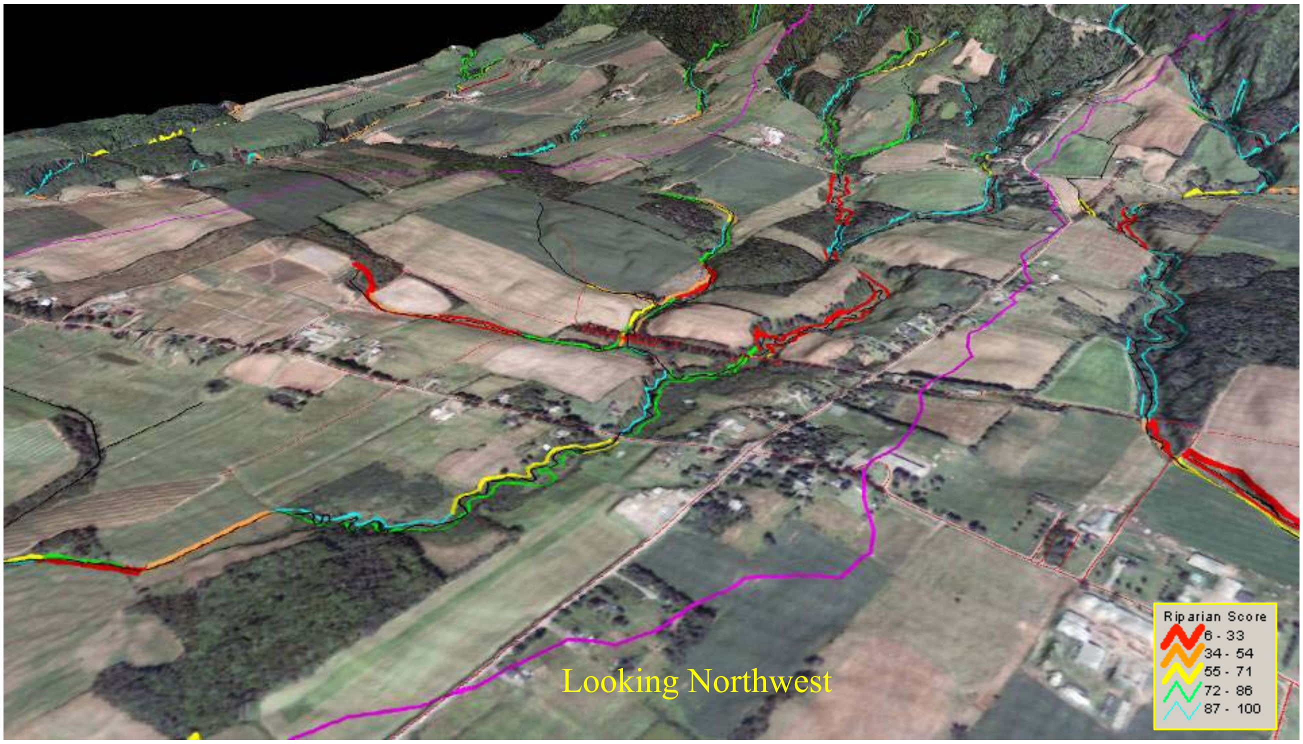


Figure 11. Three dimensional perspective plot showing satellite image and RHA data over elevation.

Summary of satellite data characteristics, data costs, processing technologies, other uses in agriculture

Assessing the value of remotely sensed data for riparian mapping and for many other applications requires a careful consideration of a number of factors. First and foremost is resolution and scale at which the data is to be used. In the Thomas Brook Watershed study site the watercourses are quite small and the available satellite image data lacks the resolution required to plot its course. Riparian vegetation is not essentially unique and therefore cannot be distinguished from non-riparian vegetation, with the exception of possibly bog and fen wetland structures. Therefore there is no direct basis for the delineation of the riparian zone using remotely sensed data. However, mapping the boundaries of the riparian zone can be similarly problematic using ground survey techniques as well. The single greatest value for satellite image data is in the derivation of land use / land cover maps. As a general rule, the value of remotely sensed data for land use / land cover mapping, an essential element of riparian mapping, increases with increasing size of the area of interest and/or with a decrease in accessibility to the area of interest. In larger watersheds containing correspondingly larger watercourses the value of the remotely sensed data escalates significantly.

There are a number of sources of satellite image data that can be acquired for riparian mapping. **Table 2** provides a comparison of the available satellite data systems, spatial resolutions, and cost.

Table 2. Comparison of the available satellite data systems, spatial resolutions, and cost.

Satellite	Product	Bands	Spectral Range	Dynamic Range	Revisit	Res (m)	Swath (km)	Min Order (sq km)	New $sq/km (USD)	Archive $sq/km (USD)	Per scene (new)	Order Fee (USD)	Cloud	Scene size sq km
OrbView	Panchromatic	B&W				0.41	8	64 archive, 192 new	$10.00	$10.00	$640		< 20%	64
	Multispectral	IR, R, G, B	450 - 900nm	8 bit	3 days	1.64	8	64 archive, 192 new	$10.00	$10.00	$640		< 20%	64
	Bundle						8	64 archive, 192 new	$20.00	$20.00	$640			64
Quickbird	Panchromatic	B&W				0.67	16.5	25 archive, 64 new	$22.00	$16.00	$5,984		< 20%	272
	Multispectral	IR, R, G, B	450 - 890nm	11 bit	3 days	2.70	16.5	25 archive, 64 new	$22.00	$16.00	$5,984		< 20%	272
	Bundle						16.5	25 archive, 64 new	$28.00	$17.00	$7,616		< 20%	272
IKONOS	Panchromatic	B&W				1.00	11.3	49 archive, 100 new	$18.00	$7.00	$2,970		< 20%	165
	Multispectral	IR, R, G, B	450 - 900nm	11 bit	3 days	4.00	11.3	49 archive, 100 new	$18.00	$7.00	$2,970		< 20%	165
	Bundle						11.3	49 archive, 100 new	$25.20	$9.80	$4,158		< 20%	165
RapidEye	Multispectral	IR, IR red edge, R, G, B	440 - 880nm	12 bit	1 day	6.50	77	5,000 new	$1.21			$960	< 20%	5,000
								1,000 - 20,000 archive		$1.21			< 20%	
								1500 kiosk			$1.90		< 20%	
SPOT	Panchromatic	B&W				5.00	60	1/8 scene (20 x 20)	$2.15	$1.87	$6,750	$1,000	< 20%	3600
	Multispectral	SWIR, IR, R, G	500 - 1,750nm	12 bit	1-3 days	10 (SWIR 20)	60	1/8 scene (20 x 20)	$1.22	$0.94	$3,375	$1,000	< 20%	3600

The graph in **Figure 12** provides a graphical representation of the relationship between resolution and cost per square kilometer. As can be seen in the graph there is an increase in cost per square kilometer with increasing spatial resolution with the exception of the OrbView system. The potential reason for the lower cost of this data relative to the IKONOS data is the difference radiometric resolution. OrbView data is collected with 8 bit resolution whereas the IKONOS data is acquired at an 11 bit depth.

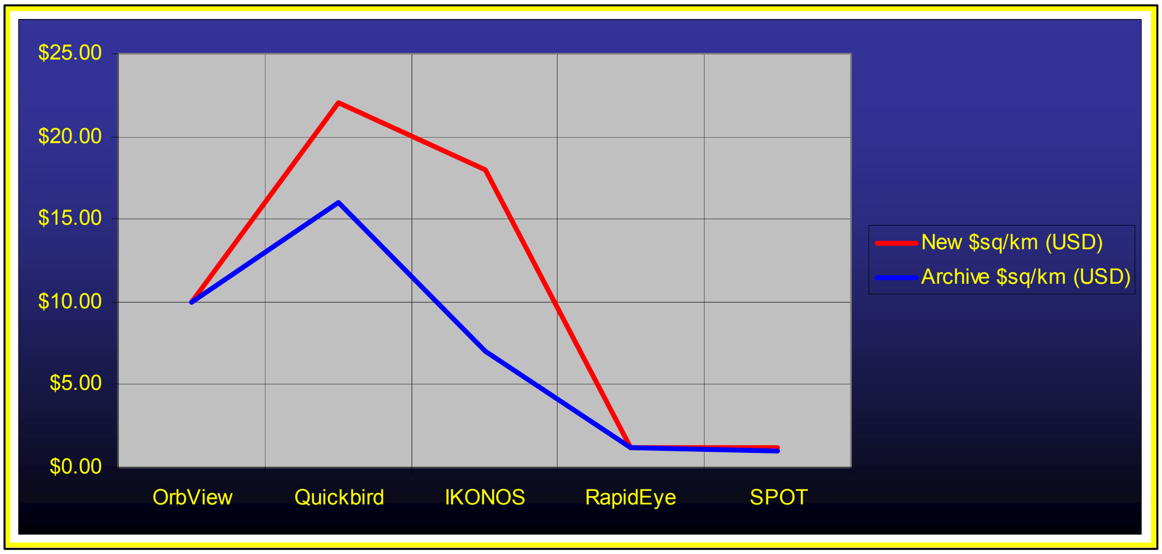


Figure 12. Graphical representation of the relationship between resolution and cost per square kilometer.

As a general rule, the value of the satellite image data increases with addition of other data layers such as elevation, forest inventory, and topography. The additional contextual information provided by the integration of elevation data with the satellite image data is significant.

The value of remotely sensed data (both elevation and Satellite image data) should not be evaluated on a single use basis. The development of a field registry system from the satellite data will directly support other agricultural applications including:

- Food safety
- Crop insurance
- Farmland Identification Program
- Environmental Farm Plan
- Agricultural Statistics

The use of remotely sensed data for riparian mapping applications presupposes the use of significant resources in terms of data processing technology and personnel. More specifically the following is a list of specific resources required for riparian mapping using remotely sensed data:

- Digital Image Processing and Analysis Software (PCI Geomatica, ENVI, ERDAS, ERMAPPER, etc.)

- Geographic Information System (ArcGIS, MapInfo)
- Surface Interpolation and Gridding (Vertical Mapper, ArcGIS Spatial Analyst, etc.)
- Technical Knowledge
- Subject Knowledge

It should be noted that while these items are required for processing, analysis, and general preparation of the remotely sensed data, the actual use of the data once preparation is completed is relatively easy. The data can be accessed by individuals using a minimum of technical resources (i.e. simple desktop or web mapping software) or in hardcopy format.