Riparian Zone Workshop

A Review and Discussion of Ontario's Riparian Zone Issues.

PROCEEDINGS

OSCIA. 1997. Managing Agricultural Drains To Accommodate Wildlife.
(Illustration: Irene Shelton)

Venue:

Grand River Conservation Authority
Administration Office

Cambridge, Ontario

October 28 - 29, 1998

ACKNOWLEDGMENTS

These proceedings were compiled and produced for distribution to the participants of the Riparian Zone Workshop held on October 28 - 29, 1998. Many thanks to the over 120 participants in this workshop. Summaries of the breakaway sessions, as well as summaries of the speakers' papers are included. These thoughts, observations and recommendations will help to mold the next steps in our goal of Riparian Zone Management.

I wish to thank the members of the Riparian Zone Workshop Committee for their professionalism, enthusiasm and commitment to the concept of riparian management. Their contribution guaranteed the success of this workshop. On behalf of the Committee, I would like to extend our gratitude and appreciation to all the speakers over the duration of the workshop. Their presentations were vital to the success of the workshop and were key to stimulating lively discussions in the breakaway sessions.

I would also like to thank the financial supporters and the many contributors - without their assistance this workshop would not have been possible. Our list of contributors:

American Fisheries Society - Ontario Chapter
Ducks Unlimited Canada
Ministry of Natural Resources
Ministry of the Environment
Ontario Soil and Crop Improvement Association
Regional Municipality of Waterloo
Soil and Water Conservation Society - Ontario Chapter
University of Guelph
Wellington Stewardship Council

Grand River Conservation Authority
Special mention to the GRCA for their provision of staff, office logistics and workshop facility.

Special thanks goes out to Jennifer Hawkins of the Grand River Conservation Authority for her work in organizing the logistics for the workshop and the preparation of these proceedings. Thanks also to Mark Wilson who prepared the Literature Review.

Jack Imhof
Workshop Chairperson
Aquatic Ecologist
Ministry of Natural Resources
December 3, 1998

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APPENDICES

1.1 Introduction

The goal of the Riparian Zone Workshop was to bring together those working with all aspects of riparian zones in order to discuss the state of the practice and the state of the science in riparian zone management. It was also designed to provide a networking opportunity for all those that attended. From the Committee and Speaker List (Appendix A) and the Participant List (Appendix B), it is evident that we reached a wide variety of scientists, resource managers and practitioners of various disciplines.

Riparian zones are defined as the three dimensional zone of interaction between terrestrial and aquatic ecosystems. Their control over the functioning of landscape processes is much greater than their predicted land areas effect. They represent the final region through which substances pass when moving from the terrestrial to the aquatic ecosystem. This gives riparian zones the conclusive opportunity to modify, incorporate, dilute or concentrate stream-bound materials. Because of these attributes, riparian zones have been found to assist in the regulation of landscape geomorphic and hydrologic processes, the control of surface water quality, and the protection and provision of both aquatic and terrestrial habitat.

A strong interest is developing for the management and restoration of functional riparian zones as both productive and valued components of stream corridors and as buffers to ecologically damaging upland landuses. Extensive implementation programs are likely to occur over the next few years and gaps in our understanding of riparian zones, their function, composition and structure need to be addressed by focused research questions in order to provide sound tools for their design and management.

These proceedings provide an overview of the 2 day workshop and are designed as a working document from which we will move forward. (See Appendix C - Agenda). It is therefore an interim product that will be formalized in the future with further input and collaboration.

Section 1.0 includes the introduction and the workshop context. Section 2.0 and 3.0 contain speakers notes, often in point form and comments. Care has been taken to ensure that these represent the presentation and viewpoints given by the speaker. A compilation of the discussion groups entitled ‘Knowledge Gaps’ and ‘How Can We Balance and Better Implement Land Management in Riparian Zones?’; are presented in sections 4.0 and 5.0. Major themes and concepts from the discussion groups have been compiled into section 6.0. Conclusions and future recommendations are found in section 7.0. The appendices include: contact lists for the committee, speakers and participants, workshop agenda, bus tour information and comments from the evaluation forms.

A Literature Review: Overview of the State of the Science. An Examination of the Functions of Riparian Zones has been prepared as a stand-alone document and will be posted on the Watershed Science Centre website at Trent University (www.trentu.ca\academic\wsc).

1.2 Workshop Context

The Riparian Zone Workshop was organized with the vision of bringing together researchers, managers and practitioners in order to:

- Discuss the state of the science and the state of the practice in riparian zone management;
- Discuss the functional role of riparian zones within watersheds;
- Determine new opportunities, constraints and barriers to the management of riparian lands;
- Determine what management issues are not being addressed and then identify additional research needs required to foster stewardship of riparian lands;
- Provide a means to develop co-operative networks and partnerships between researchers, managers and practitioners;
- Determine how we can better improve our management and understanding of riparian zones.

2.0 STATE OF THE SCIENCE
WORKSHOP PRESENTATIONS

2.1 Existing Tools and Responsibilities: Policy, Regulation, Planning, Programs, Voluntary
Ala Boyd, MNR

Riparian Zone Management
- Legislative Basis:
    - Common Law Aspects
    - Statutory Context
- Stewardship and Voluntary Activities

Common Law Aspects and Riparian Zones
Definition of Riparian: “of or on river bank”[f. L. *riparius (ripa* bank)] Source: Oxford
Two “Riparian” Aspects
1) Riparian interests of those features and life occurring “of or on a river bank” and therefore the watercourse
   – Watercourse aspects “*Aqua currit et debet currere*” *or water flows naturally and should be permitted thus to flow*
2) Riparian Property Rights of land owners who abut river bank

Definition of a Watercourse
The Courts have said, that to constitute a natural watercourse, the channel bank formed by the flowing of water must present to the eye on casual examination the unmistakable evidence of the frequent action of running water. On another occasion that a watercourse is constituted in there is sufficient natural and accustomed flow of water to form and maintain a distinct and defined channel. It is not essential that the supply should be continuous or form a perennial living source. It is enough if the water rises periodically and reaches a fairly defined channel of permanent character. A natural watercourse does not cease to be such if at a certain point it spreads out over a level area and flows for a distance without defined banks before flowing again in a defined channel. Often it is the valley through which the stream runs, and not its low level or low water channel, which is the watercourse.
Source: MTO Drainage Management Manual 1997

Riparian Property Rights
- Allow right of access to water that abuts his land, the right to fish, the right to receive water flowing past undiminished in quantity and quality and the opportunity to take action against those who interfere with these rights.
- Implied obligation incumbent upon the riparian owner to respect the rights of upstream/downstream riparian zones.
- Statutes introduced to strengthen established common law principles.

Stewardship, Voluntary and Other Resources

- Conservation Authorities and Local Municipalities (by-laws)
- Stewardship Councils
- Ontario Land Care
- Ontario Streams
- Friends of the River
- Advocacy Groups (AFS, SWCS, FON, OFAH)
- Wetland Habitat Fund Program
- Community Fisheries Involvement Program
- Community Wildlife Involvement Program
- Great Lakes 2000 Clean Up Fund
- Ontario Environmental Farm Plan Program
- Eastern Joint Venture Habitat Program
- Ducks Unlimited … and many others…..

Potential Management Issues

- Delineation of an arbitrary distance from top of bank
- Present tools (criteria and setbacks) deal with other issues (e.g. floodplains)
- Policy basis for management not explicit for riparian zones
- Can be used for riparian zone management with additional guidance

Effectiveness of Approaches

- Is the present web of legislation, stewardship activities and resources sufficient and effective for riparian zone protection and management?
- If not, what can we do?

Tables and Figures include:
Table 1 - Legislative Influences and Riparian Zones
Figure 1 - Potential Tools and Approaches for Riparian Zone Management
Figure 2 - Legislation Affecting Stream Corridors

Table 1 - Legislative Influences and Riparian Zones

Legislation	Potential Riparian Management Application	Advantage - Disadvantage
Conservation Authorities Act, Fill, Construction and Alteration to Waterways Regulation	• Management of natural resources on a watershed basis • Provides for regulation of activities adjacent to watercourses	• Allows for protection of watercourses and establishment of a corridor • Implementation occurs on regulated watercourses • Provides a mechanism for riparian zone protection
Planning Act, PPS: 1.1.1.e) Developing Strong Communities	• "Coordinated Approach" for ecosystem, watershed, shoreline and riverine hazards	• Riparian zone not explicitly stated as a desired objective • May be used to provide for riparian zone management within watershed, providing mechanism for continuous corridor protection
Planning Act, PPS: 2.3 Natural Heritage Policies	• Development not permitted in Significant wetlands, significant portion of habitat of endangered and threatened species • fish habitat, Canadian Shield Wetlands, significant valley lands - no negative impacts on the natural features	• riverine and coastal wetlands may be considered as riparian areas • not explicitly defined • fish habitat - technical manual identifies adjacent lands - vegetated buffer • significant valley lands: well defined use stable top of bank, less well defined use presence of riparian vegetation, flooding hazard limit, meander belt width or highest general level of seasonal inundation
Planning Act, PPS 2.3.3	• "Diversity of natural features in an area, and the natural connections between them should be maintained, and improved where possible"	• consideration of links, provides basis for landscape ecology connectivity between natural heritage systems • Provides opportunities for restoration of natural features and connections
Planning Act, PPS: 3.1 Natural Hazards Policies	• development directed away from Great Lakes - St. Lawrence, rivers and streams impacted by flooding erosion and dynamic beaches	• Provides criteria for development setbacks • Public health and safety intent
Lakes and Rivers Improvement Act	• Regulates activities within active channel, does not regulate activities outside channel (e.g. placement of fill in floodplain)	• protects riparian rights

Others ….

Figure 1 - Potential Tools and Approaches for Riparian Zone Management

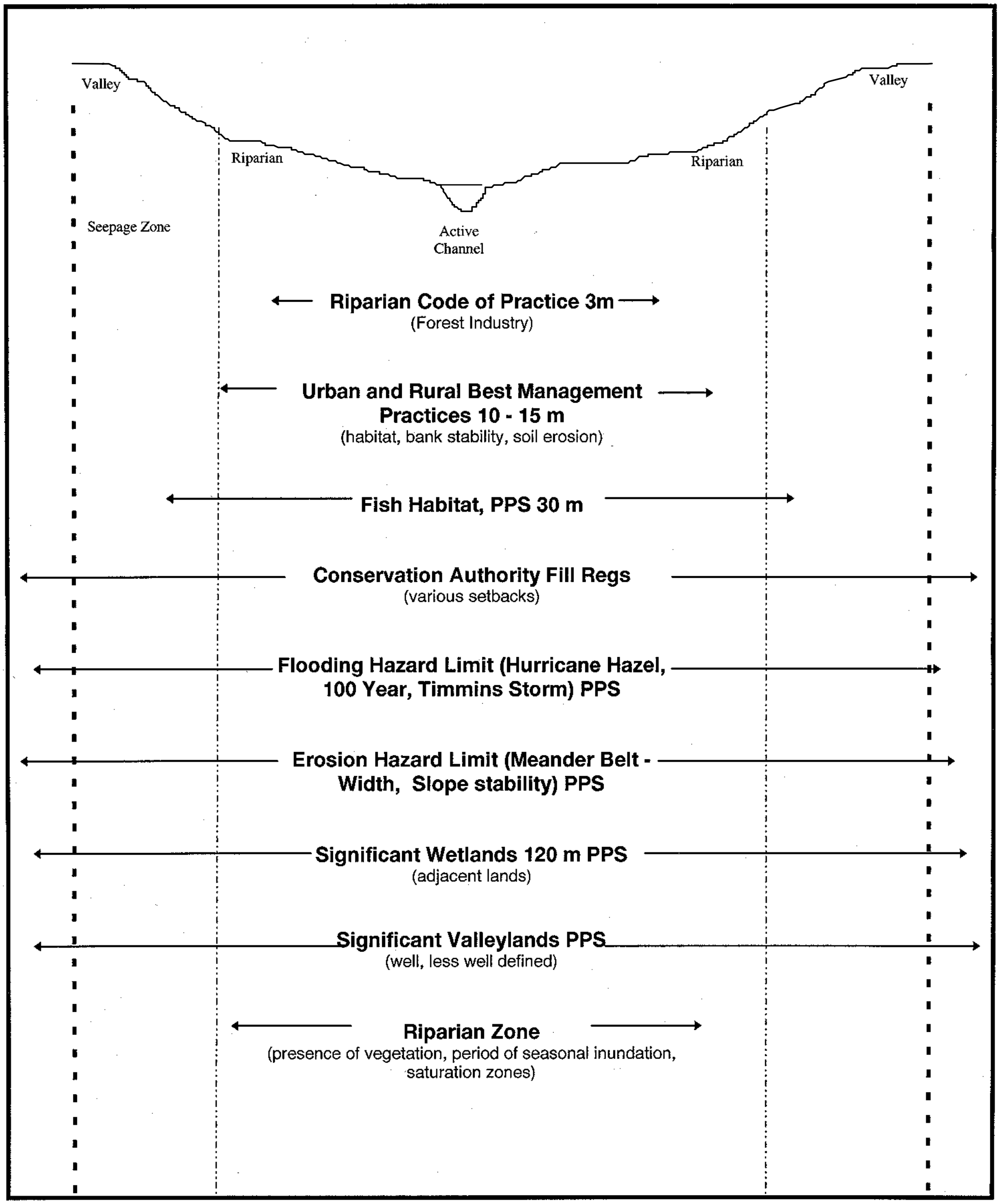
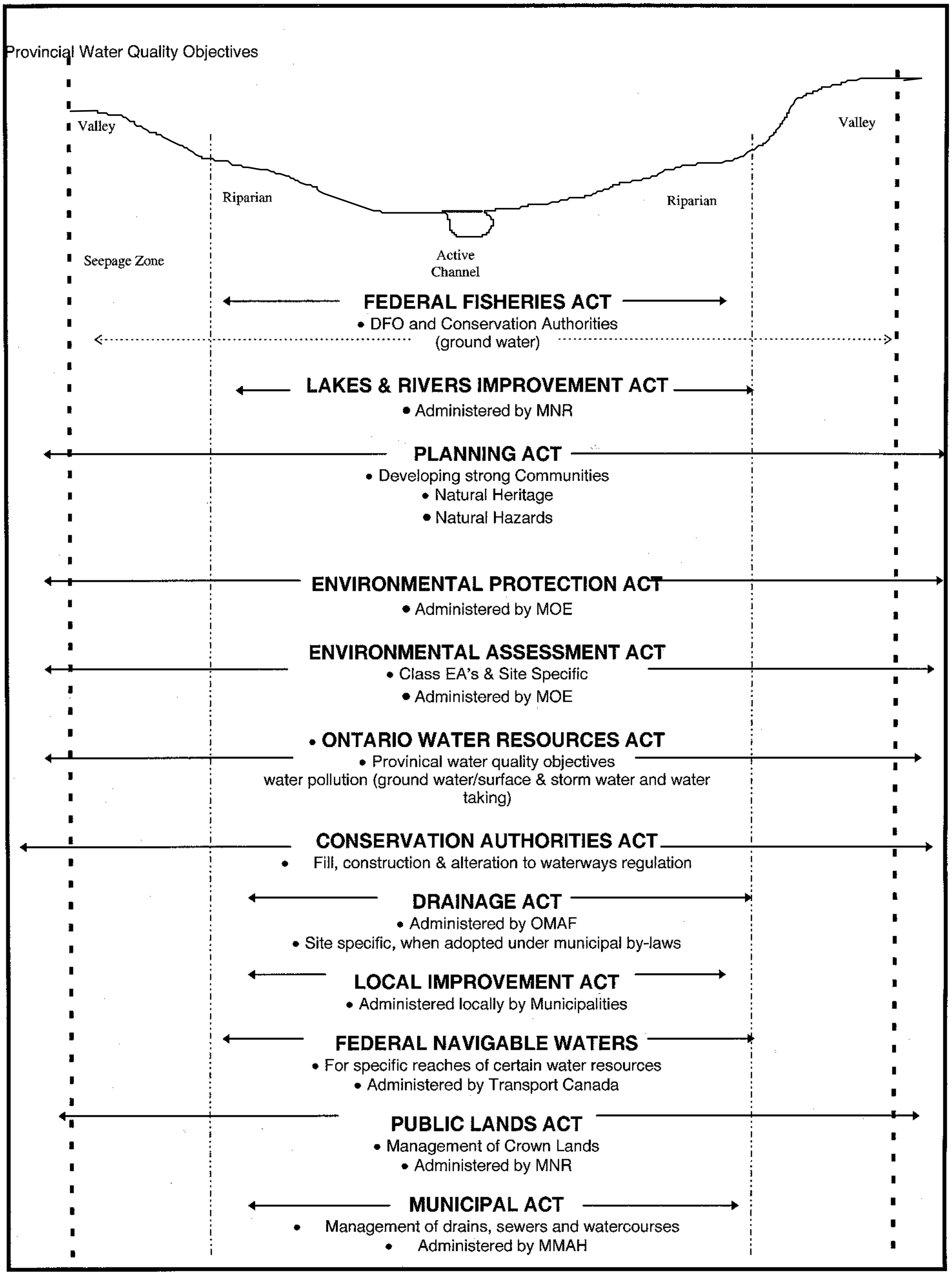


Figure 2 - Legislation Affecting Stream Corridors



2.2 State of Science - Literature Review

Dr. Bill Snodgrass, MTO

Master Concepts to Understand the Science and its Design Applications

1. Master Unit

The riparian system is a geomorphic unit which includes the stream and secondary channels, the stream's floodplain and those portions of the surrounding lands that are periodically inundated with water or have hydrophytic vegetation. In essence, it may be defined as the relatively hydrologically (surface and groundwater) active portion of the stream corridor in contact with the active stream channel.

2. Defining Sketches

The unit is defined longitudinally by its' planform within the valley. This includes an understanding of width, length and contiguousness of vegetation as well as the location and characteristics of lateral flow from the surrounding landscape.

It is also defined by its hydraulic cross-section which identifies the relationship between the riparian zone, its width, elevational characteristics, vegetative forms in relation to the stream and its various flow elevations.

3. Hydrologic Pathways through the "unit"

Water movement through riparian systems can be complex and depends upon the structure of the zone, its elevations and the flow event. During very high flows such as periodic floods, water movement into the zone will come from upstream overflooding of the banks. During more frequent rainfall events, water movement may be lateral from the surrounding landscape either as surface water, deeper groundwater, vadose (interflow) water or a combination of all of these. In addition, water flow may come into the zone in dispersed flow, as sheet flow, as concentrated flow in channels, or as a combination of all of these.

4. Desired Vegetation Functions

The structure and composition of vegetation within the riparian zone plays an important role in all aspects of the zones' functions (i.e. physical, chemical, biological, ecological). The functioning of the riparian zone as well as its composition and structure is also partly controlled and modified by the dominant adjacent landscape, its vegetated system (i.e. Ecological Land Classification) and the adjacent human landuse gradients.
In Ontario, the dominant landuse activities that can alter and modify vegetative characteristics of riparian zones include: forestry, agriculture (i.e. row crop monoculture, tiles, drainage, pasturage), urban development and urban landuse management; and others (golf course, aggregate extraction, base-metal mining).

5. Thinking Process i.e. State of Evolution

There are many ways in which to view riparian zones and their functioning. Two thought processes that are current today are found in the USA and in Ontario. The U.S.

Stream Corridor Handbook is a manual which assists with the assessment analysis, planning and design of riparian zones along watercourses where they have been degraded.

In Ontario, the soon to be released 'Adaptive Management of Stream Corridors' manual complements the work done by the US publication and provides detailed steps for the assessment, analysis, and design of functional stream corridors and channels. The Ontario document presents an integrative design process of 11 steps for geomorpholgists, engineers, biologists/ecologists and planners. Both of these documents consider the riparian zone as a geomorphic/ecological system.

6. Design / Implement System with Adaptive Management

Long term monitoring required.
Adaptive Management may be an appropriate approach.
Reference sections - from case studies would be an important component.

STATE OF THE ART / SCIENCE/ PRACTICE

Frameworks - from Ontario
- Watersheds (WPI)
- Urban - Stream Channel Erosion (MOE)
  - most cogent from Riparian Zones

- Overview Charts - Watershed Planning Initiative
- Stream Channel Erosion - Overview, Definitions, and Conclusions
- Appendix for S.C.E. - Back-up for Conclusions
- Tools for Predicting Channel migration
- Role of riparian canopy in a solution to controlling channel erosion

STATE OF THE ENVIRONMENTAL ENGINEERING SCIENCE

(statements are relative to each other; not absolute)

1. Surface Water Hydrology and Water Quality

- Reasonably well defined - several synthesis reports.
- Limits - understanding of drainage patterns which generate concentrated flow - for such flows; little water quality enhancement (removal of pollutants) occurs.
- Piped flow systems (urban areas 90-99% of stormwater flow is piped) - little mitigation through overland flow treatment because overland flow is only a small component.

2. Groundwater Hydrology and Water Quality

- Significant amount of new work occurring
- Significant new insights into role of perched and transients of flow through the vadose zone.
- Denitrification is significant where groundwater flow occurs laterally through the root - zone (root zone provides organic matter which is a carbon source for denitrifying bacteria) - hence root zone is a redox barrier to nitrate transport.

3. Geomorphology

There are many questions in this area concerning the relationship between riparian vegetation and geomorphology. For example: what practical width is needed? How can geomorphic concepts such as entrenchment be used? Is entrenchment appropriate for certain cross sections and not others?

The literature data on the subject is limited. The data available are more qualitative than quantitative. A few pertinent observations include:

- Classification Systems for Streams differentiate 2 or 3 types of streams based on the presence or absence of vegetation i.e., with essentially the same channel gradient and bottom material, the channel with different geometrical characteristics.
- One investigation found no effect of vegetation in 5 gravel and sand transporting rivers in Western Canada.
- An Iowa investigation found that vegetation had a significant effect in 2 sandbed rivers.
- Another investigation found that root-reinforced banks were 4 orders of magnitude more resistant than non-reinforced banks to channel migration.
- Soil strength to resist shear forces is dependent on the plant species.
- The importance of riparian vegetation will potentially be explained using the hypothesis that in streams and small rivers (i.e. 1st order to 4th order):
    - Flow is the dominant factor and sediment transport is a modifier in controlling channel erosion.
    - Effect of vegetation being a modifier.
    - Contradictions about the effectiveness of vegetation can be resolved by the difference in bank height.
- In relatively flat gradient streams and especially based upon observations from large basins, vegetation alters the geomorphically stable attributes of a channel's geometry and planform in rivers which experience the stresses of large floodflows.
- In rivers at the outlets of larger basins, sediment supply is a dominant factor in channel form with flow and vegetation being the modifier. Such basin scales have not been of significant concern to channel erosion management in Storm Water Management Model (SWMM) to date.

4. Water Quality Functions of Buffers

Typical graphs of effectiveness of width on improvement in water quality - plateau after 15 to 30 metres for productivity, shade potential, sediment removal, etc.

- Length effects?

5. Aquatic Ecological Functions

Data base on aquatic functions is evolving:

- Barton et al. 1985. Need 3 to 5 km of riparian canopy to return warm water habitat to cool/cold water habitat.
- 1995/1996 Habitat data sets - degraded habitats show degree of improvement if riparian zone is located upstream of measurement site. Have much more data from the past 2 summers to be included in the analysis.
- Convenient to differentiate between canopy (provides allocthonous carbon and protects against heating) and wood debris controlled streams.
- Research findings should differentiate type of riparian vegetation, i.e. intact, partially intact, open as well as grasses, old field, shrub, mature forest - little understory, lots of understory.

- Wood debris controlled streams - establish a significantly more complex stream form than non-wood debris controlled streams.

6. Wildlife Ecological Functions
- Contingent on adjoining lands.
- Floodplain (i.e. well-defined valley vs. table lands with an intermittent ditch going through the lands).
- Potential information source - Landscape Scale literature describing patch size; primary and secondary corridors.

7. Human Ecological Interactions
- Design for core wildlife functions plus buffer thickness.
- Width of canopy necessary to buffer human activity from wildlife i.e. roadways, salt spray (1% of roadside concentration at 5m), traffic noise (exponential die off).
- Physical effect of having a corridor of trees cut through a woodland or swamp (Hounsell et al research, Ontario Hydro).
- Interior bird habitat - need 100 m to 200 m buffer width.

8 . Other Factors
Soils/Surficial Geological Structure
- Role in controlling/influencing type of canopy.
- What information about these factors can be gathered from surficial hydrogeology?

Fundamental needs to assist Science Synthesis, Management, Design
- Long -term monitoring.
- Adaptive Management.
- Reference Sections- for case studies.

NATURAL CHANNEL INITIATIVE STEPS (NCI)

NCI Step 1. Where is the Channel in its process of evolution?
NCI Step 2. What is the disturbance?
NCI Step 3. What Future disturbances are likely to occur?
NCI Step 4. What are the channel dynamics?
NCI Step 5. Stream response to Disturbance?
NCI Step 6 Determine Ultimate Configuration of Channel.
NCI Step 7 Is Intervention Feasible?
NCI Step 8 Define Intervention Options.
NCI Step 9 Complete the design.

PANEL DISCUSSION ONTARIO RESEARCH FINDINGS

2.3 Groundwater

Dr. Dave Rudolph, University of Waterloo

Role of the Riparian Zone in Controlling the Distribution and Fate of Agricultural Nitrogen Near a Small Stream in Southern Ontario

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September 27, 1998
Revised version

Abstract

Uncultivated riparian areas can play an important role in reducing nutrient loading to streams in agricultural watersheds. Groundwater flow and geochemistry were monitored in the riparian zone of a small agricultural watershed in southern Ontario. Hydraulic and geochemical measurements were taken along a transect of monitoring wells extending across the riparian area into an agricultural field. Chloride and nitrate concentrations in groundwater samples collected from the agricultural field were much higher than in samples from the riparian area. A sharp decline in both nitrate and chloride concentrations was observed near the field-riparian zone boundary. It appears that increased recharge within the riparian zone, as compared to the artificially drained field, caused nitrate-rich groundwater from the field to be diverted downward beneath the riparian zone, thus limiting the input of agrochemicals to the riparian area and consequently protecting the stream from potential contamination.

Geochemical data also indicated that nitrate was attenuated in the downward moving groundwater. Patterns of dissolved oxygen concentrations and redox potential in the subsurface coincided with the pattern defined by groundwater nitrate. These patterns indicated that conditions within the riparian zone and at depth near the field-riparian zone boundary were conducive to denitrification. A linear relation between the $\delta^{15}N$ and $\delta^{18}O$ values of nitrate from the monitored transect also supported denitrification as the primary nitrate removal mechanism. This study provides a new conceptual model of how riparian zones may prevent nitrate contamination of streams, and highlights the need for a complete understanding of both groundwater flow and geochemistry in riparian environments.

Keywords: groundwater, agriculture, riparian zone, denitrification, isotopes

Introduction

Nitrate contamination of water resources is widespread in areas of intensive agricultural activity. The nitrate contamination results from the excessive use of inorganic and organic fertilizers and/or by tillage that releases nitrogen stored in the soils. In agricultural watersheds in southern Ontario, there is ample documentation of nitrate contamination of groundwater (Gillham, 1991; Ontario Farm Groundwater Quality Survey, 1993; Robertson et al., 1996) and surface water (Hill, 1978; Neilsen et al., 1982; Hill, 1988). Much of the nitrate contamination in surface water arises from direct groundwater discharge and groundwater input by tile-drainage networks. Therefore, the abundance and fate of nitrate in groundwater can have a major influence on surface-water quality.

Most streams in southern Ontario are separated from agricultural fields by uncultivated strips of land, commonly called riparian zones or buffer strips. These riparian zones consist of narrow bands of natural vegetation (trees, shrubs, and grasses) that remain uncultivated because the land is too wet, too steep, or too difficult to clear for agricultural activity. Numerous studies have shown that riparian zones can play an important role in reducing nitrate concentrations in groundwater discharging to streams (Peterjohn and Correll, 1984; Jacobs and Gilliam, 1985; Cooper, 1990; Haycock and Pinay, 1993; Jordan et al., 1993; Gilliam 1994)

Even with the abundant evidence supporting nitrate removal in riparian areas, the role the riparian zone plays in removing groundwater nitrate remains unclear. The primary processes of subsurface nitrate removal within these riparian zones are generally considered to be denitrification (Jacobs and Gilliam, 1985; Cooper, 1990; Lowrance et al., 1995), vegetative uptake (Lowrance, 1992), or dilution (Altman and Parizek, 1995; Komor and Magner, 1996). However, in many studies the exact mechanism of nitrate removal and the role hydrology plays in nitrate attenuation have not been well established. Hydrological controls on groundwater flow patterns can have a major influence on the distribution and fate of nitrate. Still, few studies have carefully examined the link between groundwater flow paths and nitrate concentrations (Hill, 1996). To discern the actual role of riparian zones in removing nitrate from groundwater, a better understanding of the relation between groundwater flow and chemistry is required.

A variety of techniques can be used to identify the processes controlling nitrate removal. Hydrogeochemical data can be used to delineate redox conditions in the subsurface and infer the occurrence and location of denitrification zones (Postma et al., 1991; Starr and Gillham, 1993). The concentrations of conservative tracers, such as chloride or bromide, relative to nitrate, can establish the importance of dilution in decreasing nitrate concentrations. Measurement of in-situ denitrification rates using the acetylene blocking technique can provide direct evidence of denitrification (Smith et al., 1991; Starr and Gillham, 1993). Fractionation of nitrogen and oxygen isotopes, which form parts of the NO_3^- molecule, can provide additional evidence of denitrification and dilution (Mariotti et al., 1988; Böttcher et al., 1990). It may also be possible in the future to use ^{15}N isotopes to quantify uptake of groundwater nitrate by plants (Komor and Magner, 1996).

This study had two major goals. The first was to examine the relationship between groundwater flow and nitrate transport from an agricultural field into a riparian zone. The second was to assess the fate of nitrate and determine the mechanisms of nitrate attenuation within the riparian zone. Our approach includes the use of geochemical and isotopic techniques in combination with detailed groundwater flow measurements near a small headwater stream in southern Ontario.

Implications of Results

Many studies of nitrate retention in the riparian zone have concluded that nitrate is removed in shallow, organic-rich sediments of the riparian zone as a result of denitrification or plant uptake. This conclusion follows the conceptual model that shallow, nitrate-rich, groundwater flows laterally into the riparian zone and nitrate is removed chemically or biologically (Hill, 1996). Many of these studies have ignored the three-dimensional nature of groundwater flow, particularly the vertical component of flow. In some cases, these studies have been conducted in shallow aquifers that are underlain by impermeable materials, thereby prohibiting significant vertical groundwater flow. Other studies simply have not dealt with groundwater flow in three dimensions.

The conceptual model of the riparian zone in this study is much different. The apparent removal of nitrate in groundwater beneath the uncultivated strip is controlled by groundwater flow patterns. A hydrologic contrast between the recharge rates on the field where tile drains intercept a portion of the infiltrating water and in the naturally drained riparian zone resulted in a large component of vertically downward flow near the field-riparian zone boundary. As a result the high-nitrate, high-chloride groundwater from the field was forced to flow beneath the sediments of the riparian zone. Groundwater within the riparian-zone sediments is relatively poor in nitrate and chloride, and presumably represents a plume of water recharged through the uncultivated strip that has not been contaminated by agrochemicals.

In addition, it appears that nitrate is attenuated as groundwater flow from the field and is directed downward near the field-riparian zone boundary. Nitrate concentrations declined considerably (to below detection limits) with depth in this region, while chloride concentrations remained relatively constant. The coincident decline in D.O. concentrations and Eh in this subsurface region suggest that denitrification is responsible for nitrate removal with depth. Elevated $\delta^{15}N$ values in some deeper, nitrate-poor, groundwater samples and the strong correlation between $\delta^{15}N$ and $\delta^{18}O$ values also point to denitrification as the primary nitrate-attenuation mechanism.

This study clearly shows that under the conditions present at this site, the riparian zone can function as a hydraulic “barrier” to the flow of nitrate-contaminated groundwater to a stream, in addition to the chemical or biological controls found in other riparian-zone studies. The riparian zone appears to perform a vital role in preventing nitrate contamination in the adjacent stream. Further detailed work is needed to determine how riparian zones function at other locations within this and other watersheds.

Conclusions

The riparian zone in this study had a major influence on the distribution and fate of groundwater nitrate. Previous studies of nitrate attenuation in riparian zones have indicated that nitrate removal occurred primarily in the shallow, organic-rich sediments of the riparian zone through denitrification and plant uptake. At this study site, the hydrologic contrast between the tile-drained field and the riparian zone had a controlling influence on groundwater flowpaths. The hydraulic-head data and subsurface chloride concentrations indicate that the shallow groundwater from the field, which contained relatively high concentrations of nitrate, was diverted downward as it approached the stream by the nitrate-poor water infiltrating through the riparian zone. The rapid disappearance of nitrate as it moved vertically coincided with the decrease of D.O. and more reducing conditions. Chloride concentrations remained high throughout this same zone, indicating that dilution was not a significant process. These patterns provide evidence to support denitrification as the dominant nitrate-attenuation mechanism.

The $\delta^{15}N$ isotope results and the history of fertilizer application indicated that the sources of groundwater nitrate beneath the field were organic (manure) and inorganic fertilizers. Elevated values of $\delta^{15}N$ in certain groundwater samples indicated that denitrification was prevalent in the subsurface. Additional evidence for denitrification was the linear relationship between $\delta^{15}N$ and $\delta^{18}O$ values of groundwater nitrate samples. Unfortunately, the attenuation of nitrate over short (~1-2 m) intervals prevented the current sampling network from providing sufficient information for correlating nitrate and $\delta^{15}N$ data along flowpaths at the field-riparian zone boundary.

This study highlights the importance of understanding the three-dimensional groundwater flow field in riparian-zone studies. The study also demonstrates the utility of combining physical, chemical, and isotopic techniques in evaluating nitrate dynamics in groundwater environments. Hydraulic head, geochemical, or isotopic data alone would not have provided sufficient evidence to understand the role of the riparian zone. Together, though, the data provide a relatively complete picture of relevant processes controlling the distribution and fate of nitrate in the subsurface.

The following four (4) figures represent:

Cross Sections Of Study Site On Kintor Creek Showing Movements And Changes Of Various Parameters As They Move In The Groundwater From Upland Field To Riparian Zone And Stream.

Each figure highlights a different parameter.

Note Figure 7 (page 19) - Eh represents Electric Potential

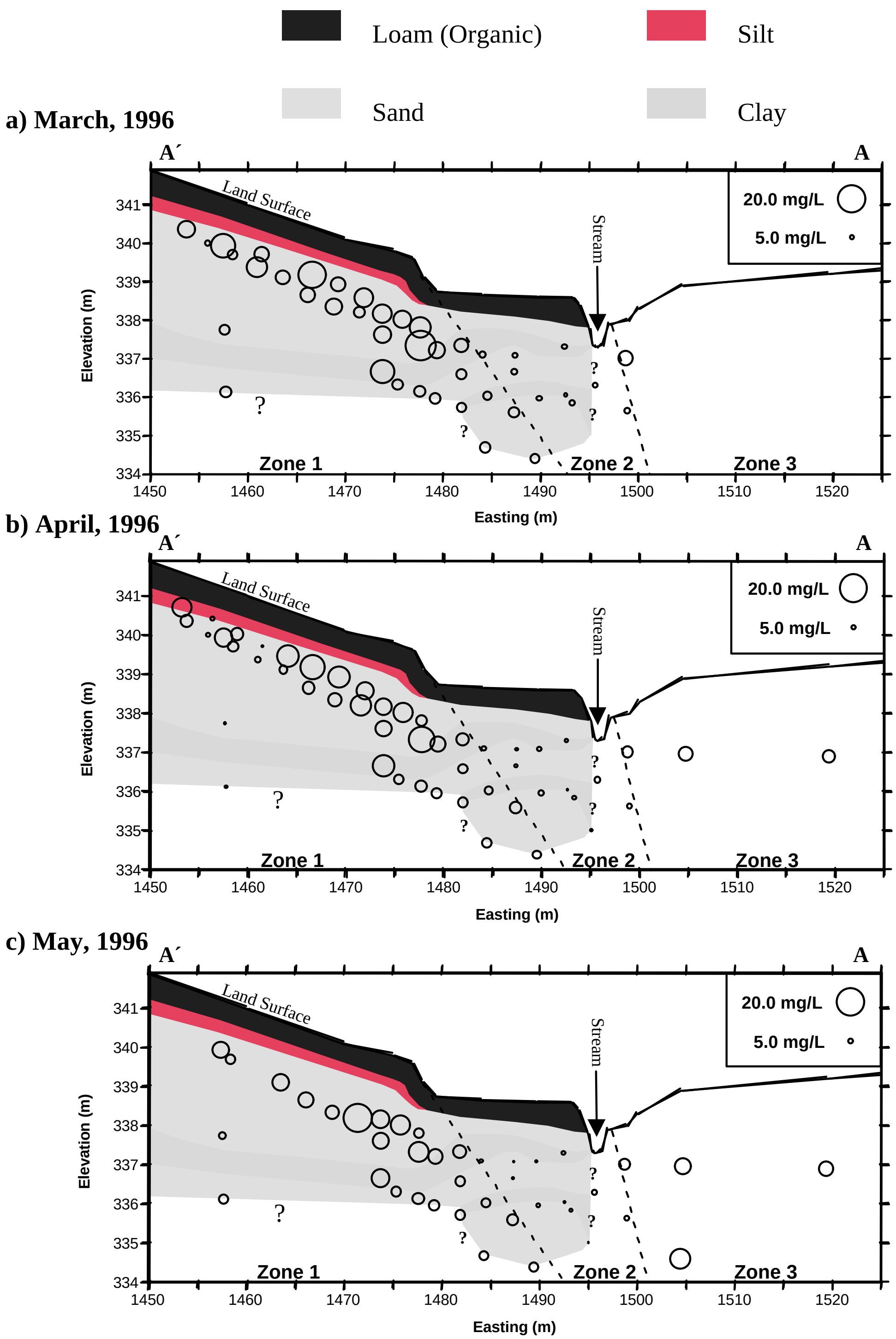


Figure 5. Chloride concentrations along transect A-A´ for a) March, b) April, and c) May, 1996 in relation to the geology. The dashed lines indicate the boundaries between zones 1, 2, and 3.

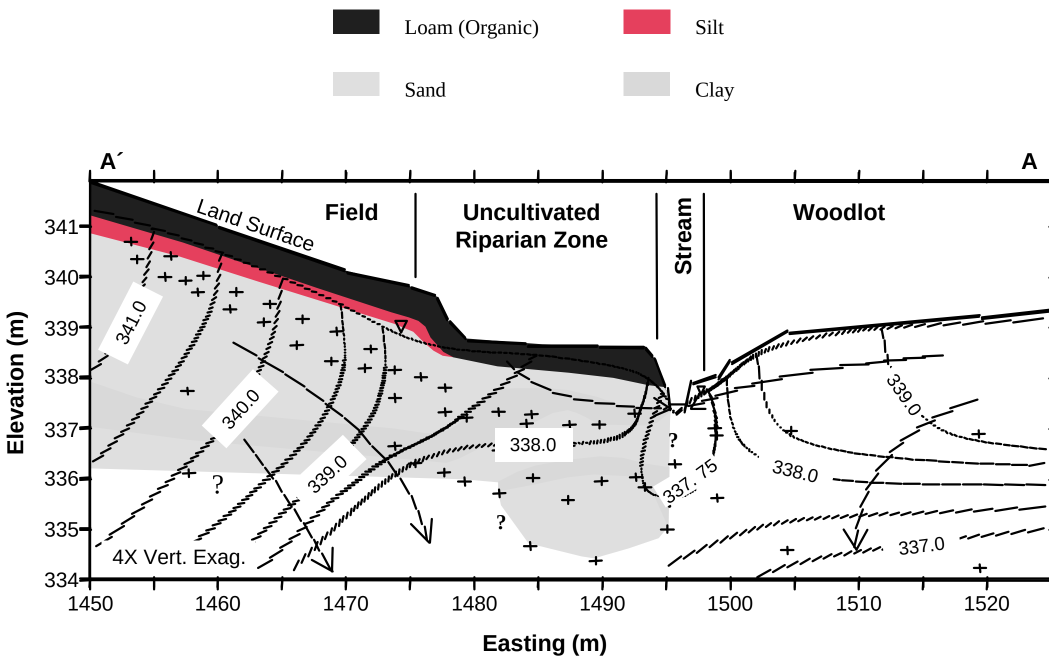


Figure 5 Vertical cross-section along transect A-A´ showing hydraulic head contours (m) set against the geology. The location of monitoring wells are shown (+) and arrows indicate the general groundwater flow directions.

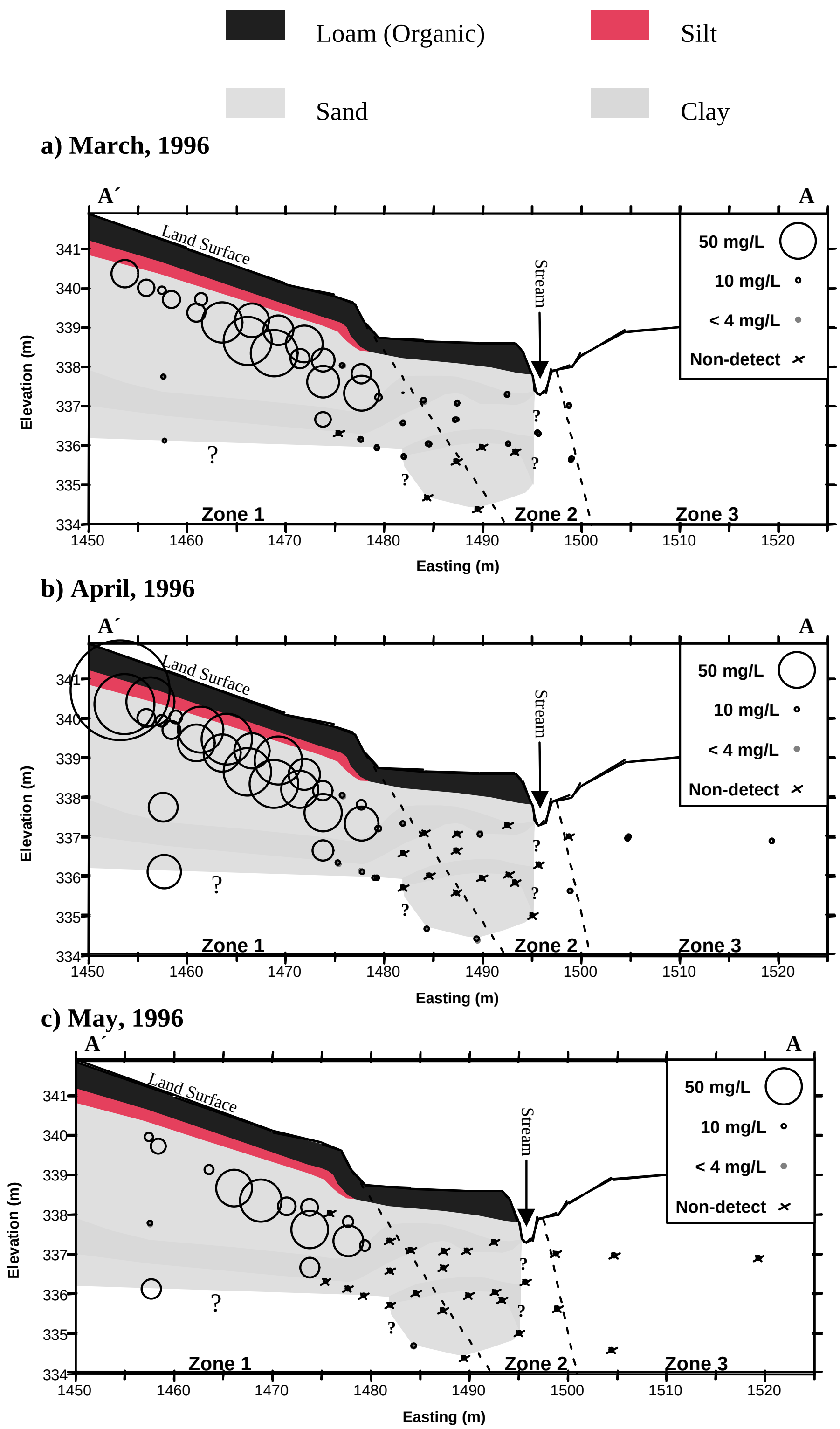


Figure 6. Nitrate concentrations (as NO_3^-) along transect A-A´ for a) March, b) April, and c) May, 1996 in relation to the geology. The dashed lines indicate the boundaries between zones 1, 2, and 3.

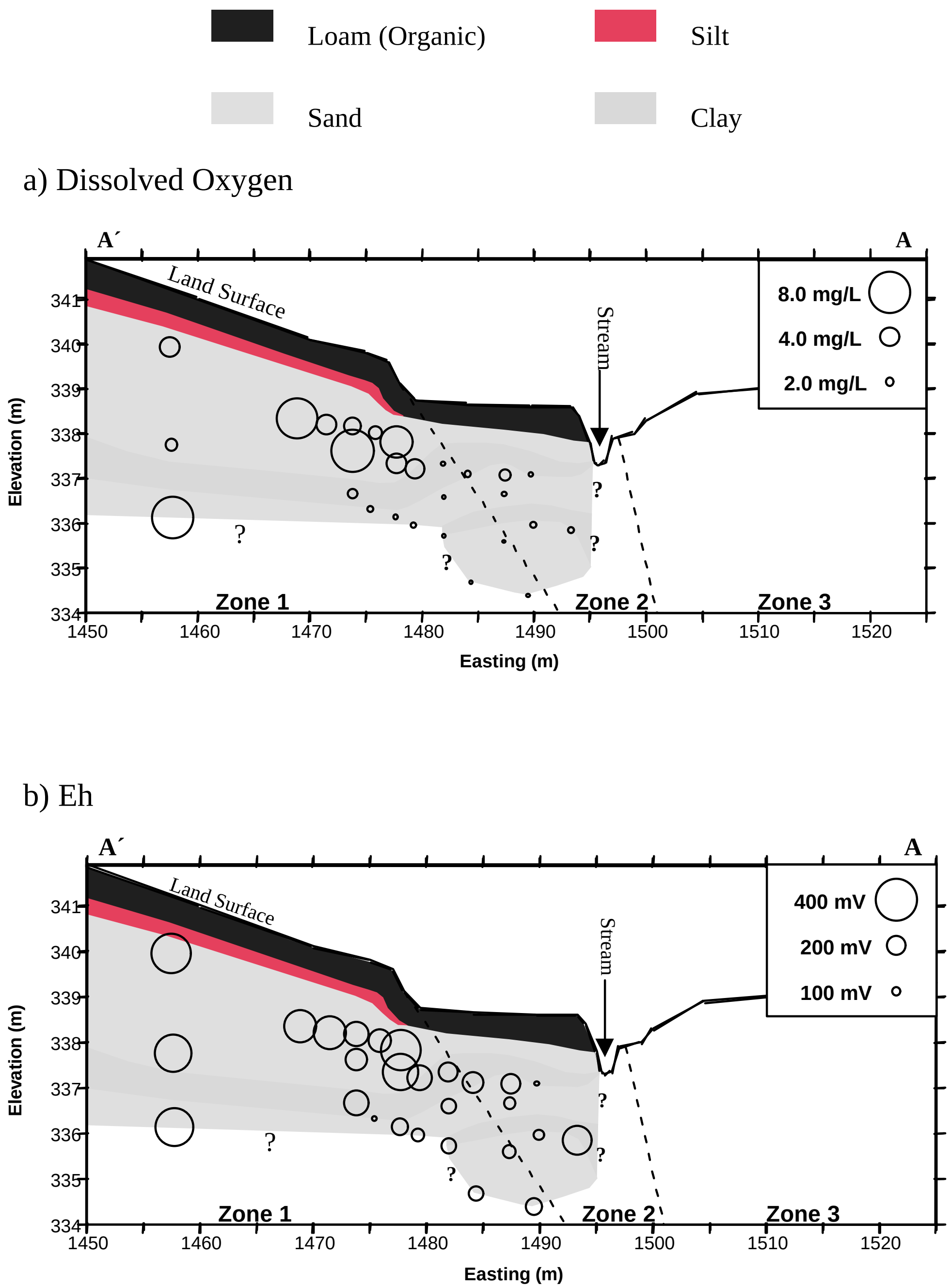


Figure 7. Vertical cross-sections along transect A-A´ showing a) dissolved oxygen and b) Eh readings for April, 1996.

2.4 Non Point Source Pollution

Ryan Stainton, University of Waterloo

The Effect of Riparian Buffers on Nutrient Input to Streams From Shallow Groundwater in Urban and Agricultural Landscapes

Most studies to date have focused on nitrate transport through riparian zones in agricultural landscapes under similar hydrogeologic settings, forcing shallow lateral flow of groundwater through the rooting zone and organic soils of the riparian zone (Table 1) - relatively high efficiency in nitrate reduction.

Sites occurring in more sandy aquifers, where lateral flow through the riparian zone is not happening, data (Table 2) have shown higher stream side concentrations, with nutrient laden groundwater potentially short-circuiting the riparian zone.

Fewer studies have looked at phosphorus in riparian zones (assumption that P movement in groundwater is not significant due to high adsorption affinity of phosphorus).

Studies looking at phosphorus in riparian zones have most often indicated an increase in concentration as groundwater flows from adjacent land use, to the stream-side monitoring wells (Table 3).

My study…

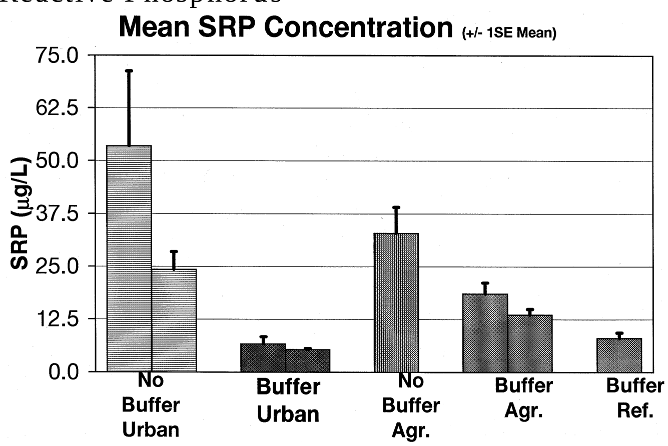
- 8 sites in total, 3 in agricultural, 4 in urban (residential) and 1 reference (used as a 'background' indicator).
- 2 agricultural sites are not buffered by riparian zone where 1 is. Two urban sites are buffered, 2 are not.
- Drive point piezometers installed into stream-bed to measure nitrate, total phosphorus and soluble reactive phosphorus (phosphate) concentrations in shallow groundwater entering the stream.
- Shallow groundwater entering the stream at this point would have had an opportunity to interact with the riparian zone.
- **Overall objective -** 'to investigate the effect of riparian buffers on nutrient input to streams from shallow ground water in urban and agricultural landscapes'.
- **Aim** is determine whether there is a significant difference in the concentrations of the studied nutrients entering the streams, in those buffered vs. non-buffered stream reaches.

GRAPHS: (I STRESS THAT THESE ARE PRELIMINARY!)

Mean Total Phosphorus Concentration

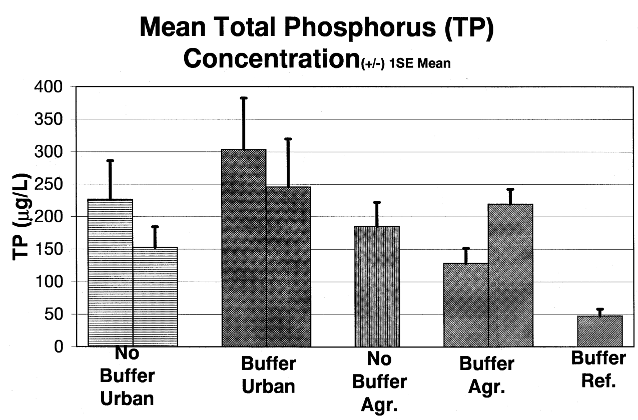
- Considerable amount of Total Phosphorus (TP) entering stream environment via groundwater.
- Concentration in groundwater higher than surface water.
- Urban sites incur higher standard error of mean -indicating more fluctuation in concentration.
- Highest concentrations occurring in urban sites with a riparian buffer.
- High degree of variability between and within categorized sites.
- Reference site showing lower 'background' values.

Note: SRP - Soluble Reactive Phosphorus



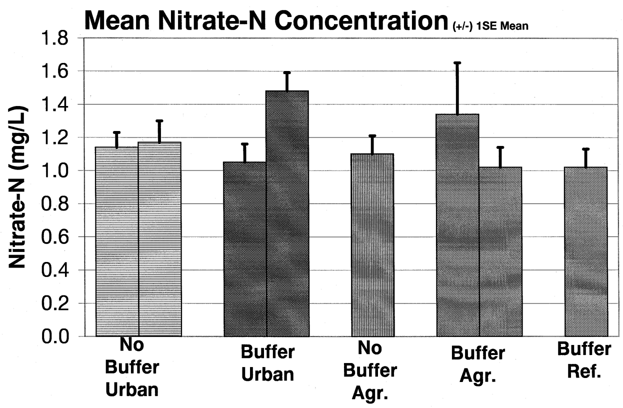
Mean PO_4^{3-} Concentration

- Standard error of the mean higher in non-buffered sites - indicating higher degree of variability in concentrations i.e. more extreme values.
- Higher mean concentrations found in non-buffered sites.
- Would seem that riparian buffers are influencing incoming groundwater concentrations.



Mean Nitrate-N Concentration

- Little variability between sites, except for the two buffered sites.
- Lowest concentrations recorded in buffered sites are marginally lower than non-buffered sites.
- Concentrations are not exceedingly high i.e. drinking water standards are 10 mg/L nitrate as N.
- Nitrate concentration entering via groundwater is lower in concentration than surface water.



Overall there is a high degree of variability between sites - great deal of spatial heterogeneity

RESEARCH DIRECTIONS, NEEDS AND KNOWLEDGE GAPS

Spatial and Temporal Variability in Nutrient Transfer and Flow Pathways

- Few studies in northern temperate climates
- Aspect of seasonal impacts on retention
- Self-sustaining -- how long??
- Storm-event efficiencies
- Heterogeneity of subsurface environment has high degree of influence.

Effectiveness of Non-Vegetated and Limited Width Riparian Zones

- Few studies in literature

Land Use

- Very few studies conducted in urban areas
- Potentially significant differences in source concentration

Buffer Characteristics (influence of)

- Vegetation type
- Slope
- Soil type
- Width
- Hydrologic regime

Table 1
Nitrate in Riparian Zones: Shallow Lateral Flow Paths With Impermeable Subsurface

Reference	Riparian Buffer Type	Input to Riparian Buffer	Output to Stream side	Hydrogeologic Setting
		NO_3^--N (mg L^{-1})		
Jacobs and Gilliam, 1985	47 m Forest	7.9	<0.1	Shallow aquifer over impermeable layer
	16 m Forest	7.3	<0.1	
Pinay and Decamps, 1988	130 m Deciduous forest	2.8 - 5.2	0	Clay at 4 m
Cooper, 1990	9 m Grass	0.6	0.32(MS)	Impermeable layer at 0.9 - 1 m
		0.6	0.03(OS)	
Osborne and Kovacic, 1993	16 m Deciduous forest	11 - 26.5	0.87	Shallow aquifer over dense basal till at 0.6-1.3 m
	39 m Grass	16 - 43	<1 - 2.5	
	No Buffer	6 -- 20	1.5 - 14	

Source: Adapted from Hill (1996)

Table 2
Nitrate-N in Riparian Zones: Sand Aquifers With Upward Flow Paths

Reference	Riparian Buffer Type	Input to Riparian Buffer	Output to Stream-Side	Hydrogeologic Setting
		NO_3^--N (mg L^{-1})		
Robertson et al., 1991	20 m Grass	39	0.6-13	Sand Aquifer >10m
Phillips et al., 1993	Deciduous forest	11.0	9	Sand Aquifer 7-20 m
Mander et al., 1995	120 m Fen	1.9	1.6	Glacial sands/clay layers
Correll, Jordan and Weller, 1997	48 m Deciduous forest	25	17	Sand Aquifer clay at depth
	37 m Cut Grass	25	14	

Table 3 - P Concentrations in Riparian Zones

Reference	Riparian Buffer Type	P Fraction	Input to Riparian Buffer	Output to Stream-Side	Hydrogeologic Setting
			(mg L^{-1})		
Peterjohn and Correll 1984	19 m Deciduous forest	TP	15	62	Shallow aquifer clay at 1.5 - 3.0 m
	50 m Deciduous forest	TP	130	247	
Osborne and Kovacic, 1993	16 m Deciduous forest	PO_4^{3-}	13	66	Shallow aquifer dense basal till at 0.6 - 1.3 m
		TP	58	122	
	39 m Grass	PO_4^{3-}	20	40	
		TP	92	91	
Akhmetieva, 1994	510 m Pine and Deciduous	PO_4^{3-}	20	10	Sandy Soils over dense loam
	Pine and Deciduous forest	PO_4^{3-}	40	20	
Mander et al., 1995	120 m Fen	PO_4^{3-}	90	300	Glacial sands/clay

2.5 Wildlife

Dr. Jane Bowles, University of Western Ontario

RIPARIAN CORRIDORS IN THE LANDSCAPE

The landscape of southern Ontario following European settlement comprises patches of naturalized vegetation in a matrix of other land uses.

Three main factors contribute to the distribution of patches in the landscape:

- Physiography, topography and soil type
- Settlement and survey patterns
- River corridors

In southwestern Ontario, most of the largest patches are along river corridors. From a landscape ecology perspective river corridors are important:

- Because they provide sanctuary as the only remaining tracts of habitat;
- Because they are more connected than other patches and facilitate movement in the landscape as CORRIDORS; and
- For planning purposes they provide a backbone for creating or restoring natural heritage systems.

RIPARIAN ZONES AS CORRIDORS - WHAT ARE CORRIDORS?

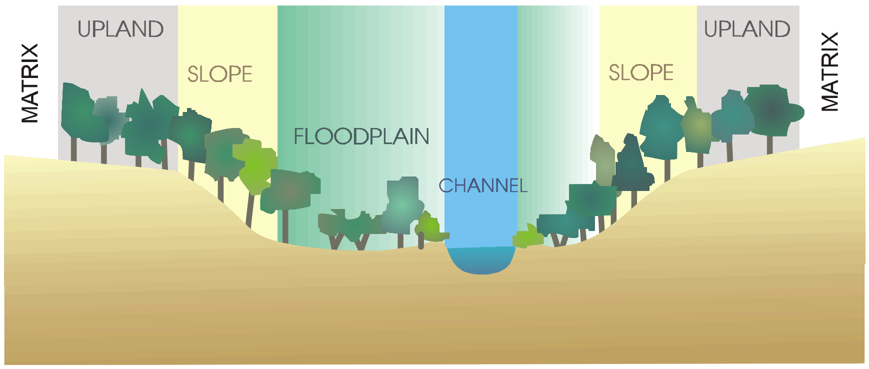
Corridors perform 5 basic functions in the landscape:

- *Habitat*:
  Many wildlife species live in corridors and use the corridor habitat for feeding and breeding. Some species move between the corridor and the matrix in their daily or seasonal movement.
- *Conduit:*
  The corridor provides habitat for wildlife to move through the landscape. Much of the movement occurs at the edge of the corridor, at the interface of the corridor and the matrix.
- *Filter/Barrier:*
  The corridor can act as a barrier, restricting or diverting wildlife movement, or as a filter, trapping wind, snow, seeds, fungal spores, nutrients etc moving across the matrix.
- *Source:*
  The corridor can act as a safe breeding site for wildlife species that later move into the matrix.
- *Sink:*
  Wildlife entering the corridor from the matrix may never return, either because they find more suitable habitat, or they die in the corridor. Turtles trying to cross the 401 is an example of a corridor (for cars) acting as a sink (for turtles).

Habitat, Conduit and Filter are probably the most important functions of riparian zones.

RIPARIAN CORRIDOR AS HABITAT

Rich environmental and genetic diversity
Habitat and protection for rare species
Oasis in arid areas



CROSS SECTION OF A RIVER CORRIDOR

TERRESTRIAL FEATURES OF A RIPARIAN CORRIDOR

Riparian corridors can be simplistically divided in a few major component parts. Each component has its' own features and functions.

Stream Bank

- Highly fluctuating water tables.
- Scouring by ice and water.
- Vegetation composed primarily of:
- Resistant species able to withstand disturbances.
- Short-lived opportunists.
- Many animals use the land-water interface.

Floodplain

- Mosaic of:
  - Soil texture and moisture.
  - Disturbance history and regime.
  - Community age and successional stage.
  - Nutrient rich and productive alluvial soils.
  - Many rare species:
  - Floodplain specialists.
  - Protected habitat.
  - Shelter and den trees abundant.

Slope and Upland

- Similar to upland communities in the matrix.

- Connection to corridor important.
- Development of interior habitat in large forest blocks.
- Refuge for floodplain species.

HABITAT DIVERSITY IN TIME & SPACE
Dynamic processes
- Flooding
- Erosion
- Sedimentation
- Nutrient flows
- Ice and water scours
- Life cycles
- Population fluctuations
- Succession

Spatial variability
- *Gradients:*
  - Longitudinal - river source to river mouth
  - Lateral - adjacent upland to river channel
- *Mosaics:*
  - Soil texture
  - Soil moisture
  - Water flow
  - Slope
  - Aspect
  - Temperature
  - Topographic position
  - Vegetation
  - Disturbance history
- *Landscapes:*
  - Variability in the landscape through which the river passes

The human factor
Human impacts on the landscape have generally led to:
- Reduction in the EXTENT of riparian corridors.
- Narrowing of riparian zones.
- Channelizing streams.
- Straightening meanders.

The variability has been reduced by loss of habitat, loss of species and flood control.

RIPARIAN CORRIDORS AS CONDUITS

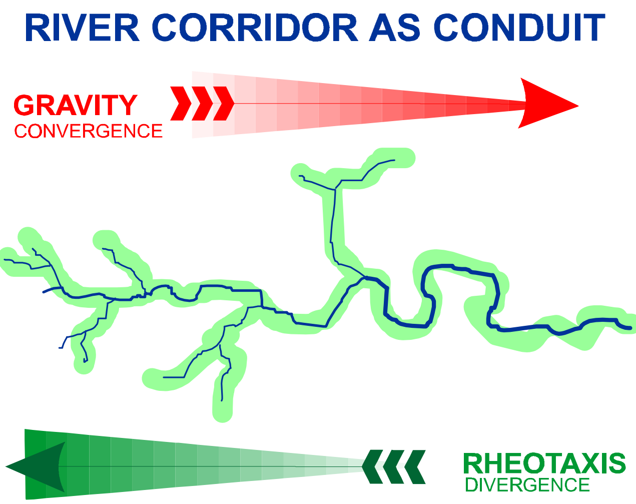
There are two main sources of movement along a river corridor:

GRAVITY

- a physical force by which particles are moved from from higher to lower areas.
- there is convergence towards one place - the river mouth.

RHEOTAXIS

- wildlife expending energy to counteract gravity i.e. swimming, flying, walking.
- movement upstream causes divergence along the stream and spreading out across the landscape



There are many ways in which a riparian corridor can be used as a conduit:

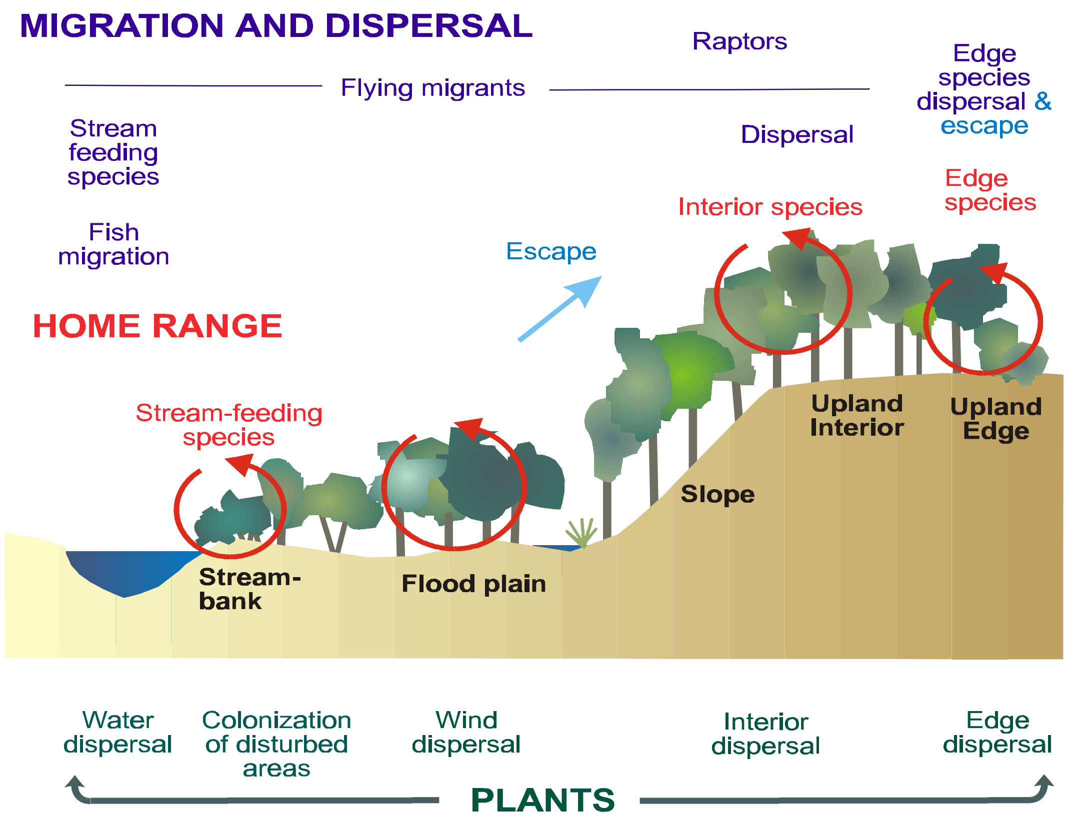
Home ranges: Daily or seasonal movement within and/or between riparian habitats.

- Home range habitats may be partitioned according to zones in the corridor.
- River dependent species use the river and its shorelines (e.g. Kingfishers, Otters, Crayfish, Dragonflies, etc.)
- Floodplain species that move within floodplain habitats.
- Forest interior species that make use of large blocks of habitat on the valley slopes and adjacent upland.
- Edge species that move between the riparian corridor and the adjacent matrix.

Migration and dispersal: Movements along and within the riparian corridor.

- Movement along the river by swimming or flying.
- Movement above the river valley, making use of updrafts from the slopes.
- Movement along the edge between the riparian corridor and the matrix.
- Dispersal between forest block along the riparian corridor.
- Escape from the floodplain to the valley slopes during floods.
- Escape from the matrix to the riparian corridor.

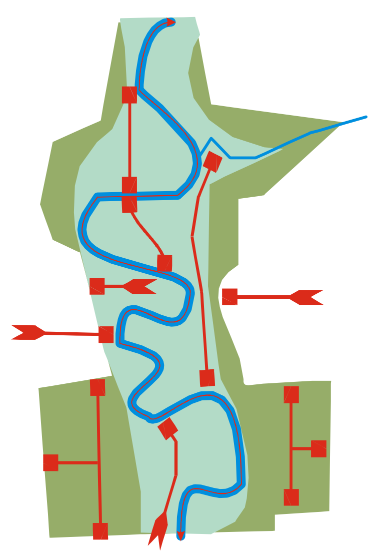
WILDLIFE MOVEMENT IN RIPARIAN CORRIDORS



THE RIPARIAN CORRIDOR AS BARRIER

- Riparian corridors can be barriers for wildlife moving across the matrix.
- Upland forests may not be continuous.
- The flood plain of most streams is not a good conduit:
- Meanders make the distance further, or mean that the river has to be crossed many times
- Floodplain habitats are very variable and some may be unsuitable or impenetrable
- The floodplain not be continuous.

BARRIERS TO MOVEMENT IN A RIPARIAN CORRIDOR



2.6 Bank Stability

John Parish, PARISH Geomorphic Ltd.

A Summary of Properties and Processes

- This presentation will differ slightly from the previous ones, as I will discuss bank stability from an applied and geomorphic perspective.
- As well, there is less emphasis on Ontario research, although future research needs will be identified.
- This talk is more of a summary, with few analytical results, mainly due to the fact that there is not much in the published literature.

Objectives

The following objectives will convey our existing understanding of bank stability and its relationship to flows and the riparian zone.

- Discuss what bank stability is
- Factors which enhance stability as well as factors which compromise it
- What are some of the tools available
- What are the needs for future research

Bank Stability

‘*A bank profile which balances its physical state with the surrounding environment, and the associated natural processes.*’

- Also entails the banks resistance to change in shape or position.
- Also brings a balance or equilibrium concept into the definition as, depending on the scale, stable channels and banks still have to experience some erosion.

Physical Controls

Climate

- *precipitation*
- *temperature*

Climate enhances bank stability through consistency, whereas it can be weakened by climatic extremes.

Geology

- *material (size)* - boulders, silt and clay enhance stability, sand gravel reduce stability.
- *stratigraphy (layers)* - stability is enhanced by thicker units and reduced by ‘weak’ zones and when groundwater uses one unit as a conduit.
- *cohesiveness* - typically measured by determining a ‘silt factor’ and there are not many analytical ways of assessing cohesiveness.
- *moisture (pore pressure)*

Modifying Controls - (All these factors act to weaken the bank and reduce stability.)

Vegetation

- *Type* - grasses to trees
- *Density of roots* - # of roots; thickness of roots
- *Depth of roots* - lateral and vertical

These vegetation factors add to bank stability by increasing the tensile strength of the bank material as well as increasing the roughness to flow, thereby reducing flow velocity.

Animals

- *Burrows* - worms, swallows, muskrat.
- *Livestock* - accessing the stream

Flow regime

- Includes sediment regime and the amount of fluctuation of each

Physical Processes

The above factors and controls are worked and altered by these processes.

Fluvial entrainment/hydraulic quarrying

- Includes the actual movement of particles and material from a bank.

Weathering

- *wet – dry cycles*
- *freeze – thaw*

These are more gradual and act as agents to weaken the bank, can also include geo-chemical.

Mass Wasting (Mass wasting is really the effects of gravity)

- *rotational failures*
- *slumping*
- Another process is a combination of several of these (i.e. where flows have created an undercut bank, which eventually fails through slumping).

The results of these processes is the form and shape of a bank and what we typically measure to define stability, including:

- Height – the higher the less stable
- Angle – the steeper, the less stable
- Undercut – presence / absence
- Relationship of root type and quantity of roots to bank height

There is really a lack of direct analytical tools.

Tools

Tools provide guidance on data collection and an assessment of stability. This requires an ‘experience’ factor.

Direct Measures Of Properties

- *Historic* - (migration rates from historic air photos)
- *Rates of change* - (bank erosion measured from pins or repeated surveys) *experience factor*

Summary Tools

- **Bank Stability Dichotomous Key**. Reference: Stanfield, Les, M. Jones, M. Stoneman, B. Kilgour, J. Parish and G. Wichert. *Stream Assessment Protocol For Ontario*. Vol. 2.1, 1998.
- **Bank Erosion Potential**. Reference: Rosgen, D. *Applied River Morphology*. 1996. (some similar parameters, although more reliance on relationships and some parameters are more difficult to measure)
- **Tensile Strength of Selected Tree and Shrub Species**. Reference: Grey, D and R. Sotir. *Biotechnical and Soil Bioengineering Slope Stabilization: a Practical Guide for Erosion Control*. 1996.

Future Research Needs - Must confess to not being completely aware of all research activities within the province

- Erosion processes of cohesive material
- Determination of relationships between modifiers and physical controls
- Development of more analytical and predictive tools
- University of Guelph – School of Engineering. Assessing the effects of vegetation on banks and controls exerted on channel form. Previously developed an equation to predict bank erosion, modified the Universal Soil Loss Equation.
- MNR has been working on the effects of the age and size of vegetation and the role on bank stability.

Banks are very complicated, as I've shown there are a variety of factors which exert an influence in a relatively small space. They are difficult to measure and we are uncertain over the inter-relationships. We need to take small steps to help gain a better understanding.

2.7 Aquatic Habitat

Dr. Bruce Kilgour, University of Western Ontario

Buffer strips provide nutrients, habitat as large woody debris, shading to maintain temperatures and bank stability. The following figures will show that temperatures are perhaps the most important feature driving fish and benthic populations in streams, and that temperatures can be maintained by riparian buffer strips.

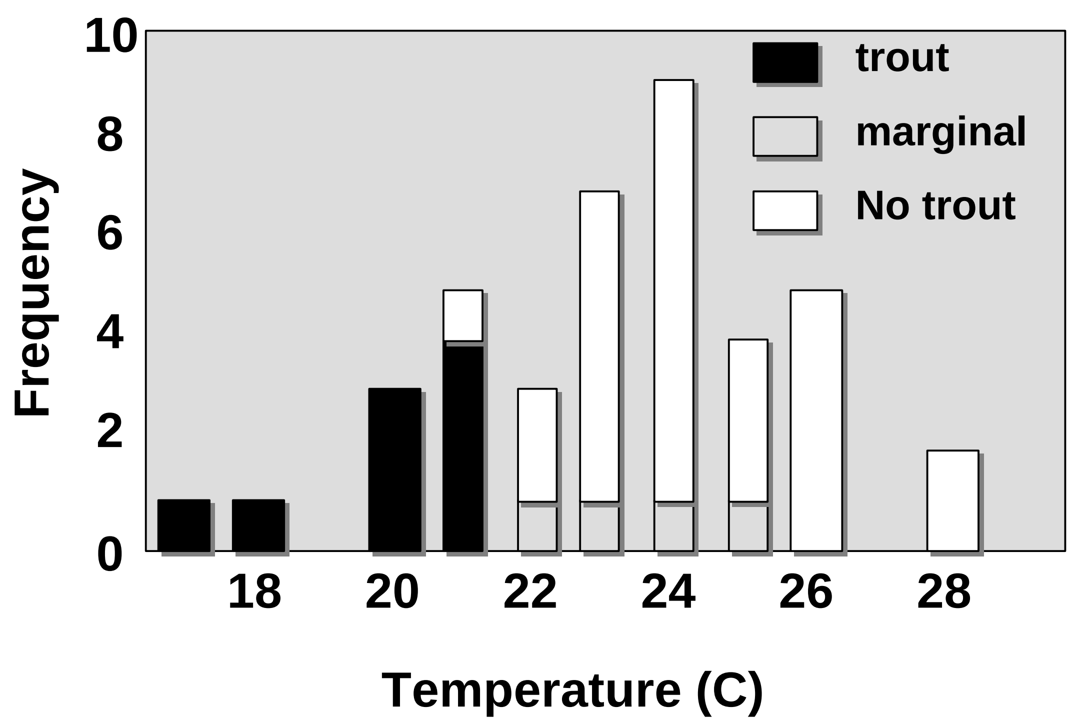


Figure 1 - Shows the relationship between maximum summer temperatures and the presence/absence of trout populations. Streams with water temperatures < 22°C supported healthy brook trout populations. Those streams with temperatures > 26°C did not support trout.
Redrawn from Barton et al. (1985).

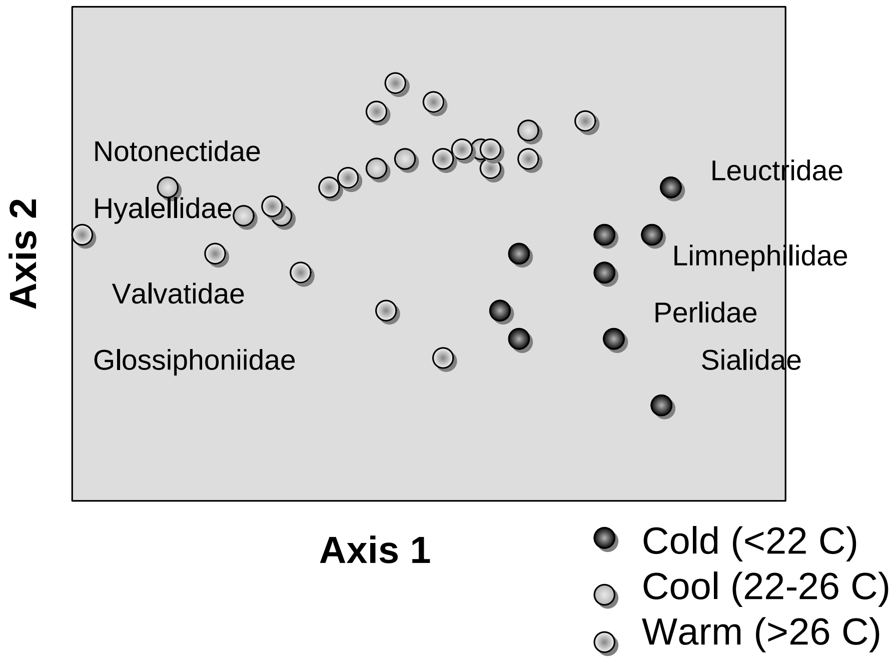


Figure 2- Shows that the benthic community composition varies with temperature. Benthos from cold-water streams are distinct from benthos from warm-water streams.
Drawn from data in Kilgour and Barton (1998)

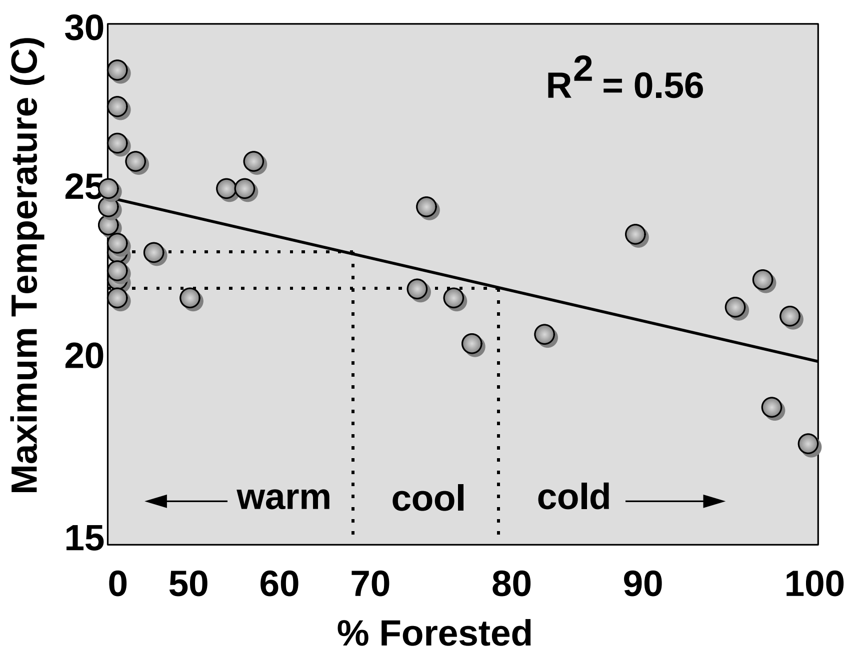


Figure 3 - Shows the relationship between the % forest in the catchment and stream temperatures. Cold water streams are maintained with 80% of the catchment as forest. Redrawn from Barton et al. (1985).

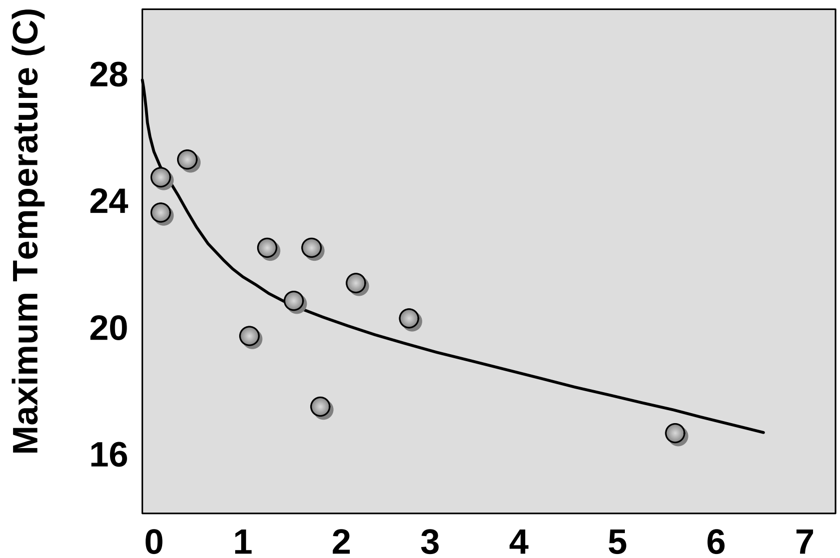


Figure 4 -This slide shows the relationship between the length of riparian buffer strips and stream temperatures. This relationship suggests that riparian buffer strips provide a cooling effect.
Redrawn from Barton et al. (1985).

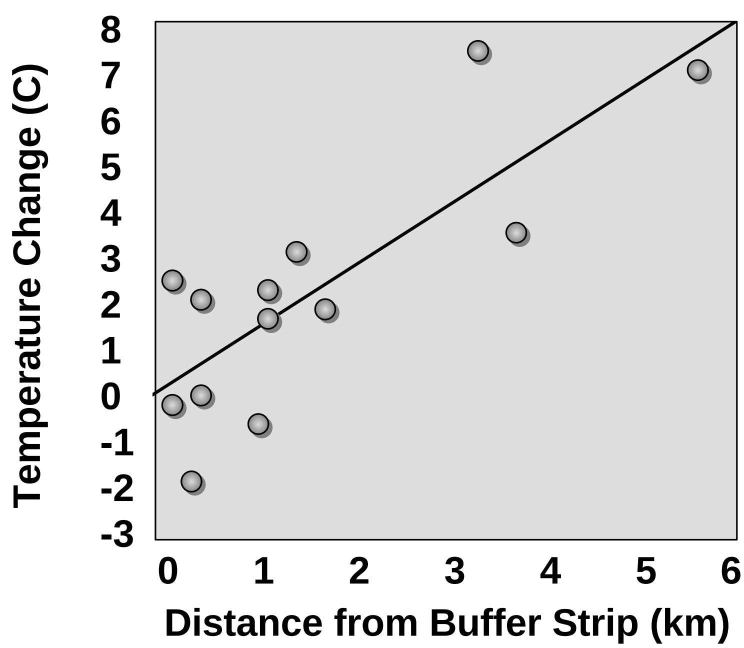


Figure 5 - Shows the relationship between distance from a buffer strip and water temperatures in streams. The relationship suggests that stream waters heat up when riparian buffer strips are absent.
Redrawn from Barton et al. (1985).

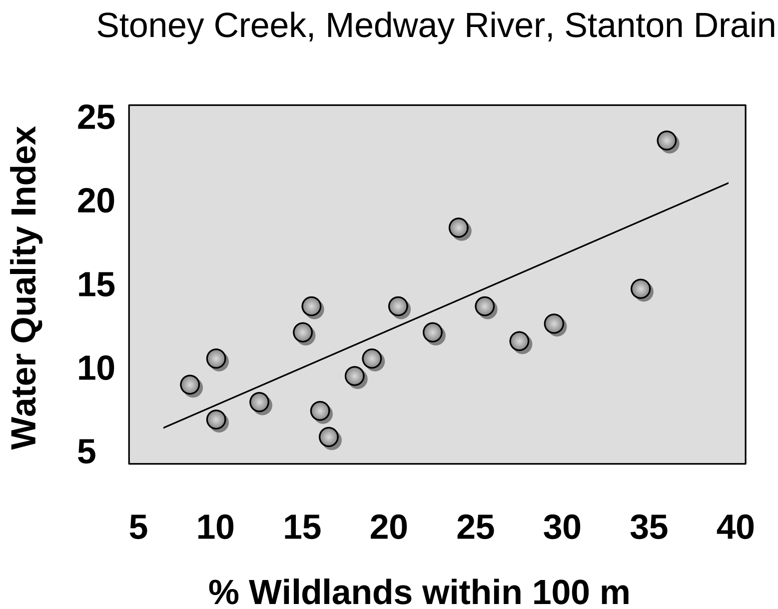


Figure 6 - Shows the relationship between % wildlands (forest) within 100 m of a stream site and a measure of benthic community composition (Water Quality Index). This relationship suggests that the riparian canopy within 100 m of a site has considerable control over water quality (perhaps temperatures).
Redrawn from Griffiths (1998).

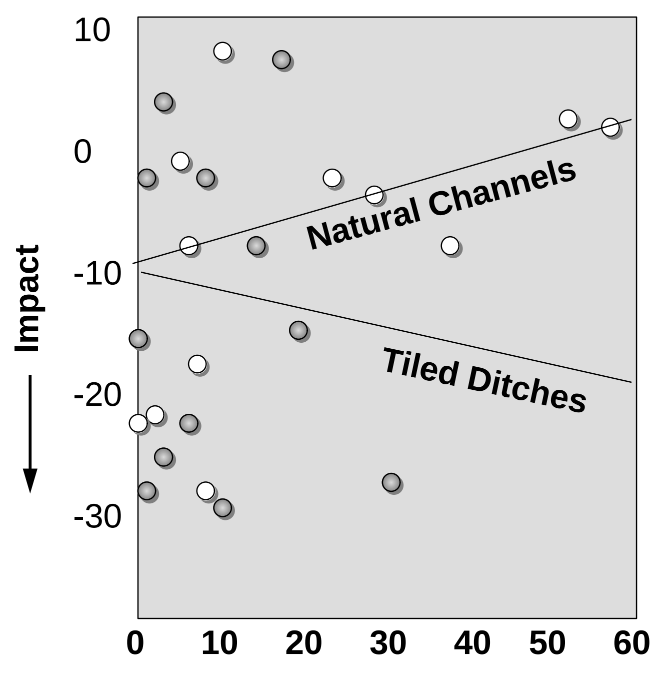


Figure 7 - Shows the relationship between degree of impact on benthic communities and % of the stream bank that is wooded. In natural channels, riparian canopies provide some protection from impacts. In drainage ditches, riparian canopy provides no protection from impacts. Ditches often receive discharges from farm tile drains which would not be ameliorated by riparian canopy.
Drawn from data in Barton (1996).

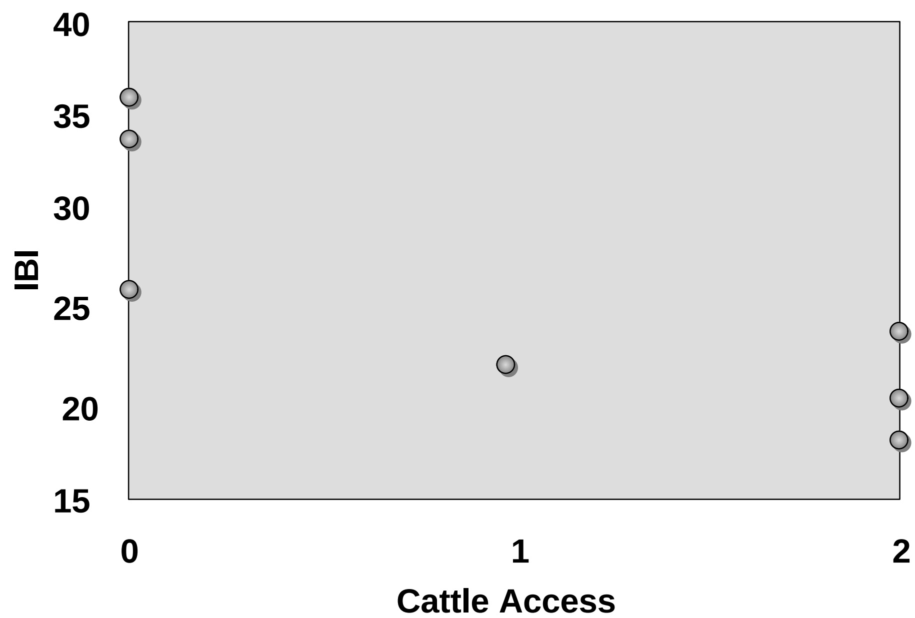


Figure 8 - Shows the relationship between cattle access (ranked as none, 0; low, 1; and high, 2) and an index of fish community composition (IBI, Index of Biotic Integrity). The relationship shows that cattle access is associated with degraded fish communities. Redrawn from a report on Dominique Charron's thesis work on Carroll Creek.

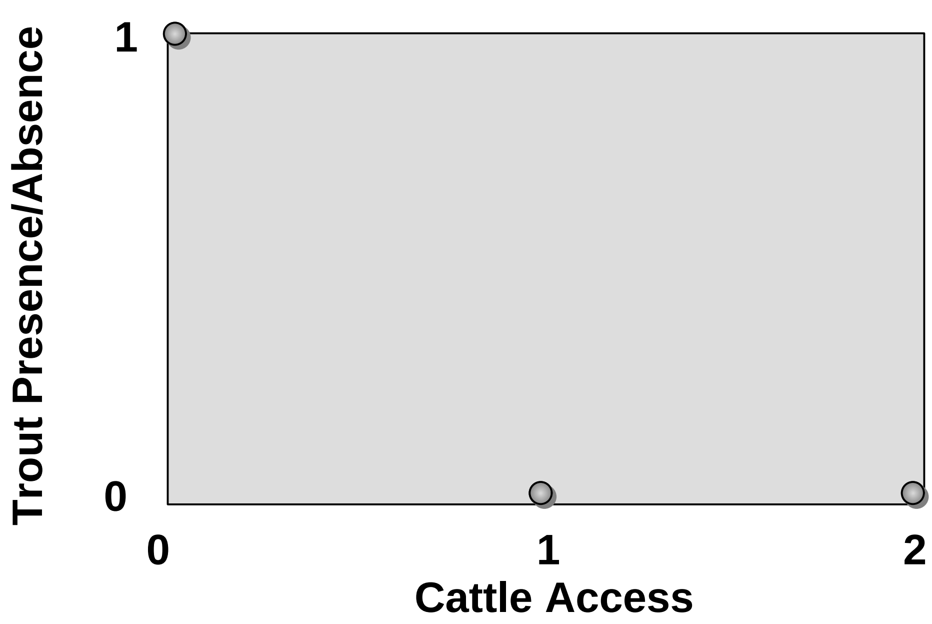


Figure 9 - Shows the relationship between cattle access (ranked as none, 0; low, 1; and high, 2) and the presence/absence of trout in Carroll Creek. No trout were found in any sites where cattle could access the creek.
Redrawn from a report on Dominique Charron's thesis work on Carroll Creek.

Summary

Fish and invertebrates do respond to riparian buffer zones. In southern Ontario, water temperature is one of the most important habitat features influencing stream benthos and fish. Buffer zones appear to protect the biology of streams by maintaining cool stream temperatures. Point sources can, however, override the benefits of riparian zones. Finally, exclusion of cattle from streams is obviously beneficial because it prevents the destruction of in-stream habitat. However, exclusion of cattle from cobble-bottomed streams may not be warranted since cattle do not tend to access (and thus impair) rocky streams.

Sources

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Kilgour, B.W. and D.R. Barton. 1999. Associations between stream fish and benthos across environmental gradients in southern Ontario. In press, Freshwater Biology.

Charron, D. Ph. D. Thesis, University of Guelph.

3.0 STATE OF THE PRACTICE
WORKSHOP PRESENTATIONS

3.1 Landowner Perceptions and Acceptance of Riparian Zones

Sue Sirrs, Rouge Park

Background
This is a review of my experience in landowner contact, with particular regard for riparian landowners. That experience includes landowners in a wide range of land use scenarios. These scenarios include: rural old order Mennonite farmers in the Grand River watershed; a multitude of landowners in the Rouge River watershed. Landowners on the Rouge River included: developers, property owners in new subdivisions, tenant farmers and rural estate owners in Canada's fastest developing municipalities of Markham and Richmond Hill. Additional experience includes undergraduate work in the Ovens-King watershed in Australia.

I completed a graduate thesis, titled, 'Participatory Approach to Riparian Corridor Design', which asked landowners about their perceptions and understanding of the health of the creek that ran through their property (Carroll Creek, Grand River watershed).

- This was one study of many that were carried out in Carroll Creek. There was a proposal to study the watershed in depth, then fence off the creek and monitor the regeneration that occurred. My thesis and subsequent work filled a gap between researchers interests and those of the local landowners.
- The hypothesis (see Figure 1 Model of Hypothesis and Objectives) was that landowners would either perceive a problem with the health of the river or not. If they did perceive a problem, they were asked why they thought the health of the river was a concern. Next they were asked about their interest and motivation in establishing a buffer zone adjacent to the creek. They were also asked what rehabilitation actions were required and what assistance they might need to do the work. This series of questions for those people who perceived a problem with the health of the river was to form the basis for an Implementation Plan.
- For those folks who did not perceive a problem with the health of the river, they were asked why they thought it was a healthy river system. They were asked what would motivate them to establish buffers. This series of questions for people who did not perceive a problem with the health of the river was to form the basis for an Education Plan.

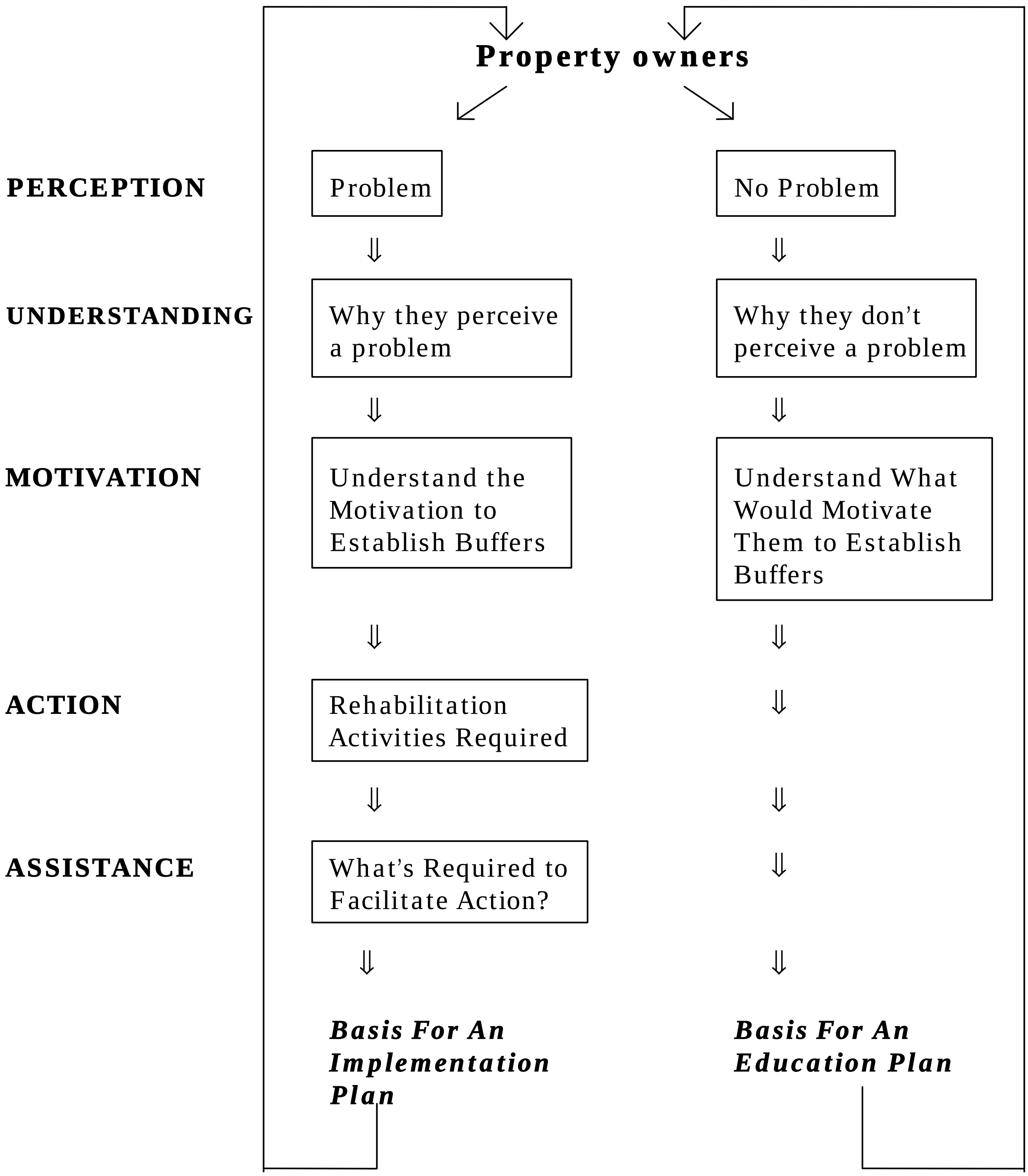
- Results showed that only six landowners perceived a problem with the health of the river. The remaining 22 landowners felt the creek was fine the way it is. Responses to specific questions are found in Table 1 Landowner Response.

The Carroll Creek watershed is predominately rural farm land with some rural residential lots and few landuse pressures. In contrast, the Rouge River watershed is many times larger and faces many landuse pressures. Changing landuse has made for a variety of different landowners including developers, speculators, farms in transition, active farms, urban and rural residential landowners as well as estate home owners. As a result, the issues in the Rouge watershed are also very different. Landowners want to know how they can get the best price for their land, how to get rid of undesirable new landowners, how to get rid of frogs because they make too much noise, the list goes on and on.

Conclusions

- There is a fundamental lack of understanding and appreciation for Canada's fresh water resource. Although people like to own property that backs onto streams and rivers, they have little understanding of the role they play in the larger landscape.
- Landowners in rural Carroll Creek watershed had a very different attachment to the landscape. Because they were long-term residents, they knew that protecting the river was important. They had done so in many ways and wanted to show me where they had stabilized river banks, minimized cattle crossings, etc. Newer landowners were more concerned but didn't have the same ties to the land or understanding of it.
- Landowners in the Rouge watershed are quite another ball game. New landowners are thrilled to have moved to the country. Old timers are trying to sell their lands for the best price to developers and move further north. Or, they're trying to stay on their farms even though development is starting to surround them. There isn't the same long-term commitment to the land that has helped to protect the riparian zone in the past.
- Landowners for the most part prefer order in the landscape over disorder. Their efforts to tame nature are evident in the classic example of the mowed lawn to the edge of the creek or pond, i.e. the landowner who removes the floodplain forest, lays sod then puts up a bird feeder on a metal pole to attract birds. These tidy landscapes are less ecologically healthy but seem to be almost universally preferred. People often apologize and explain that they haven't had a chance to clean up. There is a job to be done to educate people about what a healthy riparian zone should look like.

Figure 1 Model of Hypothesis and Objectives



Adapted from Sirrs. *Participatory Approach to Riparian Corridor Design.*

Table 1 Landowner Response

Objective 2 **Motivation**	• Lost Property or lost use of property. • Water Quality. • Negative experiences with some landuse practices.
Objective 3 **Actions**	• Bank Stabilization; planting and some use of rocks to stabilize banks. • Protection from cows; fences and bridges. • Alignment work. • channel straightening. • Protection of existing riparian vegetation.
Objective 4 **Assistance**	• Advice and guidance. • Finances. • Mediation. • Labor. • Plant material.

Objective 5
Why Landowners Don't Perceive a Problem
	• The creek is the same as it has always been.
	• Landowners look after it themselves:
	  • place field stones in eroded areas,
	  • plant trees,
	  • eliminate detrimental land uses,
	  • already established a buffer zone,
	  • don't pasture adjacent to the creek.

Objective 6 **Concerns Regarding Establishment of Buffer Zones**	• Weeds seeding into agricultural fields. • Fences will wash out in spring. • Fences will mean more work for the farmer. • Long term care of buffer zones. • Fear that won't be acceptable to have cattle crossing the creek. • Creek already has a buffer. • Land won't generate an income. • Pay farmers not to pasture on bottom lands instead of buying fences. • Trespassers. • Garbage.

Adapted from Sirrs. *Participatory Approach to Riparian Corridor Design.*

3.2 Packaging and Selling Riparian Zone Management: Issues, Programs and Mechanisms

Ingrid Vanderschot, OSCIA

Analysis of the Ontario Environmental Farm Plan Aggregate Data

The Environmental Farm Plan (EFP) is an initiative of Ontario Farm Environmental Coalition. This study administered by Ontario Soil and Crop Improvement Association will be looking at the EFP and data that has been collected under this Program. Highlighted here are: what indications have been given about farmers activities; how best to package riparian issues and also the challenges of using EFP data for reporting.
This particular study of the aggregate data funded by Wildlife Habitat Canada was to determine specifically what this data could show us with respect to wildlife habitat, which included a look a riparian areas.

EFP

- An initiative designed for site specific environmental education and risk assessment for farmers.
- It is a self-assessment, completely voluntary and confidential process which has been key in the uptake by farmers.
- The EFP involves:
    - farmers attending a workshop;
    - completing EFP manual (individual farm evaluation), 4 ratings of poor through best for series of questions;
    - developing an action plan to address areas of concern;
    - attending another workshop to help develop appropriate actions;
    - peer review;
    - incentive claims - $1500 for any of the actions.

EFP MANUAL

- Work book includes 23 worksheets with 251 questions addressing environmental concerns from wells, to energy usage, agricultural wastes and natural areas such as wetlands, woodlands, watercourses.
- Aggregate data was collected from the first 2700 EFP completed from across Ontario between 1993 -1996. Data includes 1-2 ratings per farm site, barriers to taking action on these, actions and timeline to action.
- Data also collected for incentive claims includes: what worksheet question and what action, amount claimed, true cost of action as well as time put in over and above claim.
- Two other studies done: Gallivan and Furman

This study was funded by WHC to see if EFP data could provide insight into:

- current management of natural resources
- concerns of agricultural community with respect to habitat/ farmer willingness to participate in habitat programs
- barriers to conservation actions
- technical and financial needs
- habitat benefits resulting from the EFP

One can see that this is backwards rather than asking questions first- seeing what the data shows.

To do this, we examined the following worksheets:

- 15: Soil Management: included questions addressing wind and water erosion sensitive areas and marginal lands
- 19: Field Crop Management: such as sloping areas, crop rotation/cover crops
- 21: Streams and Ditches
- 22: Wetlands and Wildlife Ponds
- 23: Woodlands and Wildlife

There is a concern with taking these questions out of context of entire EFP.

CHALLENGES

Although the data set was representative when compared with census regionally, by farm type and farm size (though on average EFP farms were slightly larger because census includes any farm of $7,000 gross income). Not as simple as saying that 5% of farmers have cattle in stream, of this 80% will fence out as a result of EFP; or X amount of acreage covered by EFP's.

Essentially, the EFP Program is not designed to be able to quantify in this way but also there are too many variables; subjective in nature; and the database and format of information collected. For example - one question which looks at leaving crop residue after harvest was interpreted by several as not being able to bale straw and therefore may have given themselves a poor rating, followed by indicating in choice of barriers that 'not a priority'. This could be misinterpreted as a high percentage thinking management for crop residue is not a priority. (Changes to EFP II reflected changes to clarify this particular question). The 'not a priority' barrier should be taken in relative context to other issues within the EFP. In conclusion, it is NOT a fair environmental indicator to look at EFP data.

FINDINGS

Instead trends in ratings, barriers, actions, timelines, incentive data and other studies were examined. Activities were grouped to look for trends, i.e. cropping practices, watercourses, livestock, and wildlife. Overall study can indicate generalities only but do confirm previous assumptions that farmers are doing a good job with respect to natural areas according to their own evaluation based on EFP criteria. Also, that there are predominantly "no barriers" to taking action within EFP context.

- Those questions relating to soil erosion and cropping practices were of greater issue requiring attention and similarly of greater priority to farmer.
- Across province with the exception of Northern Ontario, the greatest claim area relates to soil management.

- Implications for habitat will depend on action including: change of crop to forages, planting trees, etc.
- Most common change was switching to no-till or conservation tillage which benefits riparian areas through reduced runoff and sedimentation.
- Changes concerning tillage were shown to occur more readily and on a quicker time scale.
- Though costly, farmers willing to make change where applicable and feasible - putting in a lot of their own $.
- More complex farming situations (may involve clay soils) showed more barriers and complexity in actions suggesting extra technical support for complex farms and the need for site specific solutions.
- One of major concerns is water quality.
- Across entire province one of major claims made is for wells. The EFP component addressing water wells was not examined in detail in this study.
- In the Streams and Ditches worksheet, claims were made most for bank stabilization, livestock on watercourses, buffers and erosion at tile outlets respectively.
- Willingness to take actions for watercourse bank stability and tile and surface water entry, though finances are greater barrier.
- Farmers quicker to take action for tile outlets and bank stability than for buffers (more actions were required for buffers according to EFP criteria but less proportional uptake).
- Livestock on watercourses is more complex - especially for high-density (low density minimal concern compared to other questions).
- Financial barriers were highest for livestock access out of the questions looked at in this study. This requires creative program attention/solutions.
- Although most farmers indicated restricting livestock access, results showed that partial reduction of access scheduled for shorter timeline than complete reduction.
- Overall results do indicate farmers are doing a good job regarding wildlife, though of greater concern is soil erosion, livestock and stream and ditch banks.
- These indications from EFP data support the notion that farmers while concerned about water quality, must balance with business aspects of the farm.
- Selling riparian management must consider realities of farm business.

PARTICIPATION

A study by Margaret Furman indicated the strengths of the EFP, why farmers participated and participation on various stages of EFP process. Results concluded that participation is greater when:

- Involved in past programs;
- Participation in EFP will have spin-offs to other programs and visa versa;
- There is an awareness of on-site issues;
- Confidence in EFP program: self-assessment motivation, workshop leaders reputation, confidence in technical information;
- Motivated by health, concerns for soil and water quality and a desire to learn about the environment.

Participation is lower when:

- Greater complexity of issues on farm - (not as straight forward i.e. No-till, more time consuming, less directly applicable);
- Perception of risk associated with confidentiality;
- Motivated by farmer image, fear of penalty, and economic incentive.

The study also found that most actions were not claimed for under incentive program which suggests that actions occurring through EFP occur because of education, not because of fear to meet legislation.

CONCLUSIONS

- Greatest value is educational component through self-assessment - taking ownership although this is the most difficult to measure.
- We can however show this through other findings such as:
    - close to 13,000 farmers have participated in EFP
    - 7,000 have completed the peer review process where the difference represents those either in process or may choose not to - still educational value.
- We've learned it's difficult to get clear answers from a program not designed from the start to answer these questions. Must design the questions from the start.
- However, wouldn't change how data was collected because the strength of the program is in the very nature that makes it not quantifiable: site specific, self-assessment, local workshops, confidential, and voluntary.
- This study did confirm some general trends. That farmers are making positive steps forward in riparian management but do require support. Best to focus on meeting site specific needs through emphasis on soil and water quality protection over strictly the habitat benefits.

3.3 Grazing Cattle and Riparian Management: Conflict or Cooperation

Peter Doris, Ontario Cattlemen's Association

Players and Issues Review

Cattle

- Need water to live.
- Riparian area provides grass for grazing.
- Does clean water improve animal performance?

Farmer

- Needs reliable water source especially on distant pastures.
- Concerns with initial and operating costs.
- Generally "Want to do the right thing".
- Land has value $$.
- Respect/credibility.

Public/government

- Increasing environmental awareness, which includes water quality.
- Sometimes conflicting values (want to do more with less).

Riparian "keeners"

- Includes anglers, some farmers, CA, naturalist.
- Want "Pristine and Natural" riparian areas.
- Exclude other activities
- Different means to achieve goal (voluntary program vs. regulations & legislation).

Scoping the Issue

- What is the target?
    - Water quality (bacteria, nutrients, etc.), fish/wildlife habitat, rural aesthetics.
- How are you trying to reach the target?
    - Targeted watersheds or universal.
    - Voluntary incentives vs. regulations.

The Potential for Conflict

Be careful what you wish for…

- Mandated buffers could create backlash with crop and livestock producers (remember wetlands issue from early 1990's).
- Remember land has value; mandated buffers = expropriation without compensation.
- Likely result in a shift from pasture to cropland up to buffer. Is the cure worse than the disease?

The Opportunity for Cooperation

Riparian and agricultural goals not mutually exclusive.

- No-till: benefits environment (less erosion) and reduced costs with similar yields.
- Agriculture is a "gray area" with riparian areas (not development but with drainage issues, tree cutting etc.).
- Farmers will often support tree planting and water quality initiatives but $$ are limited.

Grazing livestock & riparian issues. Need to:

- Integrate livestock production/important goals with riparian/water quality goals.
- Expand toolbox of acceptable practices with water quality (fencing, grazing management strategies, density and site issues - NSWCP project).

Understanding Impacts

- Clark, University of Guelph - dry lot vs. grazing, behavior observation, etc.
- CURB - little phosphorus, some bacteria
- Barton, University of Waterloo - 66% of sites with cattle access had negative impact based on benthic invertebrates.

Learning From Programs

- CURB - targeted areas and cost share.
- National Soil Conservation Program - bid to retire "fragile" lands.
- Environmental Farm Plan - recognizing the difference between intensive and extensive.
- W3 (OCA & OFAH) - importance of initial contact and willingness to undertake projects with high % of public funding.

Future Questions

NSWCP project - Can we expand the toolbox?

- Why is impact greater on some sites and what management lessons can we learn?
- Integrate water quality important with production benefits.
- Can we use animal behavior to improve production and water quality?

Future Directions

- $$ are limited; continue to see targeting.
- Science is getting better at finding "the points" in non point source pollution.
- We may see water quantity becoming as big an issue as water quality.
- Programs will need 3 components: some public $, integration of agricultural and environmental benefits through a trustworthy delivery agency.

Panel Discussion
What We've Done and What We've Learned

3.4 Rural Water Quality Program

Tracey Ryan, GRCA

- Innovative approach to addressing water quality.
- First time a municipality has funded non-point source pollution control.
- Viewed as a model for the province.
- Locally developed program, in consultation with the agricultural community.
- Regional Municipality of Waterloo depends on surface water for up to 25% of their domestic water.
- The River also supplies assimilative capacity for sewage treatment.

Water Quality Issues
- Microorganisms, phosphorus, nitrogen, sediment.

Sources of Contamination

Point Sources
  - wastewater treatment plants
  - industrial sites

Non-Point Sources
  - runoff from urban areas and rural areas

Rural Sources of Pollution
- Storage, handling and spreading of livestock manure.
- Stream bank erosion from livestock access to watercourses.
- Direct pollution by livestock to watercourses.
- Soil erosion.
- Faulty septic systems.
- Milkhouse waste.

Regulatory Approach
- Enforcement is difficult and requires strong political will.
- Minimum standards.
- Creates friction and opposition.
- Acceptable approach to intentional polluters.

Voluntary Approach
- Higher performance achieved.
- Creates trust and co-operation.
- Accepted approach to private land issues.
- Recognizes personal responsibility.

Funding

- Region of Waterloo committed $1.5 million over 5 years.
- $225,000 from NSWCP as well as dollars from GRCA, MOE and OMAFRA.
- Matching dollars will be provided by landowners.
- Leverage funding from other sources.

Partnerships
- Involve farmers at the initial stages and build consensus among all parties.
- Create allies and champions of the program.
- Develop spokespeople in the community.

Steering Committee
- 11 local farm groups, 5 provincial farm groups.
- 3 provincial ministries, 1 federal ministry.
- 2 lower tier municipalities.
- Regional Municipality of Waterloo and GRCA.

Committee Products
- Best management practices.
- Cost-share payment.
- Eligibility guidelines.
- Marketing and promotion.
- Monitoring.

Program Basics
- Voluntary
- Educational
- Financial incentives to cost-share best management practices.

Program Innovations
- Cross-compliance with the Environmental Farm Plan.
- 3 year performance incentive for non capital best management practices.
- In-kind labour allowable for fencing.
- Cross compliance between sections of the program.

Time Frames
- Planning began December 1996.
- Funding committed February 1997.
- Steering Committee established August 1997.
- Program Launch March 1998.

Proposed Outcomes
- Cost-effective.
- Improved water quality and ecosystem.
- Adopted by other municipalities.
- Healthy rural economy.
- Sustainable relationships.

3.5 Permanent Cover/Buffer 2002

Andy Graham, OSCIA

PERMANENT COVER PROGRAMS IN ONTARIO

- Funded by Agriculture Canada (now AAFC) between 1990-93 (coincided with Ontario's Land Stewardship II).
- Delivered and administered by OSCIA.
- Permanent Cover Projects retired fragile agriculture land that was subject to:
    - Severe wind or water erosion,
    - Flooding,
    - Fragile land alongside water.
- Categories for funding consideration:
    - Grass Buffers (8' - 20').
    - Grass and Tree Riparian.
    - Block Plantings on highly erodible land (<20 acre).
    - Tree Windbreaks (also wetland buffers).

- The Bidding System is what made the program unique. There were **no set** compensation rates.
- Farmers were offered an upper limit of $10,000 and submitted sealed project BIDS, in competition with their neighbors for limited county dollars.
- Value of one-time payment was based on several things:
    - One time out-of-pocket expenses,
    - Compensation for loss in net revenue,
    - Less personal contribution.
    - *Bid selection was done by trained local staff with OSCIA
- Generally, 15 year agreements were signed between landowner and AAFC, which established responsibilities and penalties for defaulting.

RESULTS

- Programs were complete sellouts.
- Many, many more bids submitted than were approved.
- 2000 projects retiring 8100 acres.
- Average pay out of $1000/acre (over 15 years, $66/acre/year)
- $8 million paid out.

- Program also had a demonstration component. These 40 sites served as local examples, and are still in place. Something you may wish to consider if you're looking for field research sites.

A quote from Doug McVicar (who by the way was delighted that we actually **came back** to the site after 6 years):
*"I think more farmers would be willing to participate in similar land retirement projects, if there was better communication amongst the various conservation and farm groups. Farmers are looking for **ideas**, not always compensation."*

THE US NATIONAL CONSERVATION BUFFER INITIATIVE

Objective - 2 Million miles of buffer by 2002 (equates to up to 7 million acres).

- It is all across the US, and is currently in place (began in 1996).

- The Buffer Team that has been assembled to fund and promote is most impressive:
    - Natural Resource Conservation Service and many, many federal agricultural and wildlife agencies,
    - Numerous wildlife conservation and clean water groups (NGO's), and
    - Major agricultural Corporations i.e. Cargill, Monsanto, Pioneer Hi-Bred, and more.
- This program has a continuous sign-up.
- Offers from farmers and ranchers are automatically accepted, provided the acreage and producer meet certain eligibility requirements.

PROGRAM COMPONENTS:

- Grass Filter (minimum of 25')
- Riparian buffer (55' to 150')
- Windbreaks, contour buffers, grassed waterways.
- Not just streams but also within the field and field edges. This broadens the definition of Buffer.
- Keep in mind this program is intended to build on the CRP.
- Alley Cropping - Interesting that alley cropping has been included.
- Up to 2000' buffers around community wells.

PROGRAM PURPOSE

This is very interesting, and reveals, I think, why this has received such outstanding agency and corporate support.

To purchase environmental benefits for the public. For what?

- Drinking water protection,
- Soil erosion control,
- Fish and wildlife habitat,
- Biodiversity,
- More scenic landscapes,
- Ensure environmental quality,
- Continued farm productivity (profitable).

COMPENSATION FOR FARMERS

- Average Annual Cash Rent (based on soil type and reviewed annually)
- + 20% incentive (to get their attention)
- + 5% for maintenance
- Plus 50% cost share on estimate (up-front costs)
- These are 10 or 15 year contracts.

WISCONSIN

- Has 4500 acres enrolled to date between filter and riparian with an average compensation of $120/acre/year.
- General comments from Susan Butler, Program Specialist:
    - State wants 80% of named rivers and streams to be buffered by 2002.
    - 50% of the riparian strip width must be planted to trees. Trees are <u>not</u> favored along trout streams, in fear of drastically changing stream conditions.
    - Rental rates are below Wisconsin farmer expectations.

- Farmers want option to graze or hay the strips. Want more flexibility in agreements.
- Some want single payment up front, rather than annual pay outs.
- Performance to date has been modest at best.

IOWA

- Has 100,000 acres enrolled to date equates to 10,000 miles (average 85' width) of which, 80% are filter and riparian with an average compensation is $150/acre/yr.
- General comments from Duane Miller, Iowa Resource Conservationist:
  - design decisions are ultimately the farmers,
  - no requirement to put projects on deed,
  - buffers in no way provide access to public for hunting, fishing, hiking.
  - *"If there were no rental payments, we'd see only 10% of current participation. If society wants results, they've got to be willing to compensate for it."*

3.6 Lincoln Waterways
Fred High, Lincoln Waterways Working Group

Fred High is the landowner and host farmer for the Lincoln Waterways Working Group.

The nature of my farm business is diverse and the nature of my farm's soils and topography is also diverse. The task of the Lincoln Waterways Working Group (LWWG) has been to develop demonstration projects that meet the needs of the soil and watershed but also the farm business and the site conditions - plus have projects that other farmers could use on their property.

Introduction to LWWG
LWWG consists of provincial, municipal, agency and individual volunteers.

- Linda Barbetti, Ministry of Natural Resources
- Donna Speranzini, OMAFRA
- Kathy Menyes, Niagara Peninsula Conservation Authority
- John Kukalis, Town of Lincoln
- Allan Yungblut, Ontario Soil and Crop Improvement Association (OSCIA)
- Felix Barbetti, retired MNR Area Manager
- Fred High, host farmer and member of Niagara North Chapter of OSCIA

Our Challenge

- Group came together through conflict and controversy, much of which was misinformation.
- By working together, we developed a common understanding of our collective objectives. We set aside individual agendas and have all agreed to leave our agendas at the meeting room door.
- We used the skills and talents of everyone at the table.
- In 1 very busy year, we developed consensus, designed works that met common needs, found agency and community support and built the water management works that would improve soil and water quality on the farm and for the watershed.

What You See At The Farm And What You Don't See

- The 'Soil and Water Conservation - Demonstration Farm' brochure (included as Appendix E) and the display list show the wide range of works that are demonstrated at the farm.
- It is difficult to appreciate the problems that these works corrected - they were not large site problems but they contributed to an overall large watershed problem.
- I realized that "I can't farm my fields when my soil is in Jordan Harbour".
- Other members realized that they had to work with the landowner to see changes made - they couldn't come on the farm with a "tell you so" attitude, or "you can find your way back down the farm lane".
- We did as much "people work" as "physical work" to share understanding, find ways to compromise, learn how to teach.

The work continues…

- We have toured groups from Costa Rica, Toronto, Oxford, Hamilton, Haldimand and all corners of Niagara through the farm, including: public agencies, interest groups, governments, farms and children.
- Local board of education wrote tour guidebooks, curriculum guides and workbook for teachers and students. These have developed into 4 learning stations (see Appendix E) and we have trained tour guides to help people get the most information and understanding from their visit to the farm.

The learning continues...

- I have learned that agencies can work together, the farmer does not need to be caught in the middle but is an equal partner. The farmer is the key decision maker on how land and water is managed when he or she decides to participate and have a project on their farm.
- Being willing to learn from others is key.
- Conflict can be good - it can bring people together.
- We need to have an “open mind” - I was skeptical about being able to accomplish so much in so little time. However, with everyone working together, the energy, the knowledge, and the resources that each of us brings to the task, a lot can be accomplished.
- Open mindedness to get involved in a “first” project opens doors to a network of talent, and knowledge leading to participation in seminars and workshops like this - it wouldn't have happened if there was no involvement.
- Your task is to get involved and to build more opportunities for participation by researchers, landowners, farm groups and government departments.

3.7 Big Head River Demonstration
Ray Robertson, Grey County

Goal: To reduce potential conflict between agriculture, wildlife and fisheries: Focused mainly on fisheries.

Project Highlights
- Completed 120 individual projects with 60 landowners.
- Farmer driven initiative.
- Team approach to delivery.
- Partnership - Steering Committee (4 OSCIA, 1 OMAFRA, 1 MNR, 1 CA, 1 Municipality).
- Very practical approach.
- Knew we couldn't always achieve 100% solution knew 95% was better than nothing.
- Prompt attention to calls. Cheques issued quickly.

Type of Projects
- Innovative - tailor made solutions.
- Alternative watering facilities - gravity (springs, ponds), solar panels, nose pumps, restricted access.
- Crossings - truck bodies, quarry stone.
- Bank stabilization.
- Fishery rehabilitation - rock, bio-engineering.

What we Learned
- Team work critical - assigned specific responsibilities to each resource person, i.e. bank stabilization to CA's, fisheries/bioengineering to MNR, conservation tillage and alternate watering to OMAFRA.
- Monitoring - before and after pictures really effective
- Electro-fishing resulted in a 349% increase in fish numbers. Farmers said we didn't even need to test to prove numbers. They could see the increase in fish.
- Didn't monitor water quality.
- Projects have to be sustainable and will continue to improve as they mature.
- Very successful model both financially and operatively.
- Tremendous buy-in and support from the farm community and beyond.
- EFP is also a good stepping stone - stimulates the thought process.
- Still is real need for assistance to farm community. There is a willingness to improve.
- Need for a continuity of programs.

Funding and Statistics

- Over 900 volunteer hours and 235 in-kind hours.
- 12,548 metres of fencing installed.
- 35,000 trees planted.
- Funding very difficult to obtain, next to impossible. CanAdapt (Adaptive Council) and Action 21.

Beyond Green Plan Funds

Material	$13,700
Labor	$48,170
Equipment	$29,000
Other	$21,900
Total	**$112,770**

Alternate Watering - Average Cost per Project

Gravity	$1578
Nose pumps	$350
Energy Fees	$954
Restricted Access	$353

Crossings - Average Cost per Project

Flatbed	$2062
Culverts	$630
Low level	$1474
Flat slabs	$1210
Low level gabion stone	$845

Bank Stabilization - Average Cost per Project

Field stone	$40.42/metre
Shot rock	$34.10/metre
Bioengineering	$4.29/metre

3.8 James Berry Drain

Peter Bryan-Pulham, Township of Norfolk

One could say the establishment of a buffer zone could indeed be classed as a 'riparian zone'. How wide is a riparian zone? Can this be controlled by a specific number picked from years of research or simply dictated by the topography of the land?

The buffers on the James Berry Drain in fact were established at 30 feet width which basically complements our zoning by-law adopted for set-backs on drains for the purpose of maintenance. Our first mistake was the assumption that just maybe 30' could become that magic number. Topography has a lot to do with the implementation of a buffer simply from the standpoint of a farming operation. Basically it's hard to turn a tractor with a plow or disc behind it on the side of a steep hill. Or it's extremely easy to complete the same turn on flat ground.

Vegetation

What to do, What to do?
The MNR suggested a mixture of birdsfoot trefoil, white dutch clover, creeping red fescue and Kentucky blue grass. This seemed reasonable to me but then again I couldn't tell the difference. I do know that weeds that naturally take hold certainly out perform any mixture planted.

Erosion

The erosion along this drain has been reduced drastically with stabilized banks.
Specific access points for water entry to the drain has contributed to erosion control. Field erosion of sediments has been a problem in the past. Buffer strips which have natural grasses planted, i.e. the Prairie Aster, stands up to this by holding the sediment on the field and out of the drain.

Water Quality

Our small window of opportunity in testing, i.e. nitrates, seemed to display a decrease in levels at stations set downstream along the drain. Not conclusive - however exciting to think the buffer may have acted as a filter.

Maintenance

Certainly a problem which may be perceived as opposed to real, however people in general do not like weeds. Perhaps an educational program would help. Cutting these buffers seems to be the only practical method. At least with cutting, the root system remains intact and healthy. Brush for instance seems to grow thicker with every cutting.

Acceptability

Presently we've established additional buffers along Cranberry Creek Drain and more recently the Little Otter Creek Drain. A personal willingness by the landowners to make these buffers work. Good experiences seem to spread slower than bad experiences so remember pick and choose potential areas carefully.

Summary

Buffers do keep maintenance costs down. They provide access to the drain when maintenance is necessary. Planned maintenance can take place in the time frames recommended by the Department of Fisheries and Oceans and the Ministry of Natural Resources. The area of the buffer must be considered useable by the landowner whether for pleasure or worked into their specific operations. This certainly comes true when there is no financial contributions or incentives available.

Know who you are dealing with. Be specific on terms within an agreement. This particular project recently had a snag regarding fence maintenance. We ended up having an agreement in writing to secure who is responsible for what. It is now re-visited each year for plausible changes.

4.0 Knowledge Gaps
Compilation of Day 1 Discussion

The discussion from this sessions questions were recorded and have been compiled into a series of themes. Care has been taken to ensure that all participant viewpoints are listed. The discussion points remain in a raw state in order to truly represent the opinions of those involved. For a complete list of the participants, see Appendix B. The discussion did not lend itself to be slotted into the asked questions - the following questions were meant to initiate and guide the discussion.

How clear is research information on riparian zone function? What other aspects are important to understand? Where it is not clear, what is needed to heighten understanding?

Is current research meeting the needs of resource mangers and practitioners? Is it Practical? Does it address the issues?

What are your recommendations for future research and communication?

The following themes emerged from the discussion:

- General Research Thoughts
- Riparian Definition. What We Need To Consider/Include.
- What Practitioners Need?
- What Researchers Need?
- Management Issues
- Regional/Watershed Context
- Need to Link...
- Linking Research and Communication
- Research Questions/Gaps
- Monitoring
- Restoration/Rehabilitation
- Other

General Research Thoughts

- Avoid use of fast science - lack of proper literature review to support assumptions.
- Dynamic tension - need quick science because of tight timelines.
- ‘Don’t look for a global solution - value of the answer is the process.
- Are grads pursuing societal questions or their personal interests?
- Do we even know the basics?
- Is the answer a value or is it a process?
- Research is addressing the issues - just not enough research.
- How does each type of system react - need to have standards.
- In order to have clear research, we must know what scenario it was collected under.
- Keep adding to existing research from various disciplines.

- We tend to want to use a number rather than being innovative. Research is reactionary to site needs.
- Research is too segmented, looking at one problem at a time.
- Research should look at all functions of the riparian zone.
- We need to ensure that the 1st and 2nd order streams continue to exist prior to worrying about riparian zones. We need to recognize the long-term costs of preserving these ecosystems, i.e. cost/benefit analysis, future maintenance.

Riparian Definition. What We Need to Consider/Include.

- Definitions are numerous and confusing to the non-expert.
- Buffer width depends on function to be protected - we need to define function!
- Eco-tone: interface between land and water. Could easily be applied to riparian areas.
- Every discipline looks at buffer in different way. Need to consolidate functions.
- Must understand the difference between urban riparian zones and rural riparian zones.
- Define buffer vs. riparian zone. Riparian zone: adjacent to water, ecosystems periodically in touch with water. Buffer zone separates something from something else.
- Not enough scientific support for defining outer limits of riparian zones.
- Need OMB defense definition. Need scientific legislative/politically definable definition.
- Need to have multiple criteria for defining riparian zone.
- Unless we can define why we need to protect riparian zones, we will lose them.
- Combination of biological/engineering discipline.
- Define a critical buffer zone instead of a stream buffer zone i.e. trees protecting stream should be protected not just the stream.
- Include the functional characteristics: vegetation, flow, nutrient uptake, bank stability.
- Need to clearly define the needs of the manager, the issues, and the zone.
- Need to incorporate hydrology into assessment of functions and processes rather than focus on a riparian feature. Determine what features are important and preserve them.
- Has to be a science - need to get to this state in order to defend at OMB - needs to be repeatable.
- Our knowledge is good, but needs to be more practical - needs to become more defensible.
- Enough knowledge exists to document the need/use of riparian zone by user group i.e. farmers, biologists.
- Must understand controlling parameters before can integrate it into a design.
- No framework exists to look at zones or to put it into context.
- No uniformity in buffer width - forestry vs. urban. Currently, width is arbitrary.
- Technical question or ethical? Need better defense of widths.

What practitioners need?

- How do we use existing research and information in discussion with OMB and developers?
- Indirect benefits of riparian can't be quantified yet must be defensible in court. Need to be able to quantify and defend if damage is caused.
- Interdisciplinary approach to research needed.
- Key functional aspects are understood but need to be put under one umbrella.
- More detailed research on a watershed basis.
- Need a synthesis of all functions for practitioners.
- Need criteria that are flexible/site specific. Actually need to go beyond riparian zone.

- Need for applied research - look for assumptions to challenge.
- Need more collaboration and long-term studies.
- Need to close gap between data and information.
- Need to create knowledgeable information for practical application.
- Need to put scientific information into 5-6 parameters that are easily applied by practitioners.
- Research needs to be hooked into practitioner needs.
- Is it better to create a riparian zone automatic 10 m buffer or to understand the system and create riparian based on that?
- More variability of buffer width in rural areas. In rural areas, we are still into 'art' - we are missing data - information - knowledge - wisdom.
- Need to identify differences between urban and rural factors influencing riparian areas.
- Develop appropriate planting plans that suit the application, i.e. maintenance concerns, aesthetics, high flows.
- Develop multi-discipline indices for assessment of restoration goals and longer term stewardship.

What Researchers Need?
- Need multi-disciplinary teams.
- Researchers need more access to physical sites.
- Time scale is a problem.

Management Issues
- Desire to go from regulatory approach to functional approach.
- Develop a hierarchy of needs for information. Identify key information needed and tailor it to different levels and costs of collection. Determine whether landowners/cottagers can collect the information vs. a consulting firm.
- Everyone is working off different indicator charts.
- Have managers and scientists together give guidance on where to maximize efforts and how best to focus the few dollars to make most difference.
- It is not precise - must create a process. Take research and derive a process tool.
- Management has to drive the research because the concept and idea is moving so fast.
- Science alone isn't enough, we need political will.
- What objects are we managing for? Is it to buffer nutrients from agricultural land vs. habitat function. Objects then change buffer requirements.
- No congruency - how can you integrate a design when nobody can agree on the process.
- Results are so variable that how can we really give a formula without knowing all the parameters but we don't have the time or money.
- We've done a good job of selling the idea of hazards but not riparian zones.
- What do we value? Society shouldn't cover this with scientific/economical questions and issues. If creeks are valuable, then protect them.

Regional/Watershed Context

- Application of transferability from watersheds with streams and those with lakes (Northern Ontario vs. Southern Ontario)
- Comparing papers is difficult: clarity within regions is available, clarity without regions is lacking, riparian interaction with the rest of the watershed unknown.
- Forest Management Plan occurring in the north needs to be translated to the south.
- Need to include riparian issues with other ecosystems (wetlands, woodlands, agriculture) to have true watershed plan.
- Northern climatic conditions are different than many study areas.

Need to Link...

- Link educational and research institutions through job placements.
- Linking science and researchers to practical application.
- With engineers. Need for new drainage engineers report. Why should the engineer have the end responsibility? Practitioners have the knowledge to design. Could engineers release this responsibility?
- Need to link biological community research with engineering.
- Need to link graduates or college students with real issues. No facilitation here.
- Research institutions need to be encouraged to develop partnerships to help agencies.

Linking Research and Communication...

- Current research needs to be assimilated and made available to users.
- Existing information is not connected and not found easily.
- Good science but need to synthesize it and translate it to practitioners.
- Inefficient at dissemination of knowledge we have now.
- Lots of information available - needs to be synthesized, applicability to Ontario needs to be assessed.
- Identify gaps needed to develop good guidelines.
- Lots of theoretical information - need to turn this into management perspectives.
- Need communication between researchers and outside of researchers.
- Need consolidation of research - what we know. Need interrelationships of components.
- Need documentation of successes and failures.
- Need for researchers to share their undertakings and then pass this onto practitioners.
- We can all benefit from pulling research together and then identifying the gaps.
- We need a synthesis of existing information to communicate the science effectively to each user.
- Workshops like this are ways to keep up with the latest information through discussion. Otherwise looking at one scientific paper and taking it as gospel - without knowing pros and cons and issues surrounding site specifics.
- Is the gap in getting information out of an academic system to a practical system?
- Transfer of information is a problem not necessarily the information itself.

Research Questions/Gaps

- Tile drains as short circuits of riparian zones. Need to address these discharges. Have seen some research in Sweden but none in Ontario. There is research on water quality from tile drains but on how tile drains impact buffers needs to be researched. Review existing information on integrated tile drains, i.e. Chesapeake area.
- Need to incorporate tile drains into buffer zones.

- What motivates people to improve buffer - both rural and urban?
- Need research on appropriate vegetation type to suit stream location, maintenance, aesthetics.
- Define what will be lost/gained by establishing riparian zones.
- Seasonal overflow from nutrient management and recharge potential (water quality/quantity).
- Need to develop more basic monitoring techniques.
- How do we measure value of buffer zone?
- Practical riparian buffers that would be compatible with southern Ontario agriculture.
- Research components of riparian zone (soil organisms, soil characteristics, drainage).
- Link research to human health and social perspective.
- More information on biological productivity in riparian zone.
- Need basic research on basic parameters to develop recipes.
- Need guidance at reach or watershed level i.e. bank stability.
- Channel morphology. How to design corridors around different channel types?
- Need information on urban context. Currently lots on logging and fish.
- Need more information to take to landowners to convince them of the importance of riparian zones. What's in it for me?
- Need more research for specific settings. Move to predictive capability.
- Need to clarify buffer zone effects on phosphorus levels.
- Need to research legislative tools and lack of effectiveness, i.e. wetland policies cover wetland but not wetland area. Need to include sloping area in riparian policy.
- Need to understand parameters more clearly in order to apply site specific solutions, i.e. need to know where nitrates are coming from to know what to do.
- Need research on buffer width, trade-off between widths and benefits, types of buffers.
- Water overflow - groundwater research needed.
- Are abatement measures working? We need some examples of successes and failures.
- What are thresholds for sink/source habitats?
- What do you use as an indicator: benthic invertebrates, chemistry?
- What types of vegetation are best and how should they be maintained? How much clearing can be done without compromising buffer function?
- Are there agricultural uses that can be profitable to landowner and still be functional as riparian zone?
- Need to challenge landowner assumption that they lose productivity with buffer establishment.
- Dry year like this asks the question of storage and recharge. Looking at long-term benefits, concerns and rehabilitation.
- How do urban residential developments offset riparian zones? How to mitigate these effects? Limiting factors - squirrels, cats, kids, mountain bikes.
- How to promote buffers on agricultural land - economic benefits i.e. nut crop?
- Need to be able to define balance - optimum economic buffer width.
- Research the riparian zone as a functioning unit.
- If temperature is the limiting factor, determine buffer strip needs plus corridor functions.
- Need to review the applicability of various abatement technology (i.e. engineered) vs. natural processes.

Monitoring

- All monitoring programs need deliverables - presently no accountability for objectives over time.
- Time frame on studies of nutrient attenuation is too short.
- Need long term monitoring for new urban riparian areas put into the planning process.
- Therefore need monitoring in the long term.
- Develop monitoring techniques and results.

Restoration/Rehabilitation

- Restoration priorities are not clear for areas that are extremely degraded.
- Set out process for restoration based on stable ecosystem nearby.
- There are good stream rehabilitation manuals.
- There is very little expertise available easily in rehabilitation efforts.

Other

- Use % forest cover minimum requirements for healthy catchment basins.
- Issue is market failure. Need help for effective policies, programs and better decision making.
- Need to get a forester to explain function of various types of trees with respect to their ability to maintain for example, slope stability.
- Site specific aspects. Must have an understanding of individual site but policies are standardized. Need adaptability to different activities to know what type of width, vegetation.
- Site specifics make general knowledge difficult.
- Need a strategic plan to increase land to certain % forest cover.
- Trade off between research and developing a setback number. We need to balance this with site specific analysis. We need to compromise at times between science and in field application.
- Voluntary projects are currently based on art not science.
- When measuring nitrates in water maybe we are looking at landuse practices from 40 years ago.

5.0 How Can We Balance and Better Implement Land Management in Riparian Zones?

Compilation of Day 2 Discussion

The discussion from this sessions questions were recorded and have been compiled into a series of themes under the given questions. This data remains in a raw form in order to present a true representation of the discussion. Care has been taken to ensure all participant viewpoints are listed. For a complete list of participants, see Appendix B.

Is riparian zone management necessary and if so, important to whom and to what degree? If not, why?

If riparian zone management is necessary, what implementation tools and vehicles are needed by landowners to increase adoption?

How appropriate are current programs, policies and regulations? What is lacking?

IS RIPARIAN ZONE MANAGEMENT NECESSARY AND IF SO, IMPORTANT TO WHOM AND TO WHAT DEGREE? IF NOT, WHY?

Important to whom…

- To agricultural community/farmers.
- To municipalities.
- To communities (people).
- To fish and wildlife, recreational users, hiking, canoeing, naturalists, anglers/hunters.
- To educators (guides, scouts, teachers).
- To eco-tourism.
- To landowners.
- To communities that take water.
- Ultimately important to society as a whole! Means different things to different people.
- To developers.
- Need to manage riparian zones with equal value to other entities (farmer, recreation).

Important for…

- People don't know the value and don't value or understand the interconnectedness.
- To ecology, both composition and function.
- Wildlife and habitat.
- Water quality.
- Water quantity.
- Farm productivity.
- Property value.
- Aesthetics.
- Community health.

- Economics (i.e. tourism, recreation, farmers).
- Biodiversity.
- Long term sustainability.

Concerns
- Trespassing - liability, vandalizing, trampling.
- Possible restrictions on land use.
- Loss of productive land.
- Not going to pay for public/common good.

IF RIPARIAN ZONE MANAGEMENT IS NECESSARY, WHAT IMPLEMENTATION TOOLS AND VEHICLES ARE NEEDED BY LANDOWNERS TO INCREASE ADOPTION?

Several themes arose from this question, they are:

Communication/Education Plan
Rural
Mediums
Economics
Other Management Issues
Urban
Community
Demonstration Sites
Tools

Communication/Education Plan
- Landowner education is key to change land use or management of riparian zones. Need to show impact on their lives.
- Develop public education program, i.e. elementary/high school, university/college, adult.
- Back to School systems - children will take information to parents.
- Try to communicate 'the why' so contractors know and build their knowledge.
- Present benefits for all participants.
- Protection - Restoration - Recreation.
- How do we reach developers - not just farmers?
- Need a COMMUNICATIONS plan. Who is the audience? How to target them?
- Need new blood so don't burn out few that are involved.
- Need public support for research. Inter-disciplinary approach to a functional system.
- Sell it through the hydrologic function - storm water.
- State the objectives of the riparian zone. Translate objectives into a series of minimums, i.e. with 2 m this will be the effect, with 10 m you get this.
- Learn and relay lessons from those projects that have failed.
- Show everyone the big picture. Healthy riparian zones = healthy rivers = healthy watersheds = healthy oceans = clean water = improved human health.
- Everyone has a responsibility to participate in protecting riparian zone. Stress global implications of local action.
- Communication - style and presentation among different perceptions, cultural groups, urban/rural i.e. define beautiful creek!
- Clear up misconception that neat, controlled and mowed is beautiful and healthy.
- Marketing ⇒ values ⇒ community opinion ⇒ leaders ⇒ politicians ⇒ Members of Parliament ⇒ Foundations ⇒ Non-Government Organizations.
- Develop and implement a course for PPI Professional Planning Institute such as the Wetland Restoration Course. Need to get information to managers through training course.

- Education on natural variability in the ecosystem. Develop forecasting technique using landuse and forest cover about how a system would evolve over time.
- Need to get riparian awareness like wetlands.
- Need to get young people on track with this. Current curriculum does not allow for this.
- We need an education process to get those affected to understand.
- Currently there is a lack of a coordinating (champion) body that keeps research integrated and relevant, keep citizens informed and politicians accountable. We have to learn from experience (concept of adaptive management) i.e. successes and failures.
- Develop a network. Practitioners need to be kept informed of research.
- Need better communication on Drainage Act/Water Resources Act.
- Need to establish a group to take leadership and coordination roles.
- Need to improve communication - pull together all disciplines.
- Develop partnerships with universities and municipalities.
- Need to change mindset from geometric to natural.
- Need to train engineers in sustainable development and natural channel design. Need for curriculum change in university course.
- Often landowner doesn't see functional aspects of riparian zone - only weeds. Need to change this.

Urban

- Issue of landowner/privacy.
- Need to educate urban citizens before will get action in urban riparian zone.
- Need riparian zone management in parks and promote benefits to 'landowner'.
- In urban setting - riparian zone is a set-back zone. It looks nice but low function.
- Double standard exists. Rural landowners are pressured to keep cattle out of the streams and develop riparian zone. Urbanites won't relinquish part of their land for riparian establishment.
- In both urban and rural situations, economics is a strong factor in riparian implementation.
- Somewhat easier to sell the idea of natural landscape in new developments - depends on local municipality and build it in before houses.
- In existing urban development you have to retrofit it in which is very difficult, long-term, deal with previous mistakes, lack of land base.
- UDI - Urban Development Institute (municipal planners). Get into these organizations.
- Urban residents are appreciating green space more and may support an increase in riparian areas.

Rural

- Need to convince rural land owners of benefits.
- Issue of landowner/privacy.
- Need urbanites and farmers to work together.
- Rented land - less stewardship - harder to negotiate buffers. Do you work with tenant farmer or absentee landlord?
- Rural landowners have more connection/ownership to land.
- Easier to see results in rural settings.
- Recognize that rural and urban situations are very different.
- In both urban and rural situations, economics is a strong factor in riparian implementation.

Community

- Peoples concept of time limits their understanding of what the landscape should look like. Especially taking into account the improvement since the 1960's.
- Local community wants to try and influence politicians except they don't know where to push.
- Get everyone involved in community projects, even those who don't own land. People have to see that they are linked to the watercourse.
- Need to acknowledge landowner issues. Without landowners, we can't do what we want to do.
- Mennonite community has special concerns - require patience.
- Source protection programs are a good example how public pays for environmental protection.
- Biggest leap in urban areas is getting designation then develop community stewardship.
- Get the voters interested and council has no choice but to follow.
- Community involvement is a catalyst to implementation, i.e. school groups, youth groups, naturalists, etc..
- Need human touch - 4-H, Friends of ... etc. will generate more interest.
- Need to go beyond site specific. Community outreach will guarantee involvement.
- 'Think watershed, act on a site-specific basis', neighbors working together will make things happen, creating a sense of community and pride.

Mediums

- Need to develop communication mechanisms. Lack of photos/images. Are we talking about the same thing from the start?
- Produce a video on functions (OMAFRA or Town & Country).
- Brochures.
- Media (local newspapers), magazines, farm publications.
- Riparian bulletin/journal.
- TV Commercial.
- Use testimonials for landowners with projects.
- Are web sites effective? Does it get to landowner?
- Need a BMP manual. Re-package existing information into a BMP format.
- E mail is means to keep the managers connected but not landowners.
- Hot lines and websites are helpful for public but must be ongoing and updated.
- Workshops are great but need to be initially interested before even going to a workshop or open house.
- Put on workshops like this for farmers but instead of charging, provide an incentive for attendance.
- Need for more workshops focusing on riparian areas and functions of riparian zones.
- If multiple landowners are concerned hold an Open House/Public Information Forums. Use visuals. Soft sell rather than pointing fingers.
- Need a centralized list of ongoing or recently completed research.
- Directory of all people involved - researchers, community groups and demonstration projects.
- 1-800 number to centralize information: education, research, assistance, programs.
- BMP for naturalizing golf courses.

Demonstration Sites

- Demonstration sites go a long way in getting message across.
- Combine resources to rehabilitate a small watershed as a real-life example.
- Spearhead 1 or 2 landowners to do it right, earn their trust and they will spread the word.
- Ideal situation is to have a good example in each watershed. You need local results to get uptake in the area - then the landowner spreads the word.
- Actions should be suitable to regions i.e. in Eastern Ontario - maintenance, in Durham Region - improve, in urban areas - mitigate degradation.
- To increase public awareness - be visible and do the demonstrations well.
- Innovation backed up by demonstration with data describing benefits, if any, to rural/urban situations.
- Benefits are viewed by people who aren't involved and peer pressure wins them over.
- Small projects are important for total cumulative impact. Variations of scale - continuity for small projects in perspective of big picture.
- Signage is important.
- Reinventing the wheel isn't profitable - need to catalogue existing demonstrations.

Economics

- Define distinction between shareholder and stakeholder. Need to involve shareholder.
- Need full cost accounting for ecological function.
- Need to show economic benefit to landowner/farmer.
    - Promote alternative economic functions, i.e. buffer with Christmas trees/fruit trees.
    - Need to collect information on herd health benefits. We presently rely on anecdotal.
    - Need to identify benefits, i.e. rotational grazing schemes.
    - Parallel riparian zones to no-till which was sold on agronomic benefits not environmental benefits.
- Different perspectives on time scale - environmentalists want long-term benefits and farmers want an annual crop.
- Must compromise with landowner to balance landowner costs.
- Have there been any objections to corridors because of wildlife, i.e. crop damage/predators?
- Need more creative methods of combining buffers with crops or agroforestry.
- Sociological benefit works over dollar value.
- Sweat equity by farmer - farmer will manage land.
- Tax incentives/rebates.
- Develop cost benefit analysis in laymen's terms.
- Green economics - attach value to clean water, clean air.
- Issue of Tragedy of Commons (tile drains and landowners). Need to include economics so as to show true cost of making changes. Who pays? Not just farmer cost, it's a societal cost.
- Need to make buffers more attractive economically so it's an easier sell.
- Put a value on functions performed by riparian zones.
- Who pays?
- There are commonalties with implementation - communicating leading to economics, data/understanding.

Tools

Landowners need…

- Knowledge.
- Materials - education and construction materials.
- Technical assistance. Challenge in community projects to get proper technical expertise on site for major projects
- More volunteer coordinators to manage grass roots projects. Coordinators need to be paid to ensure that priorities are determined and resources maximized.
- A streamlined stewardship process - through GRCA or municipal office.
- Urban tools of planning - keep what is working and fix what is wrong.
- Implementation built from the bottom up. Give the people the tools to implement and manage the riparian area.
- Develop the existing tools that work.

Other Management Issues

- Not managing riparian zones - we are managing people or human use of riparian zones.
- Just as there is no one riparian zone answer - there is no one management plan. Need a consistent approach rather than a single answer.
- Management may or may not be necessary. It may or may not be wanted by landowner.
- Landowners have a static view of landscape evolution, i.e. keep it tidy.
- What is good riparian management to one is not to another.
- Need to get all players at the table despite initial pain involved. Costly for time and effort but will work in long run. Spread through word of mouth for a common cause.
- Need some agreement on language before we are able to communicate, i.e. buffer = corridor = riparian area?
- Analysis of gaps - develop knowledge tools needed.
- Are there projects around where buffers were designed with wildlife habitat as the main criteria? Have these been monitored?
- Must be managed within the context and must include other aspects, i.e. flood ponds.
- Need suggestions to guide watershed scale planning efforts.
- Access is problematic.
- Given that buffer zones are established - who manages the zone? Depends on what the use is.
- If buffers are retired, will one agency be assigned to the zones?
- Not a quick enough response, i.e. 1998's dry year should be used as an education/marketing tool.
- Networking keeps you in touch and up-to-date but as people retire/move and with cutbacks, the network breaks down.
- Fixed buffer widths breakdown in small order stream situations. Spatial issue - functional features are accounted for in large and medium systems. What do we do with smaller streams?
- If managers and scientists can not determine exact guidelines and widths - how could the landowner?
- Need a balance in use and non-use. Can we manage for both natural and human functions?
- Our management has gone ahead of our knowledge.

- Set guidelines from the other end. Set standards that must be met by the riparian zone and the width is determined by the landowner in response to the criteria.
- Wildlife and other components are not encompassed in plans for management.
- Difference in how we treat rural/urban landowners. Property rights issues.
- How do we recognize landowners successful BMP's?
- Kettle of fish - pressure of society vs. compensation to owners.
- Social issue - what people perceive of something we use?
- Riparian Rights - our responsibility to the land.

HOW APPROPRIATE ARE CURRENT PROGRAMS, POLICIES AND REGULATIONS? WHAT IS LACKING?

Programs

- Is information getting out on what programs are current? NO. Need a 1 800 number to centralize information: education, assistance, programs.
- Need a program to back up regulation and provide positive incentive. Size of buffer/type of buffer linked to expected results linked to incentives. The more you do the more money you receive.
- We don't fund programs, we fund projects.
- Build on the following concept for riparian zones. Wildlife habitat getting money from duck stamps - a portion of money goes back into environment. Various programs in the US that are linked to anglers and hunters.
- Money come from syntax for a green fund.
- Model the EFP - completely voluntary approach.
- Funding for riparian zones should be voluntary and long term. Farmers will choose 50% of manure storage funding and avoid low return, on-going maintenance projects like riparian zones.
- Need maintenance payments funded.
- Need organization to continue funding.
- Municipal governments doing source protection programs should develop a program for urban taxpayers to help urbanites understand their role in riparian zone management.
- Stewardship - people have to feel they have a stake in it. This takes time to mature and is the real problem of no long-term vision or funding commitments.
- Ministries and Farm Groups should lobby for a 'Buffer 2002'-type program.
- US programs - society is renting buffer strips - not sustainable.
- CFIP, MNR Stewardship programs - bring people and money together.
- Need to create incentives to establish buffers, i.e. tax incentives.
- Need to obtain a 'buy in' program. Get them to tell you why they (landowner) must do it and its' importance.

Policies and Regulations

- Need an easy to follow document on what legislation kicks in when and where.
- Do need legislation to enforce those extreme non-compliers but now municipalities only need have 'due regard for' so even though it is in the policies, its up to municipalities to be more green or brown.
- Existing policy is obviously not strong enough when blatant destruction of riparian zones is evident.
- Need explicit protection for riparian zones under one act - whether a new act or a revised existing one. Current fines are lunch money for large scale developers.

- Policies can work with regulation. How do you sort out balance between policies?
- Policy ⇒ Regulation ⇒ Legislation. Degree of flexibility in buffer size should reflect uncertainty in function needs.
- Recognize the need for riparian zones. Established that it is desirable and should be left on the landscape. How do we plan for it?
- Regulations are the least favorite in rural areas. Use what you have now. Can protect riparian zone if they exist. Remember that minimal standards = minimal environmental benefits.
- Too much bureaucracy.
- Urban development in rural areas. Need to develop more progressive policies, adaptive management policies, policies/criteria with 'long' vision and criteria rather than policy.
- Include riparian areas in Planning Act.
- Make municipal and regional governments accountable.
- Municipal implementation process is a barrier. Zoning by-laws and site plans need to be flexible. Innovation is discouraged by major delays in the approval process.
- Need guidelines/policy/better planning tools.
- Need information for planning and for implementation.
- Need political/regulatory will to enforce.
- Need strong provincial standards - currently what exists is piecemeal.
- Tile drains/ditches/Drainage Act - don't jive. Legislative problem.
- Incorporate watershed planning in official plans.
- Need data analysis to support policy.

What is lacking?

- Can't consider legislation until we have a number. Important to have the right number. Degree of flexibility needs to relate to the degree of uncertainty.
- If we can't define it - how can we regulate it?
- Inter-agency collaboration is needed.
- Lacking - how do people know where to go for funds.
- Lack of a continuity in programs and follow-up.
- Lack of consistency in delivery.
- Lack of a water budget for information of general functioning of watersheds..
- Lack of cumulative assessment on water taking permits.
- Lack of people and money for programs, research, monitoring and analysis.
- Lacking a State of the Environment Report.

6.0 SUMMARY OF DISCUSSION GROUPS

6.1 Knowledge Gaps
Summary

Research information provides good theory. However, more quality control is needed to: document findings, provide better definitions for uniformity and clarification of outcomes and synthesize knowledge and information. Scientific research needs to meet the needs of resource managers and practitioners. We need common standards based on a watershed scale as a context for: developing additional local criteria for adoption and application; implementing frameworks for rural vs. urban and urbanizing contexts; documentation of successes and failures and full economic analysis of riparian zone as a valuable commodity.

How clear is research information on riparian zone function? What other aspects are important to understand? Where it is not clear, what is needed to heighten understanding?

Clarity of Research
- For all fields of research - What and how do we define riparian zones?
- Researchers conspicuous by their absence during discussions. How can we as managers and landowners pull them into the process? (i.e. management related research)
- Many bits and pieces are available but puzzle is not put together yet.
- Researchers may be good at research but not at communicating it to public. Is this their job?

What is missing?
- Spatial and temporal gradients
    - large rivers to ditches
    - urban to rural to natural
- Inter-disciplinary approach to the science in order to understand
    - Thresholds of change
    - Cause: Effect
    - Trade-offs: Consequences
    - Economics, social, physical, water quality and biological

- Are graduates pursuing societal questions or their personal interests?

Is current research meeting the needs of resource managers and practitioners? Is it practical? Does it address the issues?

Needs, Practicality, Issues

- Apparently not... especially for solutions... but are we asking the right questions? In many cases, we don't even know what is out there.
- Is the long term answer a '#' or 'value', or is the answer a process?
    - Dynamic tension between prescription and understanding of functions.
- How do we balance functional integrity with human needs? This must lead to understanding of trade-offs. Costs: benefits to landowners vs. society.

What are your recommendations for future research and communication?

- Technical transfer has broken down in agencies. We need a better/new mechanism to get information out.
- Link managers and rural communities with Universities and students. This can work both ways - more knowledge to managers and public and better applied research.
- Development of a network of people (researchers, managers, public). I.e. website, chat line
- More research must be published in the popular press and other public outlets.
- Critical need for more and better inter-disciplinary research focused on major management issues.

Communicate - Issues

⇓

Consolidate - Contextual

⇓

Synthesis - Understanding

⇓

GAPS - Issues Unresolved

⇓

New Research

6.2 How Can We Balance and Better Implement Land Management in Riparian Zones?

Summary

All participants agreed that better management of riparian zones is necessary. Promotional vehicles and implementation tools are needed for landowners and communities to increase adoption. We need to develop more innovative approaches for planning, policy, and "how to" management tools. Current programs need to be more visible. More demonstration sites need to be developed, including: issues of urban vs rural; generic management tools and better analytical processes. We need more local criteria and stewardship programs in the larger watershed context for goal setting. Issue of tile drains and field conditions of riparian/buffer zones needs to be addressed i.e. tile outfalls can "short-circuit" the potential benefits of a riparian zone. There is a need for incentives and influence values (urban vs. rural), professional liabilities, and benefits/trade offs for owner.

Is riparian zone management necessary and if so, important to whom and to what degree? If not, why?

Important to whom…

- To farmers and municipalities, specifically
- Ultimately to society as a whole. Means different things to different people.

Important for...

- To ecology, both composition and function.
- Water quality and water quantity.
- Economics.
- Ecological health.

Concern of possible land use restrictions placed on land and paying for the common good.

If riparian zone management is necessary, what implementation tools and vehicles are needed by landowners to increase adoption?

- **Landowner education** is the key to riparian management. Need to show the impact that riparian zones have on their life.
- **Economics and community involvement** also play important roles in riparian zone implementation and management. Need to show economic benefit to landowner/farmer/municipality. Perhaps an economic/environmental assessment module on riparian zone management through the Environmental Farm Plan
- Landowners need **knowledge, access to materials and technical assistance**.
- Need to develop a BMP Manual for Riparian Zones.
- Need a 1 800 number to centralize resources: education, research, assistance, programs.

- Not just managing riparian areas - managing people/human use of riparian areas.
- **Rural/Urban Issue**
    - Double standard exists between rural and urban landowners concerning property rights and riparian zones.
    - Need a Communication plan and technical products targeted to different audiences - urban, rural, different cultures, etc.
- 'Tragedy of the Commons'. **Who pays?** - Not just the landowner, it is a societal cost.

How appropriate are current programs, policies and regulations? What is lacking?

Programs

- Need a program to back up regulation and provide positive incentive.
- We don't fund programs, we fund projects.
- Funding should be: voluntary, involve maintenance payments and have long-term vision.

Policies and Regulations

- If we can't define it - how can we regulate it?
- Need explicit protection under one act - whether that be a new act or an existing act.
- Too much bureaucracy involved.
- Must include riparian areas in the Planning Act.
- Watershed Planning into Official Plans.
- Need the political/regulatory will to enforce Acts.

7.0 Conclusions

Where do we go from here?

Building on the success experienced at this workshop and on the feedback that the Committee has received, there is:

- A strong interest in follow-up workshops. Appendix F lists comments from the Evaluation For on What You Would Like To See Next. A few examples include:
    - Working with landowners
    - Urban context and implementation.
    - Implementation/stewardship approaches
    - Development of a BMP and technical materials
    - Lobbying for a Riparian 2004 type program.
    - Developing scientifically defensible process of riparian zone assessment (i.e. widths, length and composition)

- Strong interest in increasing communication and developing research agenda between researchers and managers.

- Interest in developing a riparian chatline/website. This is a future possibility. Currently, the Watershed Science Centre at Trent University has posted the Proceedings and the Literature Review on their website (www.trentu.ca\academic\wsc)

Appendices

A. Contact List - Committee/Speakers

B. Contact List - Participants

C. Workshop Agenda

D. Riparian Zone Applications Tour Notes

E. Soil and Water Conservation Demonstration Farm - HIGHVIEW FARMS
(Compliments Presentation by Lincoln Waterways Working Group)

F. What Would You Like To See Next! Comments From Evaluation Form.

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Agenda

DAY 1

8:30 Registration
9:00 Welcome and Overview - *Peter Krause, Chairman, GRCA*
Jack Imhof, MNR
9:15 Existing Tools and Responsibilities: Policy, Regulation, Planning, Programs, Voluntary
Ala Boyd, MNR
9:45 State of Science - Literature Review
Dr. Bill Snodgrass, MTO
10:30 Break
10:45 Panel Discussion - Ontario Research Findings

- Groundwater - *Dr. Dave Rudolph, University of Waterloo*
- Non Point Source Pollution - *Dr. Mike Stone, University of Waterloo*
- Wildlife - *Dr. Jane Bowles, University of Western Ontario*
- Bank Stability - *John Parish, Parish Geomorphic Ltd.*
- Aquatic Habitat - *Dr. Bruce Kilgour, University of Western*

12:30 Lunch
1:15 Discussion Groups - Knowledge Gaps
3:00 Riparian Zone Applications Bus Tour - Local Farm Demonstration Sites
6:00 Bus Returns to GRCA

DAY 2

8:30 Coffee
8:45 Report of Day 1 Discussion Groups
9:00 Landowner Perceptions and Acceptance of Riparian Zones
Sue Sirrs, Rouge Park
9:30 Packaging and Selling Riparian Zone Management
Issues, Programs and Mechanisms
Ingrid Vanderschot, OSCIA
10:00 Break
10:15 Grazing Cattle and Riparian Management: Conflict or Cooperation
Peter Doris, Ontario Cattlemen's Association
10:45 Panel Discussion
What We've Done and What We've Learned

- Rural Water Quality Program - *Tracey Ryan, GRCA*
- Permanent Cover/Buffer 2002 - *Andy Graham, OSCIA*
- Lincoln Waterways - *Fred High, Lincoln Waterways Working Group*
- Big Head River Demonstration - *Ray Robertson, Grey County*
- James Berry Drain - *Peter Bryan-Pulham, Township of Norfolk*

12:30 Lunch
1:30 Discussion Groups
How Can We Balance and Better Implement Land Management in Riparian Zones?
2:45 Reports from Discussion Groups
3:15 Where Do We Go From Here? - *Jack Imhof, MNR*

Riparian Zone Workshop Tour

Stop 1: Webfoot Farms

Location:
Lot 4 Concession 1 of Pilkington Township, Wellington County

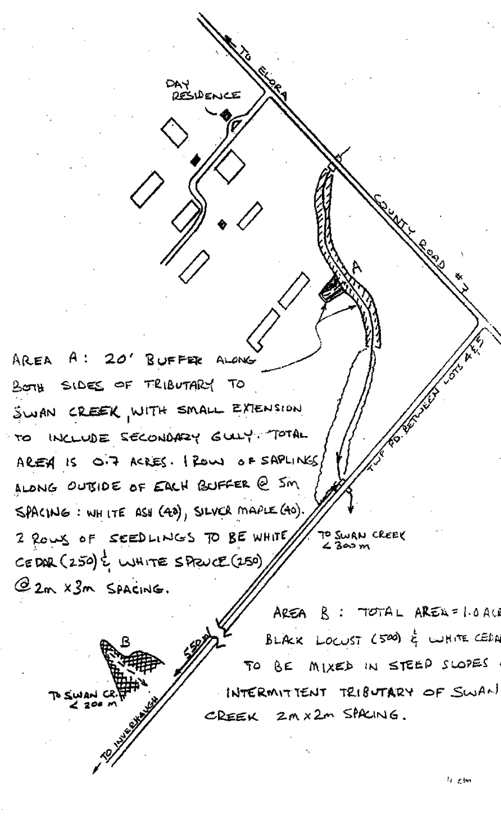
Farm Description:
Webfoot Farm and Hatchery is a domestic waterfowl production and evisceration facility. The breeding flock consists of 6000 ducks and 2000 geese. Cash crops are grown on approximately 1400 acres.

Issue:
Prior to 1993 the geese had unlimited access to over 230 metres of a small tributary of Swan Creek. Geese and ducks are very close grazers, very little cover was left on the soil. The area was severely eroded. (Photo # 1) Concentrated runoff through the pasture had created a washout that was 50 metres long. Some portions of the gully were more than a metre wide and a metre deep. (Photo # 3) The stream banks were bare and eroded. A great deal of silt was entering the stream. (Photos 5 & 7)

Action:
In 1993, a 6 to 7 metre wide vegetated buffer strip was established on both sides of the stream. The geese were fenced out of the watercourse. Three rows of trees were planted on each side of the stream (40 white ash, 40 silver maple, 250 white cedar and 250 white spruce). (Photos 2, 6 & 8) The washout was reshaped and reseeded with a creeping fescue based grass mixture. (Photo 4) The most effective erosion and runoff control has been a change in the grazing management. Grazing pressure has been reduced and the geese are allowed on pasture for limited periods to avoid over grazing. The total area taken out of production is 0.07 acres.

Trees were also planted to protect steep slopes bordering an intermittent tributary in an adjacent field. Five hundred black locust and 500 white cedar were planted on approximately 1 acre.

The Grand River Conservation Authority and the landowner completed the project in partnership with funding from Agriculture and Agri-Food Canada through the Permanent Cover II Program. The total project cost approximately $5,000. The landowner's inkind contribution was the land taken out of production and the duck fencing.



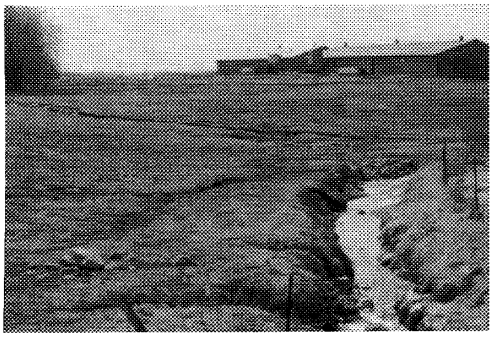


Photo 1: The duck pasture April 1993.

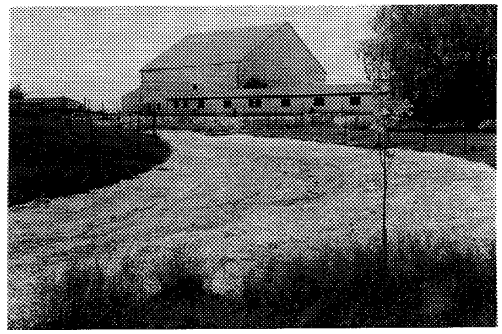


Photo 4: The gully in August after being reshaped and seeded.

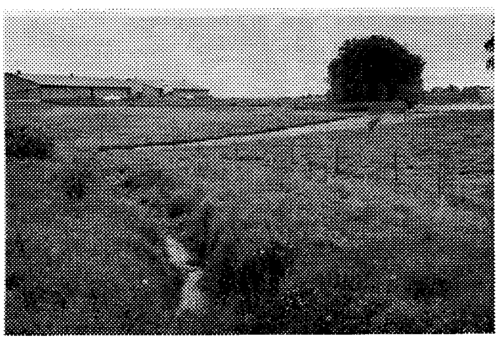


Photo 2: The rehabilitated site August 1993.

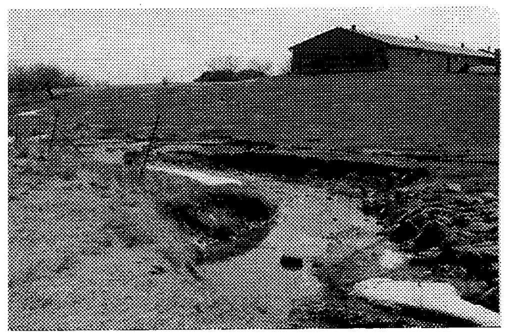


Photo 5: Erosion and bank instability due to a lack of vegetation (April 1993).

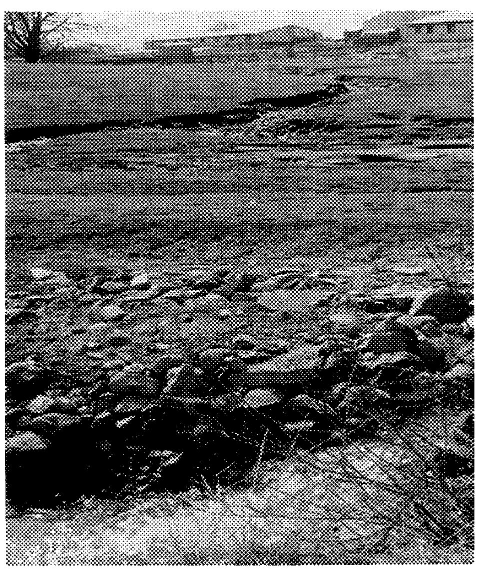


Photo 3: Close grazing removed the vegetation and allowed this gully to form. Photo taken April 1993.

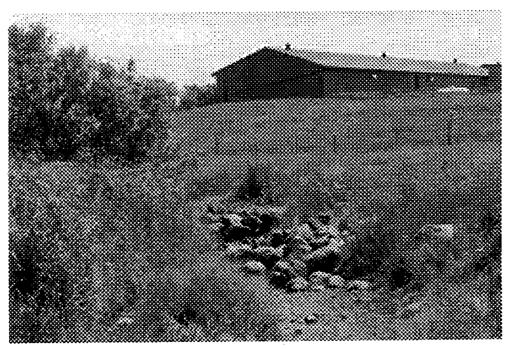


Photo 6: After Rehabilitation. August 1993

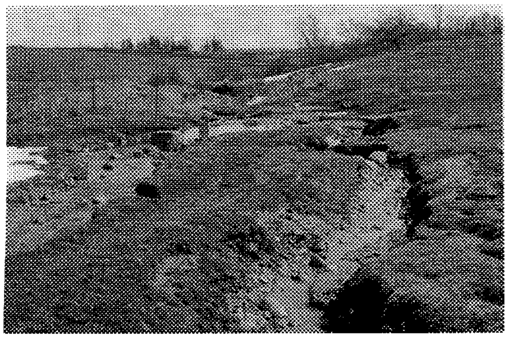


Photo 7: Washouts and bank erosion in April 1993. Notice the location of the large boulder in the stream.

Photo 8: Improved water quality, decreased stream width due to vegetation growth. Note the same boulder as photo 7.

Stop 2: Paddock Farms

Location:
Lot 15 & 16 Concession 1, Puslinch Township, Wellington County

Farm Description:
Millcreek (or Galt Creek) is a cold water trout stream originating in Puslinch Township flowing into the Grand River in Cambridge. Mr. Paddock pastures approximately 150 cattle along the creek.

Issue:
Livestock access on the Paddock farm was impacting the stream and causing problems for Mr. Paddock. The unstable stream banks and adjacent wetland areas caused hoof and leg problems. Cattle also got stuck in the mud on occasion. Cattle access to the stream and wetland was destroying fish and wildlife habitat and impairing water quality.

Action:
In 1984 the stream and adjacent wetland area on the Paddock farm was fenced to eliminate cattle access. Two bed level crossings were installed. The bed level crossings consist of filter cloth and gravel. The filter cloth provides a strong base for the crossing and has enhanced the life span of the crossing. The GRCA, K-W Fly Fishers and MNR did the work with funding by Community Fisheries Improvement Program (CFIP) from MNR.

The same groups have done a great deal of instream work to improve the stream channel and enhance fish habitat. As a result of the fencing and instream work the stream width has decreased by two thirds. The landowner and the groups have an ongoing commitment to the project and replaced some of the fence in 1998. Mr. Paddock is very supportive of the work and has felt that herd health and productivity has benefited from the project.

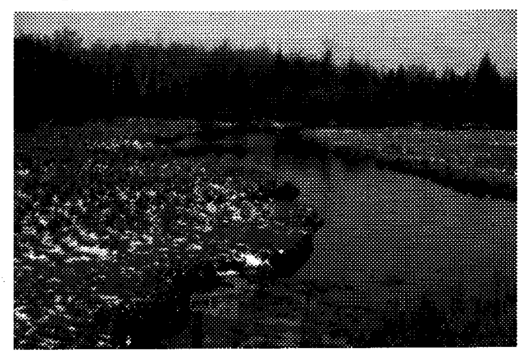


Photo 1: The east pasture in 1983.

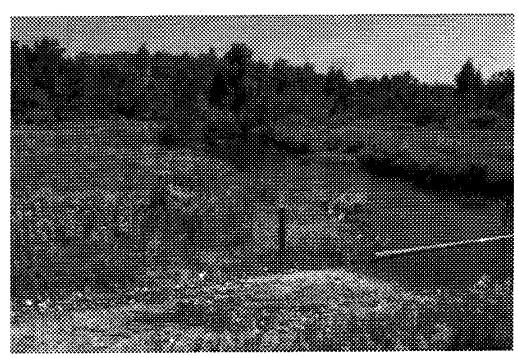


Photo 2: The east pasture in 1987.

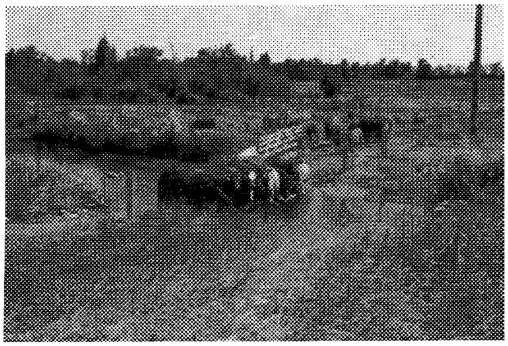


Photo 3: The cattle crossing in action (photo 1989)

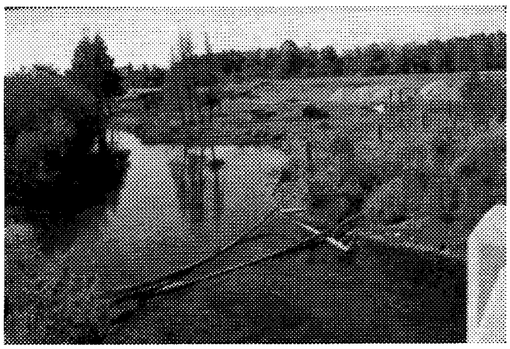


Photo 4: The west pasture in 1983.

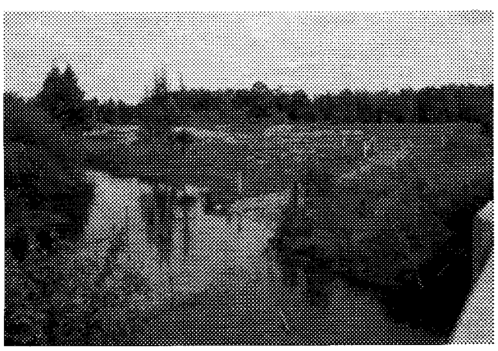


Photo 5: The west pasture and cattle crossing in 1986.

Stop 3 - Carroll Creek Watershed Research Project

Location:
Carroll Creek is a rural watershed of approximately 126 km2 which flows into the Grand River 5 kilometers south of the Town of Elora. Two sites are highlighted during the tour. A site at the crossing of Middlebrook Road and a site immediately upstream of Middlebrook road on Pilkington Side Road.

General Description:
Carroll Creek is typical of many of the agricultural watersheds in this part of southern Ontario. Agriculture makes up approximately 80% of the landuse of the watershed, much of that use including use of the valley floor and riparian zone of the stream. Historically the stream held good populations of brook trout and a few other species of coldwater fish. These populations persisted in many parts of the watershed and its tributaries until the late 1950's to early 1960's after which agricultural intensification, including enhanced agricultural drainage and aggregate extraction occurred.

A co-operative research project was undertaken in 1994 with permission of landowners and participation from the Ontario Ministry of Natural Resources, Universities of Guelph and Waterloo and the Grand River Conservation Authority.

Issues and Objective:
There is a perception that intensive agricultural use of riparian zones within watersheds has an affect on a number of characteristics of streams including: degradation of channel health; loss of fish habitat; deterioration of water quality; and impacts of the population of animals in the stream. One of the objectives of the project is to examine the possible effects and interactions of landuse activities on the stream its riparian zone. The objectives included a better understanding of the role of riparian zones on the health of the aquatic environment of the stream.

Site 1- Middlebrook Road
From this point on Carroll Creek downstream of Middlebrook Rd. the stream flows out of areas of intensive agricultural use and into reaches where riparian zone has been allowed to re-naturalize for periods ranging from 5-10 years to 50-100 years. The reach immediately upstream and downstream of Middlebrook Rd. has been allowed to go fallow for approximately 5 years upstream of the road and

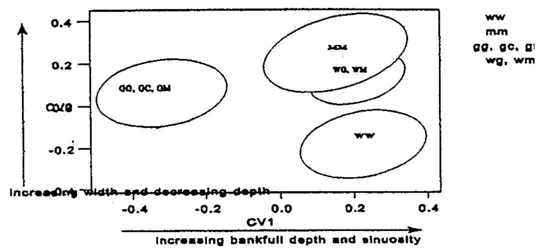
8 years downstream of the road. Differences in channel structure and vegetation are discernible at this location, especially when comparing this location to the second stop on Pilkington Rd.

Site 2 - Pilkington Rd.
The riparian characteristics at this location are quite different than those seen at Middlebrook Rd. On both sides of the road vegetation indicates active cropping by livestock with no woody plants in evidence. Bank erosion is more discernible and relative channel depth and complexity is lower when compared to Middlebrook Rd.

The stream at this location has only been recently fenced from cattle on the downstream (north side). Whereas cattle are still free to roam on the property on the upstream side (south side) of this property. Channel width, bank stability and habitat quality appear to be impaired downstream whereas this is not as evident on the upstream side. This suggests that density of livestock and general riparian and channel characteristics may affect the extent of alteration to the health and structure of the stream.

Results:
Preliminary analysis of 40 aquatic stations and 120 terrestrial stations (2 banks per terrestrial station) demonstrates that there is a relationship between channel form and landuse. A comparison between major riparian landuses and stream channel structure demonstrates significant differences in shape and structure of a stream channel based upon landuse. In active use areas such as grazed/grazed (two descriptors are used to denote major landuse of each bank), grazed/meadow and grazed/cropped. Channel forms are significantly different in width and depth in the gg, gc, and gm portions when compared to riparian zones allowed to go fallow for periods of 5-10 years (meadow/meadow; wooded/meadow; wooded grazed) and locations were activities were curtailed 50 - 100 years ago (wooded/wooded).

Figure 1. 95% confidence ellipses for sites grouped by land use. Axes interpretations come from examination of standardized canonical coefficients and demonstrate both differences in channel health (deep and sinuous) versus degraded channel health (wide and shallow for the major combinations of landuses found in Carroll Creek.




Carroll Creek


Carroll Creek

Stop 4 - Kolb Creek Enhancement Project

Location:
The Kolb Creek enhancement project is located on Forwell Rd. off Victoria St. in Kitchener.

General Description:
Kolb Creek drains a large portion of Kitchener including a large wetland complex near River Road and Manchester Ave. The stream is small and was once a coldwater stream. The stream is now considered a drain and exhibits the typical form of an urban stream. It is highly entrenched with a wide low flow channel and flows behind subdivisions and a commercial strip along Victoria Street near Breslau. The stream ultimately discharges into the Grand River downstream of Breslau. The stream captures both groundwater and stormwater from sub-divisions, portions of the Conestogo expressway and Victoria St.

Issues and Objective:
Because of the inputs of urban run-off from subdivisions and especially the commercial strip along Victoria St., the stream channel (drain) in this section by 1993 displayed accelerating bank erosion and degraded water quality. In addition, the portion of the stream that crosses and then re-crosses Victoria St. was threatening the integrity of a parking lot at a commercial business. There was a demand to "fix" the creek.

In 1993 the City of Kitchener decided to repair the drain/stream. Three major objectives were identified: create a "floodway" to route floods away from Victoria St. (the old channel still crosses Victoria St. twice); create a "stable" new channel to convey both low and floodflows downstream of the new floodway; use a Natural Channel Design approach to the design of the new channel which would include a stable channel form and functional riparian zone.

Results:
The Floodway was installed in the fall of 1993 and the new channel and riparian zone was installed in the fall/winter of 93/94. A new channel form was developed based upon the slope of the stream's valley and the stream surface slope required to ensure a stable channel form. Hydraulic cross-sections were determined, planform geometry calculated and the new channel, including deep pools at the outside bends was built. Riparian vegetation, typical to the area around Kitchener was planted with the aid of a specialist in natural landscaping. Bio-engineering approaches were used to increase stability on the bends of the new channel rather than rip-rap and pocket wetlands were created to capture sediments and improve water quality.

The new channel has withstood 4 years of low flow and flood flow events and has maintained its integrity with no maintenance to date. It has developed a lush vegetated riparian zone while maintaining the integrity of the channel to move water and sediments. Little scouring damage has resulted from the many flood events.

Kolb Drain reconstruction

Appendix E

Soil and Water Conservation Demonstration Farm HIGHVIEW FARMS

(Compliments presentation By Lincoln Waterways Working Group)

What Do You Want Next?
Comments From Evaluation Form.

Would you be interested in a follow-up workshop? If so, focusing on what topics?

- Yes (x3).
- Yes. May be useful to have a workshop where you work on scenarios to get a better idea of data needs as well as does and don't's for implementation.
- On implementation schemes, i.e. ways of, where to establish demonstrations.
- Yes. Use of riparian zones for water quality improvements.
- Yes. Water quality and remedial action implementation.
- Yes. Urban riparian buffers.
- Yes. Defining specific matched between situations, tools and expectations.
- Yes. If focused on practical management techniques.
- Yes. Research needs and updates - progress toward design specifications.
- Yes. On legislation and regulation.
- Yes. More information on research - leading trends and specifics. Would also like a workshop for non-agricultural areas.
- Yes. Focus on programs. Synthesis of knowledge. Political action to direct more $$$ to the environment.
- Yes. On the obvious common messages and issues. Direct right questions to researchers and academics. Share information (communication, network). Integrate values (economic and environmental).
- Need to capture details of workshop - get all players to raise common issues.
- Yes. More of an urban context, i.e. dealing with developers and contractors.
- Helping to strengthen link between practitioners and researchers.
- More on the processes of managing a riparian zone, once the data or definition are found. This way it could narrow down the specific areas.
- Sure. I personally would like to know more about the legislation at present which is in place to guide activities in riparian zones. Would also be interested in a workshop on what we know presently about success/appropriateness of certain techniques for rehabilitation.
- Yes, riparian zone tools and which design may be best.
- Types of riparian practices i.e. grass buffers, rock banks, rock chutes, trees and shrub buffers. More in-depth look at what works and is best for the watercourse.
- Yes. Urban and rural strategies. Techniques that do and don't work in riparian restoration. A look at the restoration side, less focus on the research. Guidelines and processes to be considered in riparian design.
- Yes. Hammering out details on guidelines for more focused study on this topic, i.e. rural, urban, public contact, defining riparian and guidelines.
- I would love a workshop detailing 'progress' on ideas and suggestions/recommendations from this workshop. Gives us a sense of progress.

Riparian Zone Workshop

LITERATURE REVIEW:
Overview of the
State of the Science

Grand River Conservation Authority Administration Office

Cambridge, Ontario

October 28 - 29, 1998

An Examination of the
Functions of Riparian Zones

Prepared by

M. Wilson,
University of Guelph
and
J. G. Imhof,
Ministry of Natural Resources

RIPARIAN ZONE WORKSHOP
Literature Review:
Overview of the State of the Science

INTRODUCTION

In 1971, US and Canadian governments acknowledged a concern over Great Lakes water quality by initiating a working group to research the relationship between landuse and water quality (Cywin and Ward, 1971). This concern arose, in part, due to non-point source pollution from a variety of landuses including agriculture and urbanization. About 20% of the world's freshwater is found within the Great Lakes and they were found, by the working group, to receive a wide range of nutrient, sediment, and pesticide loadings through their watersheds (Coote et al., 1982). Through processes, such as eutrophication and toxification, these inputs could potentially irreversibly alter the nature of our aquatic ecosystems.

Over the last 10 years, resource management programs have been developed to address some of these concerns. Two specific programs, Watershed Planning and the Natural Channel System program, apply an ecosystem approach to assessment, planning and management. The objectives of these programs are to determine the cause: effect relationships between landuses and landscape, valley and river. Some of the goals of these programs are to: protect property, reduce costs of environmental clean-up and protection and ensure the sustainability of renewable resources such as water, soil, fish and wildlife.

The Watershed Planning process occurs at a broad scale whereas management of rivers and their riparian zones and floodplains is the focus of the Natural Channel Systems program. Extensive research within Ontario and around the world has identified important properties of rivers, their riparian zones and how they function together. The management of these functions has been identified as important to the well being of natural resources, property and water quality in Ontario. Some of the key functions of a river and its riparian zone/floodplain include: the conveyance and storage of water and sediment; attenuation of flood flow within flood plains; the provision of bank stability; the protection, maintenance or enhancement of aquatic and terrestrial habitat; and the maintenance or improvement of water quality through nutrient uptake and sedimentation. Controls of these functions, to a great degree, operate within riparian zones.

Riparian zones are defined as the three dimensional zone of interaction between terrestrial and aquatic ecosystems (Gregory et al., 1991; Swanson et al., 1982; Meehan et al., 1977). Their control over the functioning of landscape processes is much greater than their predicted land area effect (Gregory et al., 1991). They represent the final region through which substances pass when moving from the terrestrial to the aquatic ecosystem. This gives riparian zones the conclusive opportunity to modify, incorporate, dilute or concentrate stream bound materials (Osborne and Kovacic, 1993). Because of these attributes riparian zones have been found to assist in the regulation of landscape geomorphic and hydrologic processes, the control of surface water quality, and the protection and provision of both aquatic and terrestrial habitat.

Worldwide interest has been focused on riparian zones and this is evident in the increasing abundance of literature devoted to the topic. The greater portion of this literature concerns their important functions as filters of non-point source pollution, specifically, sediments, nitrogen, and phosphorous. Riparian zones can also regulate sunlight inputs to the stream thereby moderating stream temperatures, reduce sediment and nutrient inputs, stabilize geomorphic processes, and provide sources of organic matter (Osborne and Kovacic, 1993).

The United States government has begun an extensive riparian implementation program to help reduce waterway pollution. The goal of the program is to restore 2 million miles of riparian zones by the year 2002. Closer to home, the Regional Municipality of Waterloo has budgeted $1.5 million over 5 years towards the control of non-point source pollution and has identified the importance of rural riparian enhancement and restoration programs to the achievement of its' goal.

Before any extensive implementation programs occur, many research gaps should be addressed as well as various related land use and social issues. Osborne and Kovacic (1993) have identified some research gaps involving the utility and efficiency of these areas in terms of structure and composition. Gregory et al. (1991) stress that the management of riparian resources must be approached from an ecosystem perspective, "integrating the physical processes, that create valley floor landforms, patterns of terrestrial plant succession, and structural and functional attributes of stream ecosystems".

This review provides an overview of the 'natural' functions and processes of riparian zones based upon a review of the world literature. It is not exhaustive but will attempt to provide the reader with an idea of the state of the world science on riparian zones and their functions. The purpose of this review is to provide a knowledge basis on which can be built and present new knowledge unearthed during the Riparian Zone Workshop Researcher Panel Discussion. For additional information on riparian zone form and function, please review the proceedings of the workshop and the summary of the various discussion groups.

METHODS

The objective of this review is to provide an overview of the world literature and determine the major scientific understanding of riparian zones. In addition, some of this review will summarize examples of widths assigned by research to various functions found within the riparian zone.

To begin this project, scientific literature, books and articles on riparian zone functioning was amassed from numerous sources including: reference libraries, journals, personal libraries, internet sources and searches, and personal libraries. The literature was reviewed and then separated into functional groupings or categories of functions. Four categories which encompass the status of riparian zone science were identified:

- **Hydrology**
- **Geomorphology**
- **Water Quality and Nutrient Flux**
- **Ecological Characteristics**

Within each of these broad categories sub-categories are identified in order to describe the functioning of riparian zones in conjunction with their landscapes, and the relationship of these functions with the preservation of water quality and aquatic ecological processes. The topics have been organized to parallel the hierarchical controls of drainage basin function and ecological dominance by physical habitat characteristics (Gregory et al., 1991; Frissell et al., 1986):

- **Valley Landforms And Physical Characteristics - Structure**
- **Channel Structure**
- **Physical System And Morphological Effects On Ecosystem Structure And Function**
- **Ecological Characteristics Of Riparian Areas - Interactions**
- **Riparian Vegetation Effects On The Functioning Of Ecological And Physical Systems**

- **Nutrient And Sediment Fluxes Involving The Riparian Zone - Buffering Capabilities**

The information for each of these categories has been summarized into a series of tables for an expedient and effective display of relevant information. An attempt was made to include information necessary for the interpretation of the importance of the specific research findings to our conditions in Ontario. The tables are divided into five columns, which include:

- **Research finding** (A result of the research or a trend noted through synthesis of research.)
- **Location** (A listing of the research location or of the extrapolated effect area. This can be used to assess the findings' importance to Ontario conditions.)
- **Factors** (Any important factors which have been identified in influencing the conditions leading to the proposed finding.)
- **Reference** (The author(s) of the paper from which the finding was found.)
- **Number of Representative Papers** (The number of papers reviewed supporting the research finding.)

RESULTS

Approximately 200 papers, including annotated bibliographies and books were reviewed and assessed for the purpose of this review. Tables 2, 3, 4 and 5 summarize information from papers that were considered state of the science for their category. These key papers, in our view, summarize some of the key points for each topic within the four categories. The total number of papers actually used per category is shown in Table 1.

Table 1: Summary of Number of Key Papers Used by Category

Category	# of Papers
Hydrology	16
Geomorphology	14
Water Quality and Nutrient Flux	8
Ecological Characteristics	16

A listing of these papers in addition to the bibliographies used in this work are listed in the references.

Although fewer papers were used to summarize information on water quality and nutrient flux in riparian zones, there is exhaustive world literature on this subject. An example of the extent and scope of this work can be seen in the 60 page bibliography prepared for the Smithsonian Environmental Research Center by Correll (1997), entitled, “Vegetated Stream Riparian Zones: Their effects on stream nutrients, sediments and toxic substances”. This bibliography alone contains 522 citations. Another major paper used is Martin et al. (1998) from the University of Guelph, which again is a review of the world literature.

The role of riparian zones in the management, movement and modification of surface and groundwater also has an extensive literature, especially as it relates to flood flow attenuation and its’ role in nutrient flux. Less well known appears to be the interaction of groundwater and surface water as it moves from upland areas into and through active riparian zones. Some of the most recent work on this appears to be occurring in southern Ontario.

The field of fluvial geomorphology examines the dynamics of change in channels and their valleys that result from the movement and storage of sediment and water over time. Although a fair body of historical work has been done on components of these interactions (i.e. channel hydraulics and flow), not a great deal has been done on the inter-relationships between riparian zone structure and composition and its’ role on controlling channel structure, erosion and in general, bank stability.

Ecological Characteristics of riparian zones are discussed in general terms by a variety of authors, but only recently has the channel and its’ valley been connected as a unit for analysis (e.g. Frissell et al.1986; Rosgen 1995; Imhof et al. 1996).

DISCUSSION

Response of landscapes to change induced by human use is well documented but not well understood. Changes to the stability of river channels, degradation of water quality, soil loss and collapse of food fish stocks is well documented by Hoffmann (1995) in 11th century medieval Europe. These changes were wrought by a major economic expansion which saw forested landscape cleared for agricultural production, rivers dammed for mills and land drainage increased to improve production. The world literature today provides many more examples and much more understanding of how these changes in medieval Europe occurred.

Our experiences in Ontario and findings of researchers from other geographical areas show that to achieve a complete understanding of the functioning of river ecosystems, effects originating from the terrestrial ecosystem must be considered (Hynes 1975; Frissell et al. 1986; Imhof 1996). In fact, the linkage between a stream and its' drainage basin began to be recognized as early as the 1940's. Since then, it has become extensively acknowledged within various disciplines (Horton, 1945; Leopold, Wolman and Miller, 1964; Schumm and Lichty, 1965; Hewlett and Nutter, 1970; Likens and Bormann, 1974; Hewlett and Troendle, 1975; Vannote et al., 1980; Schlosser and Karr, 1981; Junk, Bayley and Sparks, 1989). Influential and prominent examples of the impacts of terrestrial landscapes on the functioning of aquatic ecosystems can be found in the theories of both the River Continuum Concept (Vannote et al.1981) and the Flood - Pulse Concept (Junk et al.1989). The terrestrial-aquatic interaction is recognized in these theories as exhibiting a powerful control over aquatic community structure.

Non-point source pollution from agricultural areas has been identified as a key contributing factor to North American water quality problems (Fennessy and Cronk, 1997), although absolute mechanisms of attenuation, transformation and transport vary based upon geology, topography, soils, vegetation and climate.

The remainder of this discussion focuses on each of the four categories and examines briefly what is well known and where our knowledge is weakest. A table has been prepared for each section to summarize major papers.

Hydrology (Table 2):

Riparian hydrology is far from well understood. We have yet to produce an effective model to describe the hydrology of riparian zones and floodplains much less a model which takes into consideration the processes which take place on a yearly or longer term basis. Research in this field is essential in order to understand water quality issues and nutrient flux through riparian zones. The integration of surface flow and shallow groundwater models is needed in order to understand these functions at any reasonable level. Research needs to focus on both spatial and temporal characteristics of the hydrology of riparian zones: not only on critical events such as major high flow and low flow events but on the regime characteristics as well.

Geomorphology (Table 3):

Extensive research has provided a good understanding of the processes involved in the formation of drainage basins and the processes involved in the formation of floodplains. Unfortunately, limited information is available on the long-term rates at which riparian zones and floodplains adjust to changes in hydrology and sediment yield (Table 3). This is especially problematic in Ontario where many of our rivers, floodplains and riparian zones are still adjusting to the clearing of the land for agriculture over 100 years ago.

The role of riparian vegetation, composition and structure on bank stability and channel stability is poorly understood. Some of this complexity may be scale dependent. For example, the channels in 1st order streams in humid temperate climates may be considered vegetatively controlled because the root systems have sufficient tensile strength to withstand the shear stress created by small streams. However, in larger streams, because of the force and volume of water, the channel form may be controlled by erosive forces although modified by the vegetation in the riparian zone. The field of bio-engineering, using natural living materials to stabilize slopes is relatively new to North America and likely requires an understanding of these circumstances in order to design appropriate measures for bank stability. More research is needed on the tensile strength of roots and their role in bank stability.

Another major need is to examine the entire valley or riparian system as a unit. Although there is discussion of a systems approach to the management of stream corridors from the USDA and from the Natural Channel Systems initiative in Ontario, little data is yet available for the management of stream nutrient inputs, hydrology and geomorphological processes. It is possible that the most appropriate way to view the riparian system is as a dynamic geomorphic unit of the stream and its valley.

Water Quality and Nutrient Flux (Table 4):

The mechanisms through which riparian zones control water quality and balance nutrients is generally understood. We can predict to a certain degree of success the effects of vegetation composition and structure on the degree of nutrient attenuation, although the specific mechanisms and processes are only now being clarified. Present models do not account for the effects of long periods of nutrient filtration and uptake. Only recently has better information on the effectiveness of riparian zones been established (Table 4). More focused research is required in order to determine widths, lengths and composition of riparian zones designed to improve water quality. Riparian forests have been proposed as one means of improving water quality but long-term studies still need to be done to determine if these forests will continue to perform these water quality functions well after they mature. Osborne and Kovacic working in a riparian zone with trees in excess of 40 years cannot determine yet what will happen when growth stops and senescence occurs.

Long-term effects of accumulation of nutrients in the riparian zone must be addressed. Work in the United States suggests that riparian zones and the sub-pavement of streams are major storage areas of phosphorus. This would suggest that response of water quality in streams may lag for a long period after the establishment of a functional riparian zone, even though the riparian zone may be working well. For example, large runoff events can exacerbate bank erosion and turn over the bed of the stream channel thereby releasing stored phosphorus into the open stream system. Both processes will flush not only sediments but soluble nutrients into the stream downstream of the erosion locations. This remobilization of nutrients may mask the good work the riparian zones are doing for quite a few years. Monitoring systems need to be able to sort out the effectiveness of riparian zone restoration techniques in relation to long-term “sinks”.

The question of bacterial denitrification and its’ spatial variability within riparian zones is just beginning to be addressed from a four dimensional perspective. Information must be collected in order to estimate the rate of removal of nitrates from groundwater without riparian vegetation and then with riparian vegetation of specific structure and composition. The research must also examine these features on a seasonal basis.

Ecological Characteristics (Table 5):

There is a basis understanding of the ecological role of riparian zones in the management of aquatic systems. Riparian zones provide food for aquatic animals, modify stream temperature, provide large wood material to the stream that is used as habitat by fish, etc. Some work has been done on the response of aquatic systems to the removal of riparian zones. However, little work has been done on the time it takes aquatic systems to stabilize (biologically, physically and chemically) or return to a healthy functional state once re-established (Table 5). Work completed on whole watersheds such as Hubbard Brook in the USA and Carnation Creek in British Columbia suggest that the aquatic system responds very quickly to loss of riparian zone (e.g. 1-5 years) but recovers very slowly (e.g. 10-100 years). Imhof et al. (1996) includes a table suggesting the relationship between scale of the system and disturbance period (see Table 6).

However, less is known about the role of riparian zones in the movement of terrestrial species and the distribution of vegetated materials. The extent of species dispersal and migration patterns are fairly unknown and highly theoretical. Although some literature suggests that riparian zones can function both as corridor and as barrier, riparian barrier effects are hypothetical and have yet to be proven.

Summary

There is more and more focus on the benefits of riparian zones in the world literature. Within a watershed context, documents, procedures and science has been developing on the analysis and management planning for watersheds and stream corridors, i.e. Ontario's Watershed Planning Process and Natural Channel System Initiative. The ecosystem that has been somewhat neglected in the past is the "wetlands" that connect the stream channel or lake to the upland area, the riparian zone. This literature review reflects the growing interest in this ecosystem and the important role it appears to play in many functions important to wildlife, fish and people.

Although a great deal of research has been done on riparian zone form and function, a clear definition and set of criteria for defining riparian zones are still needed.
Work on the various functions of riparian zones, their width and characteristics is ongoing. Table 7 has been prepared as a summary of information on effective riparian widths for different functions. What is missing from the literature in general is a clear description of the climate, elevation, valley form, valley slope and geology of the study zone in addition to the length of the zone under study and its contiguousness. All these factors appear to be important variables in defining how well the riparian zone functions and how well this information can be extrapolated to other studies.

In general, work is needed to define like-for-like systems. From this type of study, we should then be able to derive an understanding of how the various functions of the riparian zone operate together within specific spatial settings. This inter-disciplinary information is critical if we wish to manage and/or restore riparian zones in Ontario. Given the possibility of more variable weather conditions over the years due to Global Climate Change (i.e. more frequent high flow events and more frequent droughts), riparian zones may act as a system that can help us to adapt and moderate the worst of these extremes on our property.

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Table 2: Hydrology			
RESEARCH AREA	***RESULTS***	***FACTORS / NOTES / PARAMETERS***	***AUTHORS***
Overbank Flooding			
General	• Flooding and floodplain processes are largely controlled by climatic events	• Floods may be intensified by soil type, topography and degree of land drainage	Burt 1992; Lewin 1992
Surface Flow			
Semi-arid, SW, USA	• Hortonian Overland Flow occurs where water input rate exceeds the rate of soil hydraulic conductivity	• Common in urban areas of low infiltration • Responsible for rapid hydrograph response	Horton 1933
General	• Saturation Overland Flow occurs when return flow, which is subsurface water resurfacing due to upward hydraulic gradients and direct water inputs both flow overland because of saturated conditions.	• Dunne and Black (1970) found this process to commonly occur in near stream areas	Hewlett 1961; Kirkby and Chorley 1967; Troendle 1985
SE, USA	• Partial Area concept proposes limited area for the origin of Hortonian overland flow which except during extreme events remains fairly constant within a specific basin	• Ranged from 4.6% to 46% on agricultural watersheds in southern Appalachians	Betson 1964
Subsurface Flow			
General	• Subsurface Storm Flow occurs when water infiltrates the soil surface and roughly follows a gravitational gradient to the aquifer	• Responsible for delayed hydrograph response	Dunne 1978
General	• Variable Source Area model explains localized source areas of storm runoff which vary during storm events or seasonally	• See Taylor, C.H. (1982) for Central Ontario example	Hewlett 1961
General	• Characteristics of subsurface flow are correlated with biotic assemblages	• These include temperature, chemistry, etc.	Natural Channel Systems: An approach to management and Design 1994
England	• Oblique flow paths are common in riparian zones	• Affects subsurface residence time (Estimated to be 5-190 days in 17m buffer)	Haycock and Pinay 1993; Fennesy and Cronk 1997
Bank Storage			
General	• When the stream flood wave rises above the water table the hydraulic head is reversed and water is pushed back into the bank • When the flood wave subsides the hydraulic head reverses pushing water back into the stream	• Rate controlled by channel morphology and material, aquifer extent, rate of floodwave rise and floodwave magnitude	Dingman 1994
General	• Bank Storage reduces and delays the peak magnitude of the event hydrograph	• Natural flood control process	Hunt 1990

Table 2: Hydrology			
RESEARCH AREA	***RESULTS***	***FACTORS / NOTES / PARAMETERS***	***AUTHORS***
NE Ontario	• Water storage can occur in the form of capillary fringe where soil pores are filled with water due to pore surface tension • This can intensify subsurface storm flow responses to precipitation events in shallow ground water environments	• Thickness of capillary fringe is affected by soil structure and soil texture • Clay and silt materials can have a large fringe effect (several metres)	Novakowski and Gillham 1988
	• Alternating wet and dry periods in the soil or the presence of aerobic and anaerobic zones creates optimum conditions for denitrification	• Prolonged anaerobic or aerobic conditions limit denitrification	Fennessy and Cronk 1997
Evapo-transpiration			
General	• Change of the phase of water from a liquid form found in the lithosphere to a gaseous form found in the atmosphere	• Affected by energy availability, humidity gradient away from surface, over surface wind speed, water availability	Henderson-Sellers and Robinson 1986
Tasmania, Australia	• Reductions in basin yield and quickflow yield were found after basin afforestation	• Similar results found in Ontario's Ganaraska river basin; see Buttle 1995	Smith 1992

Table 3: Geomorphology			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
Floodplain Characteristics			
General, USA	• Floodplains are formed primarily through lateral accretion and secondarily through vertical accretion	• Natural lateral migration of meanders is an important process to floodplain formation	Leopold et al. 1964; Lewin 1992
General	• Anthropogenic river runoff control, erosion, and the improvement of land drainage through techniques such as agricultural tile drainage greatly affect floodplain processes	• Ditching, power generation, channelization, wetland drainage, etc.	Lewin et al. 1992
USA	• The Rosgen stream morphology classification system uses physical characteristics to predict equilibrium channel forms	• Slope, sinuosity, width to depth ratio, particle size in beds and banks, stream entrenchment ratio, and landform feature stability class	Rosgen 1985
Southern Ontario	• Southern Ontario's physiography has been formed, for the most part, by glacial processes occurring in the late Wisconsinan period. Glacial spillways created large valleys which are currently occupied by modern rivers.	• Various glacial tills were deposited around great Lakes	Chapman and Putnam 1967
Sediment Budget			
	• Predictions of soil loss are generally made using the Universal Soil Loss equation	• Related to rainfall energy	Wischmeier and Smith 1965
General	• Delivery Ratios modify the gross soil erosion estimate	• Factors are: grain size of detached material, basin shape and size, relief length ratio, desity and kind of drainage system, slope, silt detention opportunities, proximity of active streams, distance from downstream location of interest	Dickinson and Wall 1977
Southern Ontario	• 75% of the annual suspended sediment yield is transported in February, March, and April • Stream bank erosion observed to be maximum during this time	• Agricultural areas are often bare during snowmelt and spring runoff periods	Wall et al. 1982
Southern Ontario	• Agricultural contribution to suspended sediments average 34% in the Saugeen basin and 68% for the Grand River basin		Wall et al. 1982

Table 3: Geomorphology			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
Southern Ontario	• Lake Huron and Erie each receive about 45% of the calculated Great Lakes sediment yield and in combination Georgian Bay and Lake Ontario receive the final 10%		Wall et al. 1982
Southern Ontario	• 70% of fluvial phosphorous loads come from cropland runoff, 20% from livestock, and 10% from unimproved land runoff and bank erosion	• Major factors are clay content and % row crop	Miller et al. 1982
Erosion and Deposition along Stream Channels			
General	• Bankfull or effective discharge has been determined as the critical channel forming discharge	• Occurs every 1-2 years	Wolman and Miller 1960
General	• River erosional and depositional patterns follow rules of a dynamic equilibrium	• Uniform distribution of energy expenditure and minimum total work	Langbein and Leopold 1964
Role of Riparian Vegetation			
General	• Vegetation can prevent bank erosion through stabilization by root systems and promote instream and floodplain sedimentation through the provision of flow resistance by vegetation stems, limbs, and woody debris	• Important to the creation of microhabitat	Gregory et al. 1991
General	• Vegetated riparian zones assists in the removal of sediments from surface runoff by providing higher soil infiltration rates through increased surface roughness and soil organic matter content reduce the rate of soil particle movement into aquatic system	• This process reduces terrestrial sediment inputs to aquatic systems	Lee et al. 1989
Oregon, USA	• Stream reaches with woody debris dams are four times more retentive of transported materials than those without woody debris dams	• Woody debris size is a factor of retention rate	Speaker et al. 1984

Table 4: Water Quality and Nutrient Fluxes			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
General	• Vegetated areas adjacent to streams can attenuate non-point source agricultural pollutants (sediment, nitrogen and phosphorous)	• Provides protection to aquatic eosystems	Fennessy and Cronk 1997
General	• Riparian vegetation can modify, form and timing of nutrient export	• 3 methods of nutrient modification are (U.S. Dept. of the Army 1991): • retention of sediment bound nutrients in surface runoff • uptake of soluble nutrients by vegetation and microbes • absorption of soluble nutrients by organic and inorganic soil particles	Gregory et al 1991
Sediment and Nutrient Retention			
Virginia, USA	• Sediment retention properties within the buffer are controlled by buffer width, length, infiltration rates, slope, and roughness (Manning's roughness)	• Properties found through grass filter strip modeling assuming shallow sheet flow	Lee et al. 1989
Review	• Buffer width is the key design variable to nutrient retention	• Phillips (1989) accounted 81% of variability in contaminant removal to width	Fennessy and Cronk 1997
(Maryland, Illinois)	• Effective buffer widths of 19 metres were used to remove sediment from agriculturally derived overland flow	• See Peterjohn and Correll 1984	Osborne and Kovacic 1993

Table 4: Water Quality and Nutrient Fluxes			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
Attenuation Effects from Plants, Microbes and Bacteria			
Phosphorous			
Review	• Surface Phosphorous is attenuated by buffers of relatively small widths	• Surface flow derived Phophorous is reduced by 50% - 80% in forested riparian zones with widths between 16m and 50m • Surface P is reduced by 61% - 83% in grass riparian zones with widths between 5m and 27m wide	Osborne and Kovacic 1993
Illinois, USA	• Subsurface (dissolved) phosphorous represents 29% of amount exported	• Varied buffer width effects have been observed	Osborne and Kovacic 1993; Peterjohn and Correll 1984
Illinois, USA	• Forest buffers attenuate phosphorous more efficiently during the growing season but release more phosphorous in the dormant than grass strips	• Leaf leaching may contribute to dormant season measurements	Osborne and Kovacic 1993; Fennessy and Cronk 1997
Illinois, USA	• Grass buffer phosphorous attenuation is higher on an annual basis	• Some release of phosphorous during the dormant season occurs	Osborne and Kovacic 1993
Nitrogen			
Review	• Surface N transport to the stream is reduced by 54% - 84% in grassed riparian zones with widths of between 9m and 27m	• 3 Studies were examined	Osborne and Kovacic 1993
Review	• Surface N transport to the stream is reduced by 79% - 98% in forested grassed riparian zones with widths of between 30m and 50m	• 2 Studies were examined	Osborne and Kovacic 1993
Review	• Subsurface N is reduced by 73%-100% after movement through a forested riparian buffer of widths between 10m and 50m	• Lower reductions have been shown by grassed zones (10%-60%, 27m)	Osborne and Kovacic 1993

Table 4: Water Quality and Nutrient Fluxes			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
Denitrification			
Review	• Denitrification is the primary mechanism and the preferred method of nitrogen attenuation	• N_2 gas is the bi-product	Martin et al 1998
Review	• Reduction of nitrate output rates down to 2mg/L can consistently be achieved	• Process rate is affected by amount of Carbon, sol saturation, bacterial activity, temperature and pH	Fennessy and Cronk 1997; Martin et al. 1998; Knowles 1982
Review	• Majority of nitrate loss occurs in riparian organic soils (56%-100%)	• Due to high percentages of groundwater movement through these soils and their high denitrifying enzyme concentrations	Cooper 1990
Review	• Variation in denitification rates occur spatially in 3 dimensions and temporally	• Spatial and temporal variability is unclear	Martin et al. 1998
Review	• Floodplain hydrology greatly affects rates of denitrification	• Tile drainage systems bypass sites of denitrification	Fennessy and Cronk 1997;Osborne and Kovacic 1993; Cooper 1990

Table 5: Ecological Characteristics			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
USA	• Forested riparian ecosystems are 1 of 6 major threatened and endangered ecosystem types in the U.S.	• Accounts for 10% of systems on list	Noss et al. 1995
Sweden; USA (Oregon and California)	• Riparian plant communities are dynamic and species rich	• Riparian zone communities are exposed to various physical characteristics (e.g.. discharge and substrate type) and disturbance patterns	Nilsson et al. 1994, Gregory et al. 1991
Maryland, USA	• Riparian ecosystems have high values of productivity	• Not as resource limited as upland areas	Peerjohn and Correll 1984
General, USA	• Riparian zones influence the structure and composition of aquatic ecosystems	• River Continuum Concept	Vannote et al. 1980
Southern Ontario	• Percent riparian forest is positively correlated with index of biotic diversity scores	• Inverse relationship with urbanization	Steedman 1988
Species Dispersal			
France	• Riparian zones are corridors for movement of both plant and animal species	• Linear landscape patterns	Decamps et al 1987
Sweden	• Water dispersal plays a role in the structuring of riparian flora	• Seed distribution patterns affected by dispersal characteristics	Johansson et al. 1996
Sweden	• Continuous river corridors are important in maintaining regional biodiversity	• Fragmentation due to damming prevents seed travel	Johansson et al. 1996
	• Bird and mammal species richness is greater in riparian areas than adjacent upland areas.	• Due to abundance of water and diversity of food sources	Chapter 2 pp51-52 USDS Stream Corridor Restoration Handbook 1997
Barrier Effects			
Hypothetical	• Barriers effect correlated with stream width increases	• Hypothetical evidence	Malanson 1993
Hypothetical	• Saturated soil conditions are barriers to the establishment of upland plant species	• Hypothetical evidence	Malanson 1993
Observation	• Some westward boundaries of tree species have been observed to approximately coincide with eastern embayment shores of the Mississippi	• Observed from: A Range Map of trees in the U.S.A. (Little 1971)	Malanson 1993

Table 5: Ecological Characteristics			
RESEARCH AREA	**RESULTS**	**FACTORS / NOTES / PARAMETERS**	**AUTHORS**
Regulators of Aquatic Habitat, Food and Nutrients to the Aquatic Ecosystem			
Central Amazon River	• Lateral exchanges of biomass, and energy between the river and its' floodplain	• Occurs during periods of overbank flooding (Large floodplainrivers)	Junk et al. 1989
Maryland, USA	• Longitudinal patterns of biomass, and energy along the river	• Decreasing edge effects	Vannote et al. 1990
Oregon, USA	• Physical components determine aquatic habitat	• Organization, structure, and dynamics	Frissell et al. 1986
Review	• Local geomorphic constraint influences aquatic communities	• Topographic, edaphic, and disturbance mechanisms.	Gregory et al 1991
Missouri, USA	• Fluvial hydraulic characteristics are related to fish species abundance	• Decreased fluvial heterogeneity	Rabeni and Jacobson 1993
Pennsylvania, USA	• Stream thermal characteristics are controlled by riparian land use	• Regulates invertebrate community structure	Vannote and Sweeney 1979
Tasmania, Australia	• Riparian deforestation decreases riffle macro-invertebrate habitat and abundance	• Increased fine sediments	Davies and Nelson 1994
Kansas, USA	• Litter storage rates are greater in forested reaches than grassland bordered reaches	• Due to increased roughness and flow complexity of forested areas	Gurtz et al. 1988

Table 6: A proposed hierarchy for the determination of the scale of measurement for geographic, geomorphic and biotic data collection and analysis within watershed systems (some elements modified or adapted from Frissell et al. 1986).

System Level	Linear spatial scale (m)	Areal spatial scale (m^2)	Areal and profile boundaries	Time scale of continuous potential persistence (years)	Time scale of persistence under human disturbance patterns (years)	Biotic Assemblage Scale	Life Activity and scale (variable time)
Watershed	10^5	10^{10}	Drainage divides between tertiary watersheds	10^6-10^5	10^4-10^3	community species (migratory)	life cycle life cycle (<20 yrs.)
Subwatershed	10^4	10^8	Drainage boundaries of quaternary watersheds within tertiary drainage basins	10^4-10^3	10^2-10^1	community/ species	life cycle (1-8 yrs.)
Reach	10^3-10^1	10^5	Minimum of two full channel wavelengths, and defined by as a specific stream type based on the Rosgen (1993) classification. Active profile boundaries up to 1:20yr flow elevation, passive boundaries to 1:100yr flow elevation.	10^2-10^1	10^1-10^0	species	life cycle/ life stage (0.1-8 yrs.)
Site	10^1-10^0	10^2	Channel segment comprising either a riffle or pool, profile including bankside riparian vegetation up to bankfull elevation	10^0	10^0-10^{-1}	individual	life stage (0.1-0.4 yrs.)
Habitat element	10^0-10^{-1}	10^1	Zones of variable substrate types or characteristics, water velocity and depth within either a pool, step or riffle.	10^0-10^{-1}	10^{-1}-10^{-2}	individual	activity (10^{-3}-0.1 yrs.)

Table 7: Literature Derived Suggested Riparian Zone Widths for the Protection of Water Quality
(modified from Large and Petts 1994; Fennessy and Cronk 1997; Muscutt *et al.* 1993; Osborne and Kovacic 1993)

Research Area	***Reference***	***Width (m)***	***Flow Type***	***Vegetation Type***	***N Inflow***	***N Reduction (%)***	***P Form***	***P Inflow***	***P Reduction (%)***	***Slope (%)***
Scandinavia	Ahola 1989, 1990	50								
	Hoek 1987	150								
U.S.A.	Rabeni 1991	Various								
UK	Pinay and Descamps 1988	30	Subsurface	Forest	5 mg/L	~100				
South Finland	Keskitalo 1990	30								
Maryland, U.S.A.	Peterjohn and Correll 1984	19 50 50	Subsurface Surface	Forest Forest						
SE, U.S.A.	Correll and Weller 1989	30								
U.S.A.	Rhodes *et al.* 1985	1-2								
New Zealand	Smith *et al.* 1989	-								
Rhode Island, U.S.A.	Simmons et al 1992	9	Subsurface	Forest	180 mg/L	61-97				
SE, U.S.A.	Correll 1991	10 20	Subsurface “	Forest “	0.6-2.5 mg/L 0.6-2.5 mg/L	Up to 77 Up to 87				

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(modified from Large and Petts 1994; Fennessy and Cronk 1997; Muscutt *et al.* 1993; Osborne and Kovacic 1993)

Research Area	***Reference***	***Width (m)***	***Flow Type***	***Vegetation Type***	***N Inflow***	***N Reduction (%)***	***P Form***	***P Inflow***	***P Reduction (%)***	***Slope (%)***
SE, U.S.A.	Lowrance *et al.* 1984	25	Subsurface	Forest	~2-6 mg/L	68				
UK	Haycock and Pinay 1993	22	Subsurface	Herbaceous	2-12 mg/L	84				
		26	"	Forest	2-9 mg/L	~100				
SE, U.S.A.	Lowrance 1992	10	Subsurface	Forest	13.5 mg/L	70-90				
SE, U.S.A.	Jordon *et al.* 1993	50	Subsurface	Forest	8 mg/L	95				
North Carolina, U.S.A.	Gilliam and Skaggs 1988	60	Subsurface	Forest	10 mg/L	~100				
North Carolina, U.S.A.	Jacobs and Gilliam 1985	16	Surface and Subsurface	Forest	10 mg/L	90			50	
U.S.A.	Dillaha *et al.* 1989	4.6	Surface	Grass		54	Total P	4.34 kg/ha	73	11
		4.6	Surface	Grass			PO_4-P	0.09 kg/ha	Increase	11
		4.6	Surface	Grass			Soluble P	0.18 kg/ha	Increase	11
		9.1	Surface	Grass		73	Total P	4.34 kg/ha	93	11
		9.1	Surface	Grass			PO_4-P	0.09 kg/ha	47	11
		9.1	Surface	Grass			Soluble P	0.18 kg/ha	55	11
		4.6	Surface	Grass			Total P	8.42 kg/ha	49	16
		4.6	Surface	Grass			PO_4-P	0.11 kg/ha	8	16
		4.6	Surface	Grass			Soluble P	0.17 kg/ha	Increase	16
		9.1	Surface	Grass			Total P	8.42 kg/ha	56	16
		9.1	Surface	Grass			PO_4-P	0.11 kg/ha	Increase	16
		9.1	Surface	Grass			Soluble P	0.17 kg/ha	Increase	16
U.S.A.	Petersen *et al.* 1992	8	Surface	Herbaceous	20mg/L	20		4mg/L	66	
		30	Surface	Herbaceous	20mg/L	50				

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(modified from Large and Petts 1994; Fennessy and Cronk 1997; Muscutt *et al.* 1993; Osborne and Kovacic 1993)

Research Area	***Reference***	***Width (m)***	***Flow Type***	***Vegetation Type***	***N Inflow***	***N Reduction (%)***	***P Form***	***P Inflow***	***P Reduction (%)***	***Slope (%)***
Eastern, U.S.A.	James, Bagley, and Gallagher 199?????	10	Subsurface	Forest		60-98				
U.S.A.	Schnabel 1986	19	Subsurface	Forest		40-90				
U.S.A.	Doyle, Stanton and Wolf 1977	1.5 4.0 30	Surface Surface Surface	Forest Forest Forest		 98	Soluble P Soluble P	0.77 kg/ha 0.077 kg/ha	8 62	
U.SA.	Cooper and Gilliam 1987	16	Surface	Forest					50	
U.S.A.	Thompson *et al.* 1978	12.0 36.0					Total P Total P	10.7 mg/L 10.7 mg/L	44 70	4 4
-	Edwards *et al.* 1983	30.0 30.0					Total P Total P	55 kg 28 kg	49 47	2 2
-	Magette *et al.* 1989	9.2					Total P	13.7 kg/ha	44	