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Status of Riparian Zones in the Anagance Watershed

STATUS OF RIPARIAN ZONES IN THE ANAGANCE WATERSHED

Kevin B. Pugh

1999

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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SUMMARY

The status of riparian zones is seen as a major factor affecting water quality. This project was undertaken to determine the feasibility of a repeatable automated procedure for determining the riparian status of watercourses in a given watershed. Aerial photographs, along with ARC/INFO and ARCVIEW GIS were used to link riparian status attributes to locational information along a watercourse.

A rulebase was developed for determining the status, nature, infringement and adjacent landuse of forest and non-forest riparian zones in the Anagance Watershed. Results from the Anagance Watershed show that most of the area (95%) is in a forest condition. At the lower end of the watershed, where stream orders get larger, non-forest conditions are encountered more frequently.

INTRODUCTION

Keywords: Riparian zone status, water quality, buffer, watercourse, and Geographic Information Systems

The advancement of computer technology and the availability of Geographic Information Systems (GIS) have allowed for an improved analysis procedure over the traditional methods for assessing riparian zone status. An integrated approach which involves the use of (i) Microsoft Excel 97 in the collection of attribute information (ii) ARC/INFO for data generation and (iii) ARCVIEW for query and display of results was used in this project.

This report deals with riparian status results generated from linear watercourse features, lakes and wetlands from the Anagance Watershed. Tabular and graphical results in percentages will be shown in APPENDIX I & II. The database consists of attribute information and associated linear lengths of riparian status of left and right stream banks of the Anagance Watershed. An ARC/INFO point coverage also exists showing the spatial distribution of the changes in riparian status. Where changes in status or nature of the riparian zone have occurred, a point has been added along the watercourses. Attributes being spatially geo-referenced to the stream or wetlands within the Anagance Watershed, will allow for similar analysis on sub-watersheds such as Hayward Brook (Figure 1.).

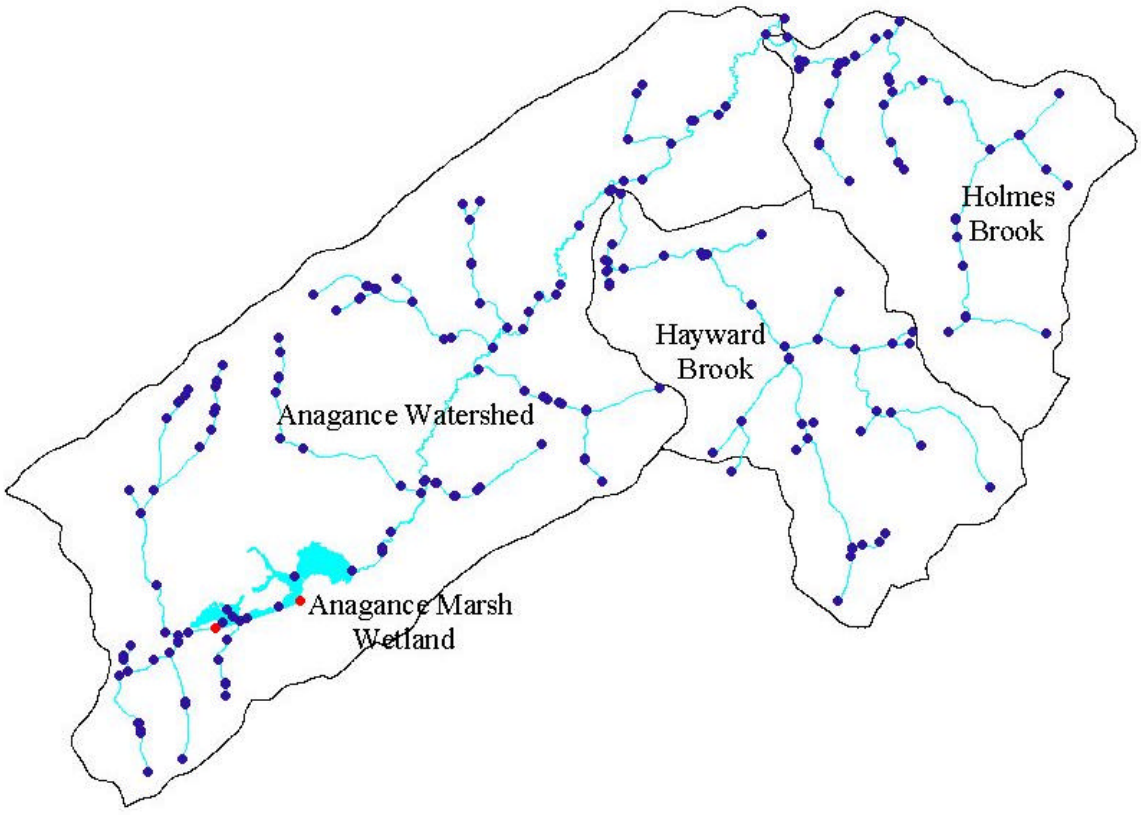


Figure 1. Points representing changes in riparian status in the Anagance Watershed.

METHODS AND RESULTS

The following is an explanation of the Data Sources, Interpretation rule base, interpretation phase, data generation using the GIS, and presentation of the results

Data Sources

An enhanced version of the Service New Brunswick (SNB) hydrographic layer (Cowie, 1999), Department of Environment (DOE) watershed layer, 1993 Department of Natural Resources and Energy (DNRE) GIS Forest Inventory, DNRE wetlands layer and 1993 DNRE aerial photography (scale: 1:12500) formed the basis for the production of the database.

A previous Fundy Model Forest report entitled "GIS Linkages for Water Quality Issues, Saint John River Basin" (Cowie, 1999), resulted in assigning unique water body identifiers and stream orders to each arc or segment within the Anagance Watershed. Water body ID's and stream orders were assigned to all hydrographic features such as: (ditchs, river single lines, and water body center lines and many more). Collectively, these hydrographic features are divided among three ARC/INFO route systems. These route systems are: (I) single line (ii) double line and (iii) lakes. For simplicity, the single line and lake route systems were the only ones chosen for this analysis. This information formed the basis for generating ARC/INFO route systems that were used to generate information on riparian zone status.

The wetlands portions of the Service New Brunswick (SNB) hydrographic layer were omitted in favor of a more definitive wetland coverage from the Fish Wildlife branch of DNRE. Each wetland in this layer was divided into separate polygons according to: (I) wetland class (ii) water regime indicator (iii) impoundment modifier (iv) percent vegetation cover (v) vegetation cover type and (vi) percent vegetation cover for specific cover types. In consultation with the Soil and Water Technical Committee, Emergent Wetland (EW) and Aquatic Bed (AB) were chosen for wetland class and emergent vegetation (EV), open water - vegetated (OW) and open water - unvegetated were chosen for vegetation cover type (DNRE, 1999). This resulted in substantial reduction in wetland part of the analysis. All other wetland portions were considered to be part of the forested area of the analysis.

In order to analyze wetlands a two step conversion had to be made.

Step One: ARCVIEW shapefile to an ARC/INFO coverage using the ARC/INFO command SHAPEARC .

ARC: Shapearc Wetland.shp Wetlands type

Step Two: Building Wetland Routes (routes are a sub-class in wetlands coverage)
General Process: Create route on a subset of arcs, then append final arc(s) to the newly created route.

In ARCEDIT: - mapex wetlands
- edit coverage wetlands
- edit feature arcs
- select path [or many] (but do not select all of the arcs in the wetlands boundary)
- make route wetland # * (click on beginning arc)
- edit route wetland
- select wetland
- append arc[many] (select remaining arc (s))
- remeasure # route - himeas (establishes correct route measures for the appended arcs)

The 1993 DNRE forest inventory GIS layer was used to reselect non-forest polygons which were adjacent to watercourses. The non-forest Land Class (NFLC) item was used to reselect codes which represent non-forest conditions (Appendix III). These were used as a guide to distinguish forest from non-forest.

The DOE watershed layer was used to outline the area where the interpretation would be done. This data was derived from watershed boundaries which were delineated on 1:10,000 orthophotography. These boundaries were then digitized to form an ARC/INFO coverage.

The most important source of data was the 1993 DNRE Aerial Photography. This provided the basis for all interpretation of riparian zone status.

The Interpretation Rulebase

The rulebase formed the basis for decision making when assigning attributes of riparian status to a watercourse. When assigning a riparian status to left and right watercourse banks the following suggested categories were used in the non-forest situation (Appendix IV).

(1) Bare - no shrub or tree vegetation present
(2) Fringe- shrub or tree vegetation present but of insufficient width to provide adequate protection to the stream
(3) Adequate - sufficient woody vegetation present to provide stream protection as per the following.
(4) Forested – Forest Inventory database shows the riparian strip to be within a forest stand

Table 1. The definition of "adequate" by stream order for riparian zone analysis
Adequate width for water quality (not according to legislation).

Stream Order	Assumed Bank Width (m)	Buffer Required*
1	<1	5
2	1-5	15
3	5-10	30
4	>10	30
5	>10	30
6	>10	30

When riparian zones occurred in a forest area they were referred to as forested status. These areas were easily identified on the aerial photography. Forest areas delineated on the 1993 forest inventory GIS layer were used as a guide.

For riparian zones occurring in the forest areas, the nature of these buffers were further described as follows: (I) mature timber (ii) regenerating stand (iii) plantation stand (iv) alder/shrub (v) adjacent recent silviculture and (vi) disturbed buffers. Identifiable changes, up to a resolution of 10.0m on the aerial photography, resulted in a change in the buffer composition or nature. The composition of non-forest buffers was not classified.

Disturbed buffers in the forest environment and all non-forest buffers were categorized according to any infringement within the buffer width, according to stream order (table.--). Identifiable infringement, occurring within or adjacent to a watercourse, up to a resolution of 10.0m on the aerial photography, were recorded as follows: (I) Roads (ii)Trails (iii) Railways (iv) Gravel Pits (v) Transmission Lines (vi) Camps (vii) Agriculture (viii)Rural Residential (ix) Industry (x) Recent Clear-Cut (xi) Partial Harvest evident. Agriculture was not considered an infringement on a forest buffer and recent clear-cut is not an infringement on a non-forest buffer.

Adjacent land-use (of forest and non-forest) within 100 m of the watercourse was identified according to the following categories: (I) Agriculture (ii) Urban (iii) Rural-Residential (iv Industrial (v) and Forestry (Appendix IV). In a small number of cases forestry was regarded as an adjacent land use where forest stands were encountered within 100m of a watercourse.

Interpretation Phase

The two main software components of the interpretation phase were ARCVIEW 3.1 and Microsoft Excel 97. The single line route system of the Anagance ARC/INFO coverage was used in conjunction with the 1993 forest inventory GIS layer. Where interpretation of lakes was needed the lake route system would be used. Separate analysis of wetlands was done using the DNRE, Fish and Wildlife wetlands layer. The following is an outline of steps for the interpretation phase:

Step One - Creation of a Pont Theme:

A Point theme (ARCVIEW shapefile) was created using a process known as “heads-up digitizing”. These points signify changes in riparian status/nature on left and right sides of the watercourse. In ARCVIEW, with the view document active, choose New Theme under the View Menu. At this point choose point as the feature type. This allows points to be placed along the single-line, lake, or wetland route system. After choosing point as the feature type, navigate to the directory where the point shapefile will be stored. (i.e. anaripstat.shp). The attributes of this shapefile have the shape and ID field. The ID field should be replaced with unique-id by highlighting ID in the attributes table and choosing delete field under the edit menu. A new field can be added be choosing Add Field under the Edit Menu when the Table document is active.

Step Two - Building the attributes Table:

The attributes table (Microsoft Excel spreadsheet) was created using the table structure outlined in Appendix VI. The enhanced SNB hydrographic layer allowed for isolation of watercourses by a water-id items. The interpretation began with the mainstem, tributaries and sub-tributaries of the Anagance system. For each point that was added to the stream network on the GIS, a corresponding point (unique-id) was added to the interpretation table. The mainstem and tributaries began with a unique-id of zero to indicate the origin of the measurement (Figure 2.).

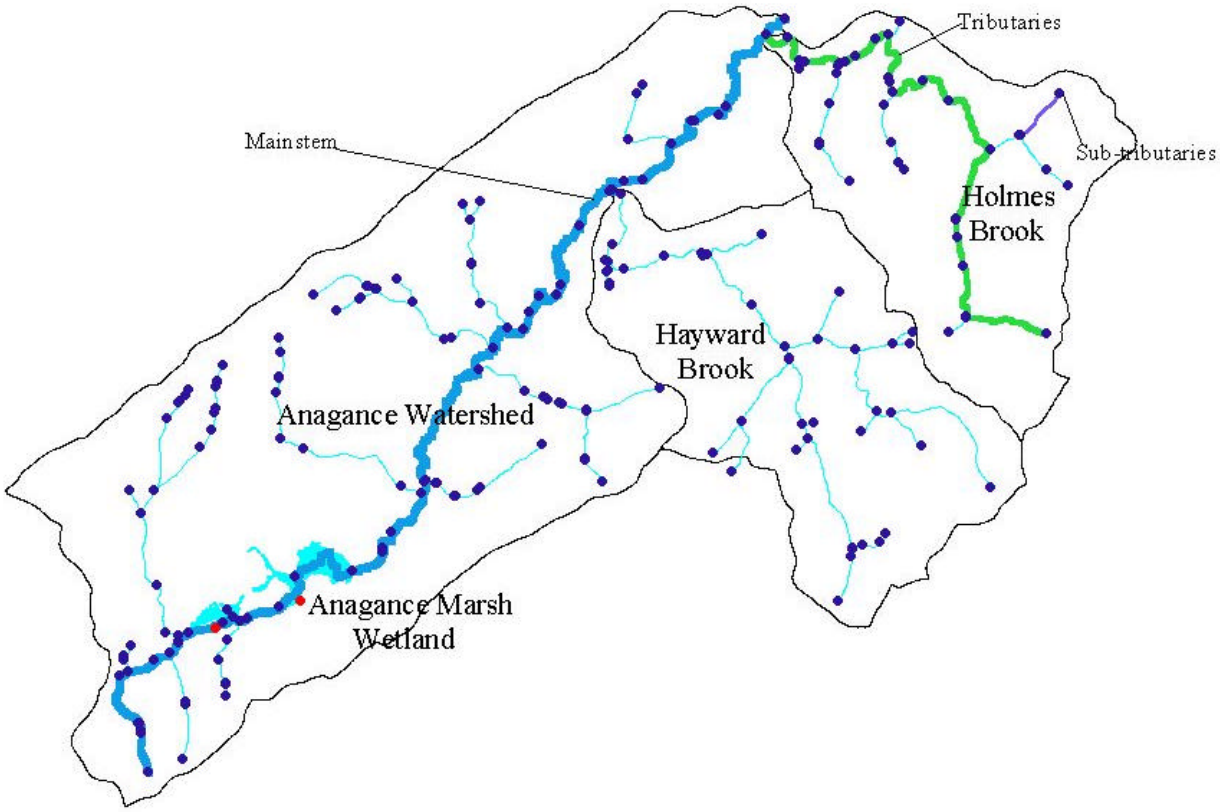


Figure 2. Interpretation procedure of mainstem, tributaries, and sub-tributaries of the Anagance Watershed

Interpretation in a clockwise direction will ensure complete coverage. Points were digitized in

sequence starting at the confluence and moving upstream until the watercourse was completed. The digitizing resumes by moving to the confluence and recording data for the next stream up from the mouth on the left hand side. Each stream is completed in the same fashion before moving to the next, moving in a clockwise direction around the mainstem.

Points were digitized along lakes and single-line stream networks, which includes centerlines for doubleline streams features. When streams pass through wetlands and lakes, start and end points are digitized, with corresponding riparian status.

Start points at the confluence of the mainstem and tributaries are recorded in the interpretation table, but only the water-id field is filled; the remainder of the record is blank.

Step Three - Data generation using GIS and Database Tools:

A process was developed to translate digitized points into stream length segments. The digitized points (shapefile converted to an ARC/INFO coverage) was intersected with stream routes to produce a new table which references the points along the stream. These locations represent the distance between points. By matching this table with the interpretation table, the lengths of each section can be determined.

The following tables were used as examples file names:

Ripstat: Point shape file and Arc Coverage
Anatable.dbf: Riparian Zone interpretation table
Ana-Event: Event table with route measures created by Arc's ADDROUTEMEASURE command.
Anagance: Arc Coverage of Anangance River.
Singleline: Singleline stream route system within Anagance coverage

Steps:

(1.) **Arc**: Convert point shape to Arc coverage (SHAPEARC)

(2.) **Arc**: Use ADDROUTEMEASURE to create an event table with route measures from the point coverage. A tolerance of 15m is needed, as points are not snapped to lines.

Arc Command:

ADDROUTEMEASURE RIPSTAT ANAGANCE SINGLELINE ANA-EVENT.EVE POINT 15

The Ana-event table will have multiple measurements for points close to several routes.

(3.)**Arcview**: Join Ripstat cover to Ana-Event through Ripstat#
Join AnaTable.dbf to Ana-Event through Unique-id

Join Singleline attributes table to Ana-Event through Singleline#

Query: Not ([route_key1].contains([Water-id].AsString))

Delete highlighted records that represent measurements on incorrect routes. The remaining number of records should equal the number of records should equal the number of points.

Arcview: Add Unique-id field to Ana-Event and calculate on joined Unique-id field from Ana-Table.dbf. Remove joined tables.

(4.)**Arcview**: Review start points in Ana-Table.dbf. There should be one record per stream.

Query; [Strm_Order]= “”

(5.)**Arcview**: Add five fields to Ana-Table.dbf

Start-ID	N	4	
End-ID	N	4	
From_Meas	N	10	1
To_Meas	N	10	1
Length	N	8	1

Calculate: [Start-ID] = [Unique-ID] – 1
[End-ID] = [Unique-ID]

(6.)**Arcview**: Join Ana-Event with Ana-Table.dbf through Unique-ID and Start-ID

Calculate: [From_Meas] = [Meas]
Remove Joined Tables

Join Ana-Event with Ana-Table.dbf through Unique-ID and End-ID

Calculate: [To_Meas] = [Measure]
Remove Joined Tables

(7.)**Arcview**:

Query: [To_Meas] > [From_Meas]

Calculate for selected records: Length = [To_Meas] – [From_Meas]

Query: [To_Meas] < [From_Meas]

Calculate for selected records: Length = [From_Meas] – [To_Meas]

The later accommodates streams which have route measures beginning at the source of the stream rather than the mouth.

(8.)**Arcview**:

Query: [Strm_Order] =””

This isolates starting points for all tributaries (ie. 40 points in the Anagance System). Set Start-ID, End-ID, From_Meas, and Length to 0. Starting points of all tributaries and the mainstem.

Results

The forest and non-forest conditions have been reported for singleline hydrographic features and wetlands. If lakes were present, results would be presented for these areas.

Singleline Hydrographic Features

Singleline hydrographic features (ie. Small streams and water body center lines for wider watercourses) account for approxiamately 98% in the Anagance Watershed. The Anagance River system has 40 individual stream segments with 226 segments of riparian status from first to fourth streams. Overall, the ratio of non-forest to forest ranges from 5% to 95% respectively, with the exception of third order streams where the ratio is 15% to 85%. This can be explained by the presence of industry and residential areas near the community of Petitcodiac.

The nature of forested buffers can be described by mature timber in the head-waters to alder/shrub in the mid-stretches. The greater alder/shrub component can be explained by the presence of the Anagance Marsh wetland area. The relatively small components of regenerating stands, plantation stands and adjacent recent silviculture indicates that the status of riparian zones in the Anangance Watershed are in good shape. The 6.2%, 5.5% and 5.7% disturbed condition of stream orders 1,3 and 4 respectively, however; zero in on problem areas that are further described by infringement patterns. The infringement in these disturbed areas can be accounted for by recent clear-cut activity and roads. In fact, 3.7%, 5.9% and 6.2% of third, first and fourth order streams are described as being partially clear-cut. (Appendix I & II)

Non-forest buffers which occupy 5% of the area are characterized by adeqaute, bare and fringe. The adequate status ranges from 17.3% to 91.4% in third and second order streams respectively. There are no adequate stream buffers appearing in fourth order non-forest streams. Fringe buffer status ranges from 0.0%, 33.2%,43.0% and 78.0% for second, fourth, first and third order streams respectively. Bare buffer status ranges from 4.7%, 8.6%, 29.2%, and 66.8% for third order, second order, first order and fourth order respectively. Most of the infringement patterns that cause bare buffer status in first and second order streams are caused by roads and trails. Transmission lines and railways cause infringement in the lower parts of the watershed. As expected, the adjacent landuse pattern for bare buffer status are forested in the upper parts of the

watershed and industrial in the lower parts. Infringement placed on the areas with fringe buffer status is caused primarily by agriculture. Adjacent landuse patterns for these streams in first to third order streams are characterized by agriculture, industry and rural residential. Graphical representation of these results are shown in Appendix II. Queries used to derive these results are also shown in Appendix VI.

Wetlands

The total linear length of wetland boundary interpreted in the Anagance Watershed was 13,381.4m. The status along this length is described as forested with a mature timber.
A railway infringement with a total distance 1451.1m of the total linear length is shown in the South West portion of the watershed. All adjacent landuse patterns are shown as being forested.

CONCLUSIONS

The integrated use is GIS and database technology has allowed for the easy assessment of riparian zone status of any given watershed. The status can easily be assessed by attaching attributes to each point along the bank of a watercourse where woody vegetation has changed. Having this database in place allows for the evaluation of any drainage area within a given watershed. It is recommended that more automated approach be used assess the riparian status, given drainage area of any size. This could be fully integrated with a Digital Elevation Model (DEM) that would be used to determine the drainage area in question.

Once this information is gathered, decisions can be made about operational activities conducted on the ground. This information can be also be used to target landowner groups for restoration work in problem areas.

LITERATURE CITED

Cowie, F. 1999. GIS Linkages for water quality issues, Saint John River Basin, Fundy Model Forest Soil and Water Technical Committee, NB Aquatic Data Warehouse, Febuary 1999.

Department of Natural Resources and Energy; 1993 Forest Inventory GIS Layer. 1993

Department of Natural Resources and Energy; Enhanced Wetland Layer, Fish & Wildlife Branch,. 1999.

APPENDIX I: TABULAR RESULTS OF THE RIPARIAN ZONE STATUS ON THE ANAGANCE WATERSHED

Sample Data Summary Sheet For "Riparian Zone Status"

Stream	Watershed Area	Mapped Linear Length of Main Stem	Gradient of Main Stem (m/km)	Linear Length of 1st Order	Linear Length of 2nd Order	Linear Length of 3rd Order	Linear Length of 4th Order	Linear Length of 5th Order	Area of Wetlands	Area of Named Lakes
Anagance	13877.7ha	28441.7m	89.6m/1.8km	46983.1m	23040.6m	27100.8m	12556.6m		50.7ha	0.0ha

(1). Percent of the Buffers that are in either a Forest or Non-Forest environment by Stream Order

	Forested	**Non-Forested**	**Total**
Stream Order 1	94.9	5.1	100.0
Stream Order 2	94.5	5.5	100.0
Stream Order 3	85.0	15.0	100.0
Stream Order 4	95.1	4.9	100.0
Stream Order 5			

Anagance System = 109681.1 X 2 = 219362.2m = 21.9km of linear length of stream bank

Area of watershed in forest condition = 13874.8ha

Area of watershed in non-forest condition = 602.9ha

Forest Environment

(2) i. Nature of Forest Buffers (All Buffers are 30.0 m by legislation)

	Mature Stand	**Regenerating Stand**	**Plantation Stand**	**Alder/Shrub**	**Adjacent Recent Silviculture**	**Disturbed Buffer**	**Total**
Stream Order 1	80.0	7.8	0.3	5.7	0.0	6.2	100.0
Stream Order 2	72.8	0.0	1.2	23.4	4.0	0.0	101.4
Stream Order 3	27.1	3.0	0.0	55.9	8.5	5.5	100.0
Stream Order 4	46.3	0.0	0.0	48.0	0.0	5.7	100.0
Stream Order 5							

(2) ii. Infringement causing disturbed buffers within 30.0m of the watercourse

Infringement	**Stream Order 1**	**Stream Order 2**	**Stream Order 3**	**Stream Order 4**	**Stream Order 5**
Roads	0.0	0.0	33.8	0.0	
Trails	4.8	0.0	0.0	0.0	
Railways	0.0	0.0	0.0	0.0	
Gravel Pits	0.0	0.0	0.0	0.0	
Transmission	0.0	0.0	0.0	0.0	
Camps	0.0	0.0	0.0	0.0	
Rural Residential	0.0	0.0	0.0	0.0	
Industrial	0.0	0.0	0.0	0.0	
Recent Clearcut	95.2	0.0	66.2	100.0	
Part Harv Evident	0.0	0.0	0.0	0.0	
Total:	100.0	0.0	100.0	100.0	

(2) iii. Percent of Riparian Buffer that is bare or a portion that is clearcut

	Stream Order 1	**Stream Order 2**	**Stream Order 3**	**Stream Order 4**	**Stream Order 5**
Bare #	0.0	0.0	0.0	0.0	
Part clearcut *	5.9	0.0	3.7	5.7	

clearcut to waters edge

* portion of 30.0m buffer clearcut but not to waters edge

Non-Forest Environment

(3) i. Status of Non-Forest Buffers

	Adequate*	Fringe**	Bare***	Total:
Stream Order 1	28.0	43.0	29.2	100.2
Stream Order 2	91.4	0.0	8.6	100.0
Stream Order 3	17.3	78.0	4.7	100.0
Stream Order 4	0.0	33.2	66.8	100.0
Stream Order 5				

*Adequate - Sufficient woodly vegetation present (1st Order-5.0m, 2nd Order-15.0m and 3rd Order+ - 30.0m)

**Fringe - Insufficient width of woody vegetation present to provide adequate stream protection

***Bare - No shrub or tree vegetation present

(4) i. Infringement causing bare buffer status in non-forest streams

Infringement	Stream Order 1	Stream Order 2	Stream Order 3	Stream Order 4	Stream Order 5
Roads	24.1	81.7	0.0	0.0	
Trails	36.1	18.3	0.0	0.0	
Railways	8.0	0.0	0.0	100.0	
Gravel Pits	0.0	0.0	0.0	0.0	
Transmission	32.0	0.0	100.0	0.0	
Camps	0.0	0.0	0.0	0.0	
Agriculture	0.0	0.0	0.0	0.0	
Rural Residential	0.0	0.0	0.0	0.0	
Urban	0.0	0.0	0.0	0.0	
Industry	0.0	0.0	0.0	0.0	
Total:	100.2	100.0	100.0	100.0	

(5) i. Infringement causing fringe buffer status in non-forest streams

Infringement	Stream Order 1	Stream Order 2	Stream Order 3	Stream Order 4	Stream Order 5
Roads	0.0	0.0	0.0	0.0	
Trails	0.0	0.0	0.0	0.0	
Railways	0.0	0.0	26.0	0.0	
Gravel Pits	0.0	0.0	0.0	0.0	
Transmission	14.7	0.0	0.0	37.0	
Camps	0.0	0.0	0.0	0.0	
Agriculture	85.3	0.0	74.0	63.0	
Rural Residential	0.0	0.0	0.0	0.0	
Urban	0.0	0.0	0.0	0.0	
Industrial	0.0	0.0	0.0	0.0	
Total:	100.0	0.0	100.0	100.0	

(6) i. Adjacent Landuse patterns of non-forest streams with bare buffer status (100 m from the stream)

	Stream Order 1	Stream Order 2	Stream Order 3	Stream Order 4	Stream Order 5
Agriculture	0.0	0.0	0.0	0.0	
Urban	0.0	0.0	0.0	0.0	
Rural Residential	0.0	0.0	0.0	0.0	
Industrial	20.6	34.7	100.0	100.0	
Forestry	79.4	65.4	0.0	0.0	
Total:	100.0	100.1	100.0	100.0	

In some cases forestry accounts for some of the adjacent landuse where forest stands are incountered within 100.0m of a stream bank

(6) ii. Adjacent Landuse patterns for non-forest streams with fringe buffer status (100 m from the stream)

	Stream Order 1	Stream Order 2	Stream Order 3	Stream Order 4	Stream Order 5
Agriculture	85.3	0.0	74.0	63.0	
Urban	0.0	0.0	0.0	0.0	
Rural Residential	0.0	0.0	0.0	0.0	
Industrial	14.7	0.0	26.0	37.0	
Forestry	0.0	0.0	0.0	0.0	
Total:	100.0	0.0	100.0	100.0	

(6) iii. Adjacent Landuse patterns for non-forest streams with adequate buffer status (100 m from the stream)

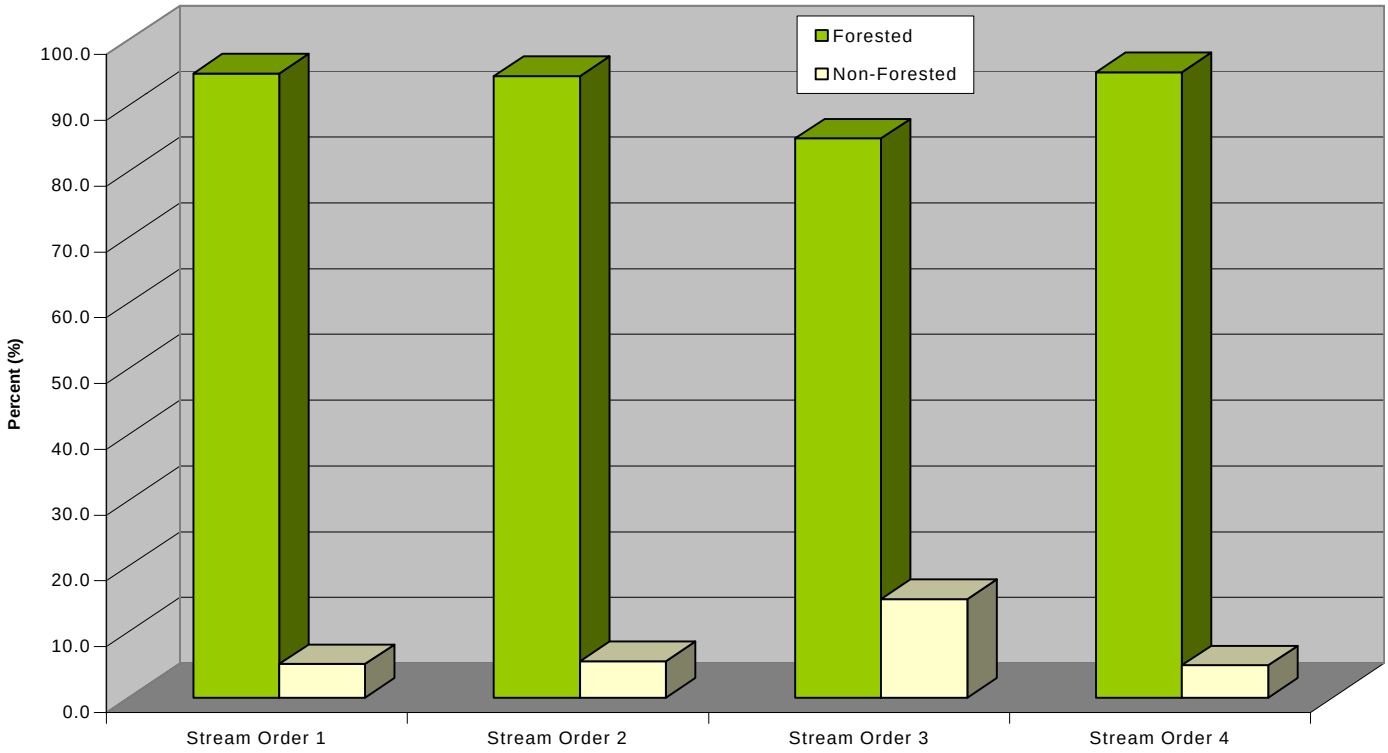
	Stream Order 1	Stream Order 2	Stream Order 3	Stream Order 4	Stream Order 5
Agriculture	54.9	65.5	0.0	0.0	
Urban	0.0	0.0	0.0	0.0	
Rural Residential	0.0	0.0	100.0	0.0	
Industrial	45.1	34.5	0.0	0.0	
Forestry	0.0	0.0	0.0	0.0	
Total:	100.0	100.0	100.0	0.0	

(6) iv. Adjacent Landuse patterns for all non-forest streams (100 m from the stream)

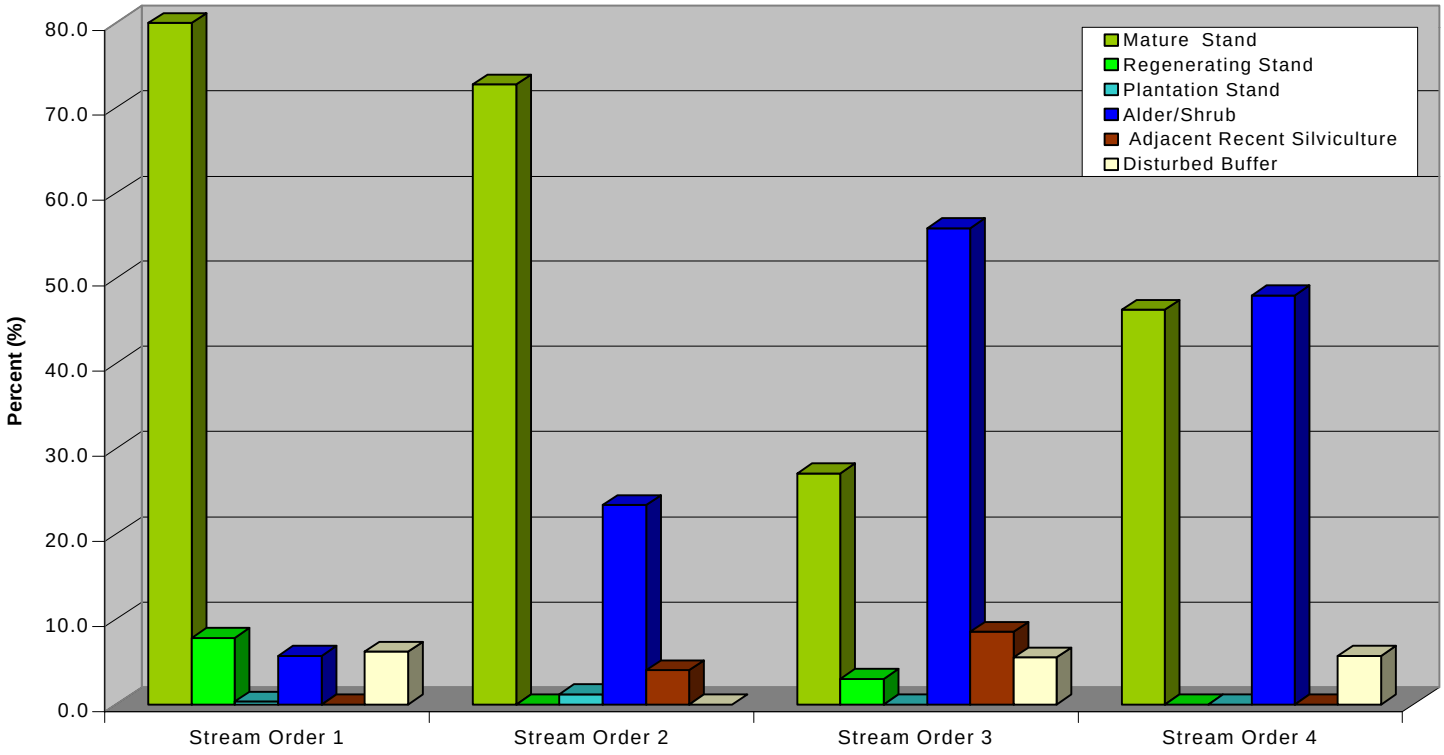
	Stream Order 1	Stream Order 2	Stream Order 3	Stream Order 4	Stream Order 5
Agriculture	36.3	59.9	58.0	20.9	
Urban	0.0	0.0	0.0	0.0	
Rural Residential	0.0	0.0	17.3	0.0	
Industrial	23.6	34.5	24.9	80.2	
Forestry	40.0	5.6	0.0	0.0	
Total:	99.9	100.0	100.2	101.1	

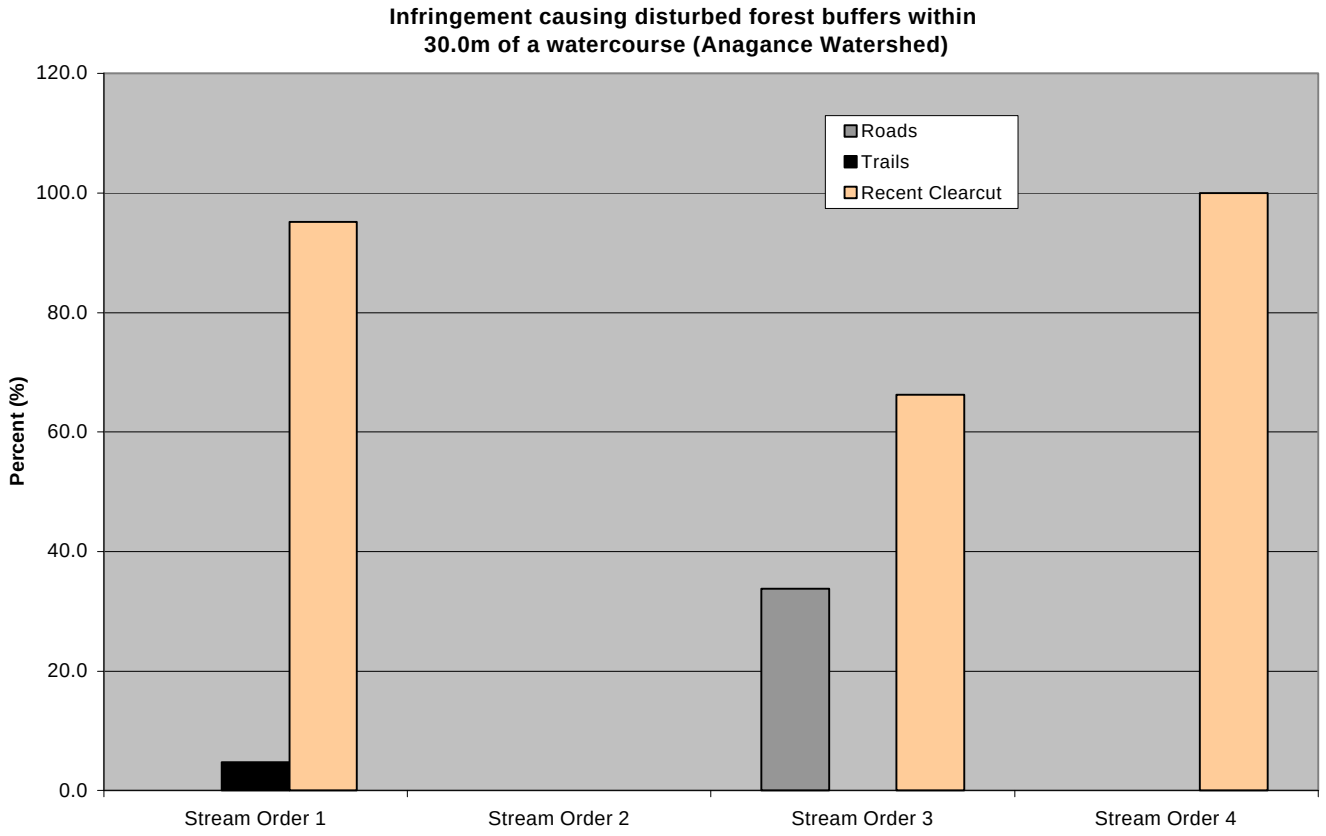
APPENDIX II: GRAPHICAL RESULTS OF RIPARIAN STATUS OF THE ANAGANCE WATERSED

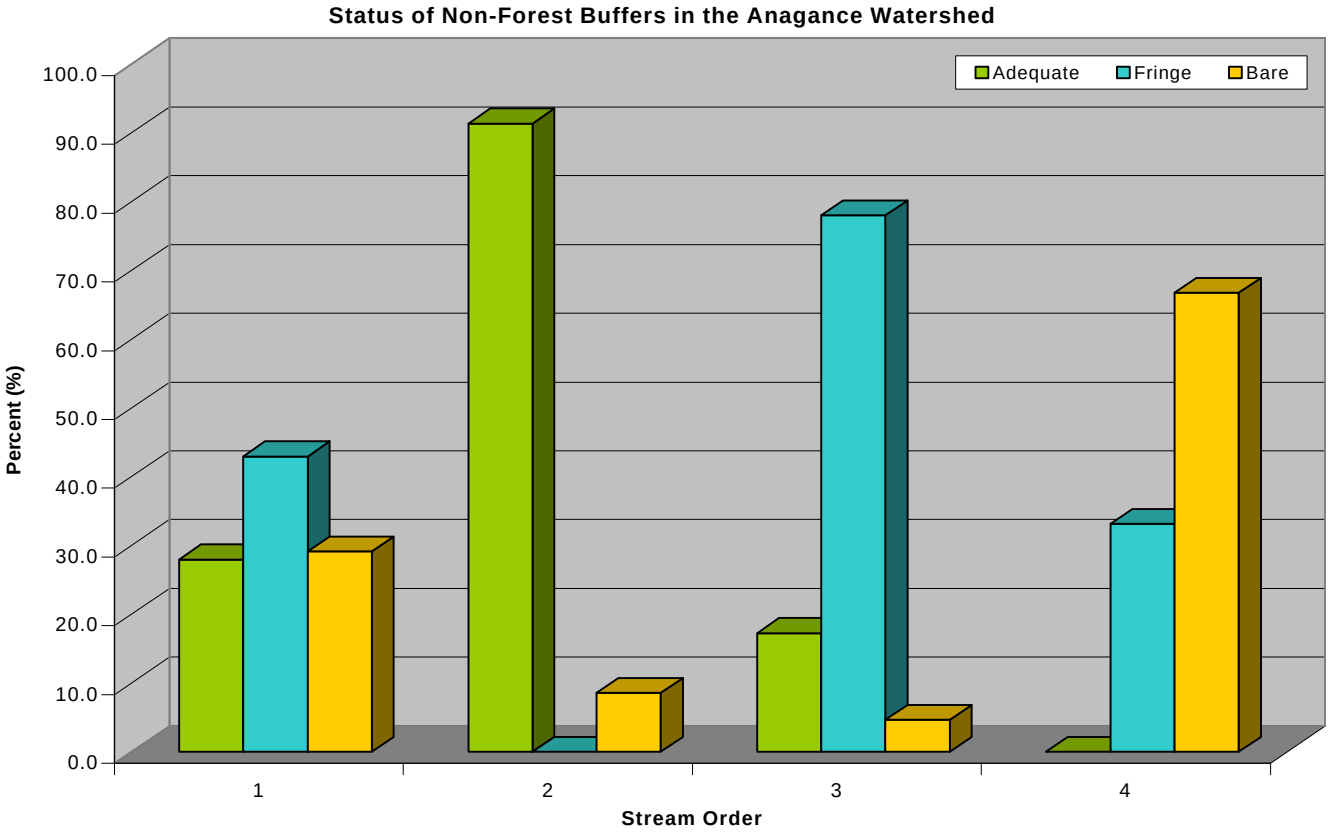
Percent of Buffers that are in either a Forest or Non-Forest environment by Stream Order in the Anagance Watershed



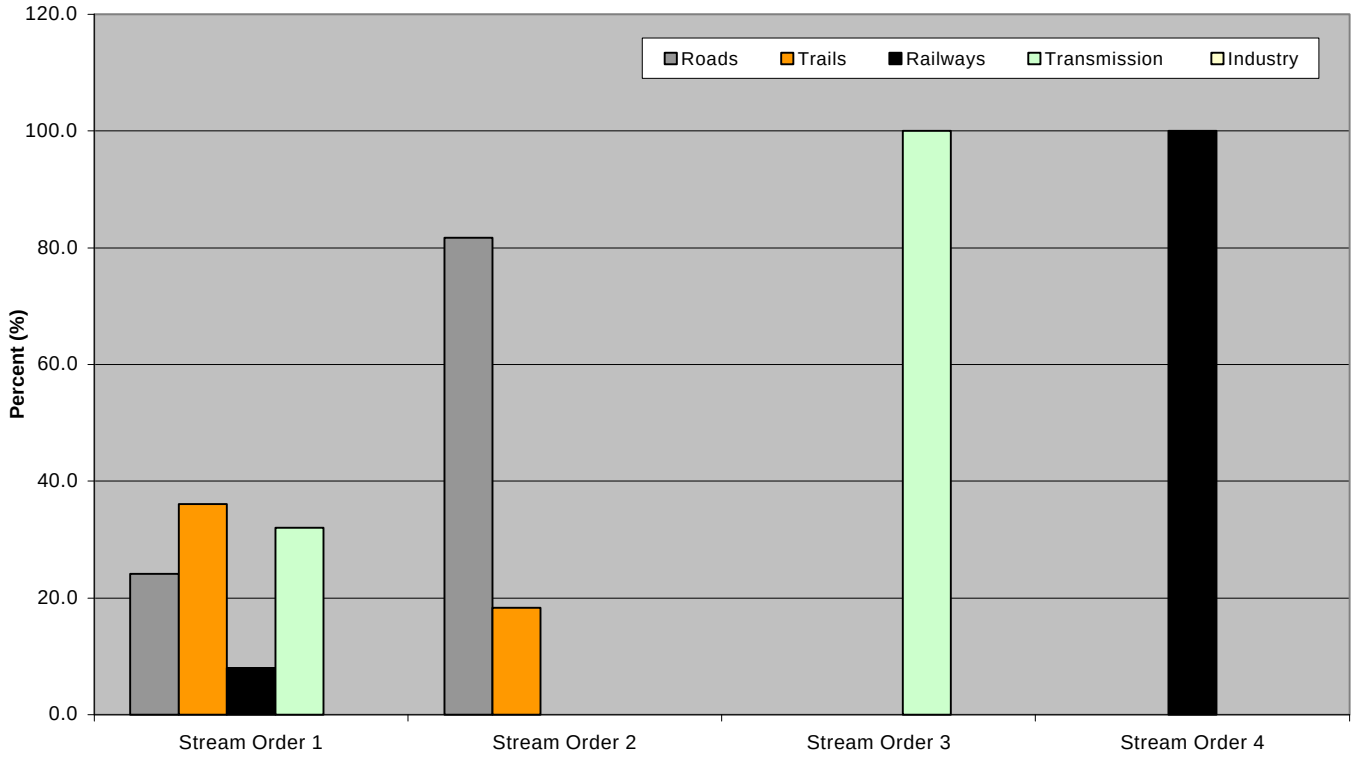
Nature of Forest Buffers in the Anagance Watershed (All Buffers are 30.0m by legislation)



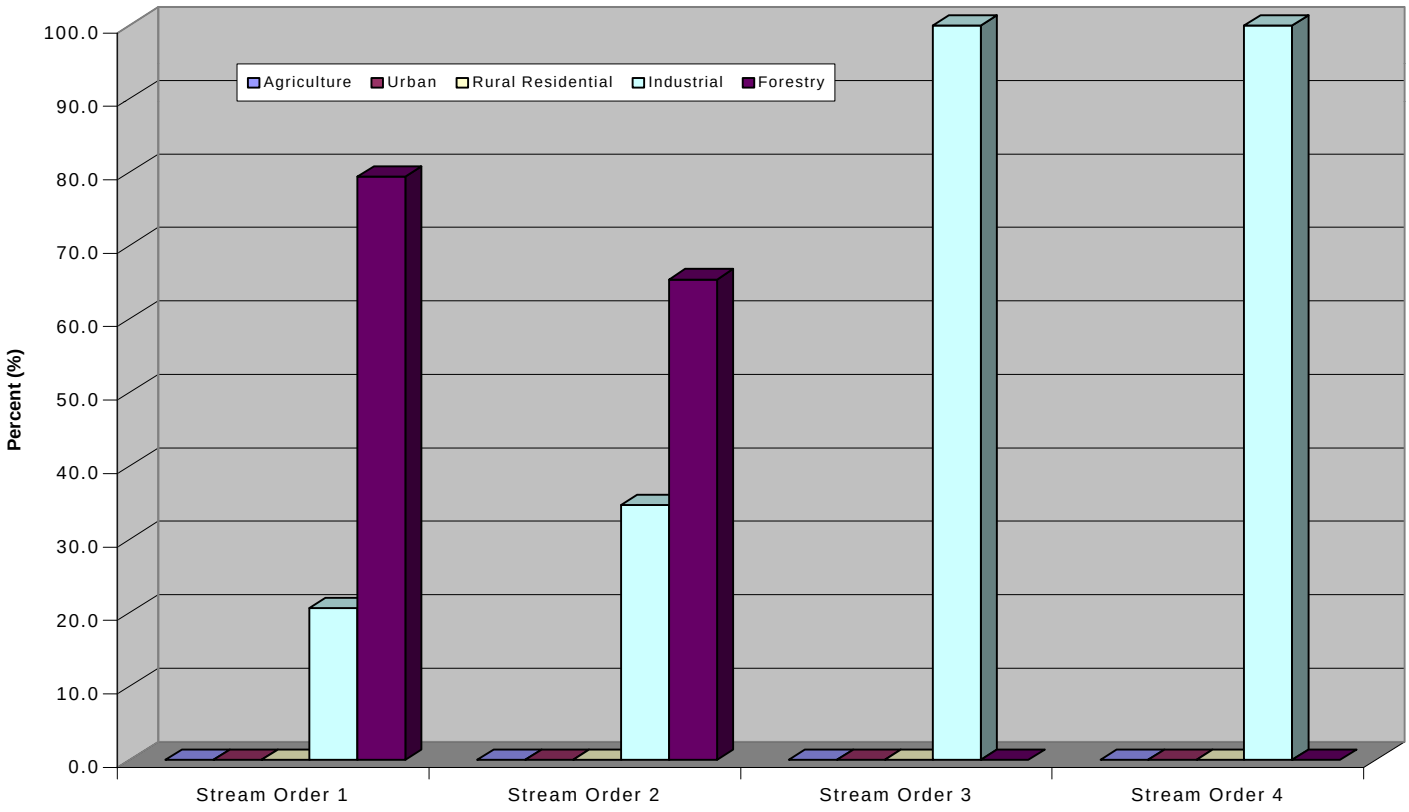

Infringement causing disturbed forest buffers within 30.0m of a watercourse (Anagance Watershed)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Percent (%)
Roads
Trails
Recent Clearcut
Stream Order 1
Stream Order 2
Stream Order 3
Stream Order 4


Status of Non-Forest Buffers in the Anagance Watershed
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percent (%)
Adequate
Fringe
Bare
1
2
3
4
Stream Order

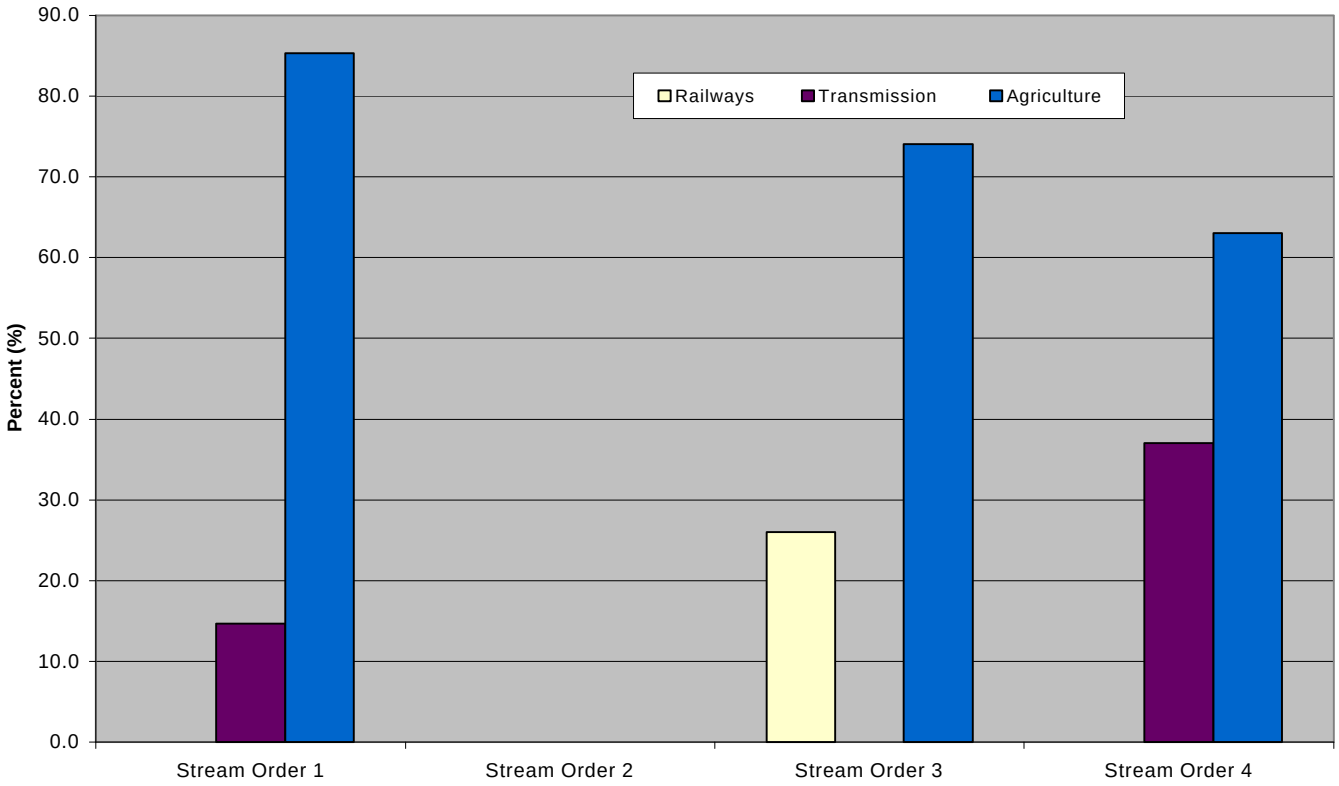
Infringement Causing Bare Buffer Status in Non-Forest Streams of the Anagance Watershed



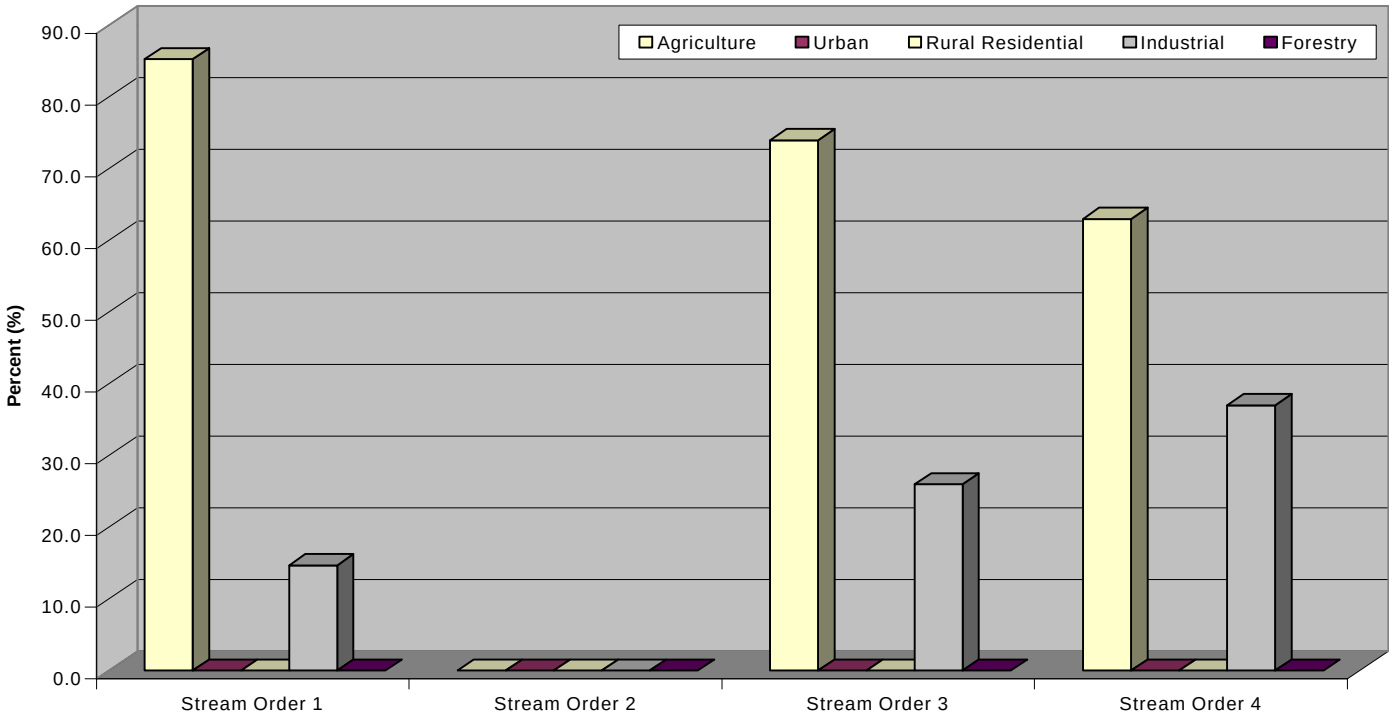
Adjacent Landuse Patterns of Non-Forest Streams with Bare Buffer Status in the Anagance Watershed



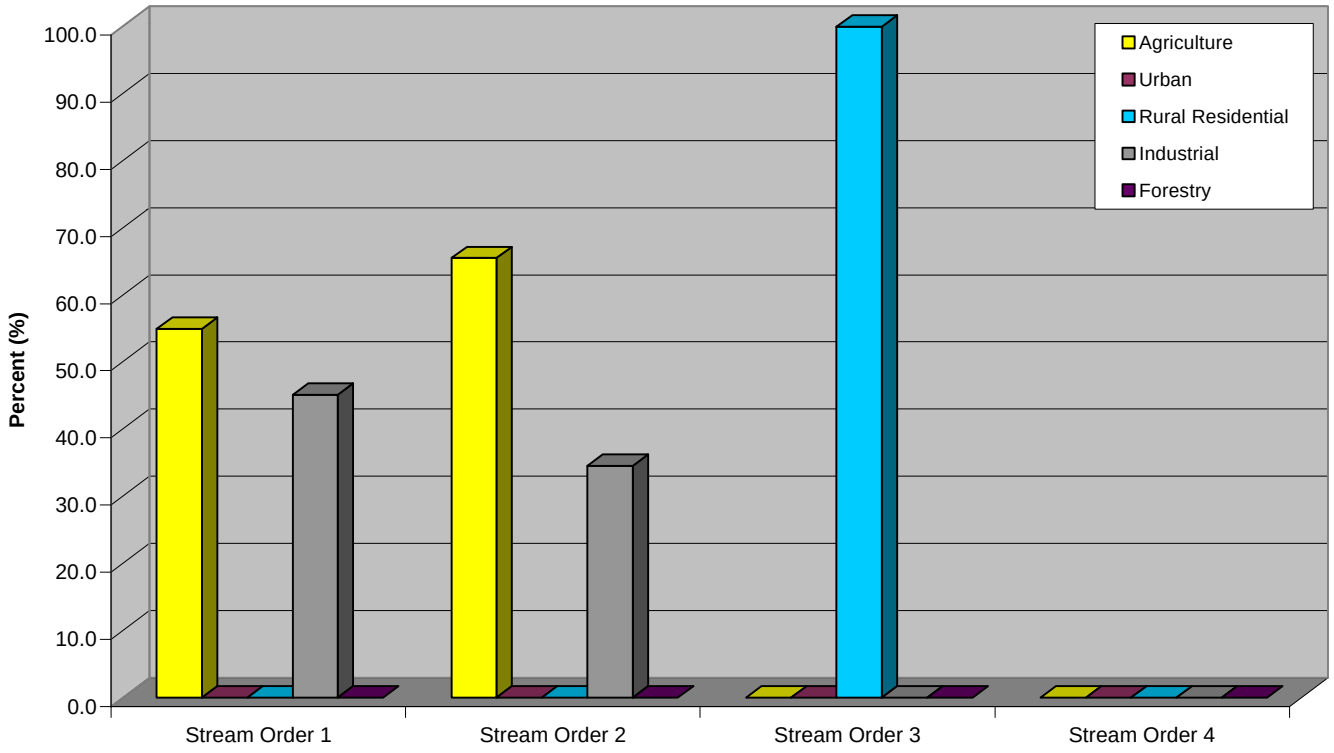
Infringement Causing Fringe Buffer Status in the Anagance Watershed



Adjacent Landuse Patterns of Non-Forest Streams with Fringe Buffer Status in the Anagance Watershed



Adjacent Landuse Patterns of Non-Forest Streams with Adequate Buffer Status in the Anagance Watershed



APPENDIX III : NON FOREST LAND CLASSES (NFLC) USED TO CLASSIFY NON-FOREST AREAS IN THE ANAGANCE WATERSHED

The codes in the NFLC **item of the** FOREST **(poly) layer of the** NBLIB **library are:**

CODE	CONTENT
AP	Alders on poorly drained sites
AC	Alders on a cut
AF	Alders on a field
AG	Agriculture Land
CL	Cultivated farm land (commercial crops)
CB	Cultivated blueberry fields
CP	Cultivated peat bogs
CO	Cultivated Orchards (apple orchards, seed orchards)
FD	Fundy Dykeland
FP	Fallow Pasture (recently abandoned farm land)
CT	Christmas tree (plantations and naturals)
AI	Airstrips
AR	Abandoned Railways
BL	Barren land (Well drained but can't produce merch. forest within a reasonable time frame)
GP	Gravel Pit
IZ	Military Impact Zones
MI	Mine
OC	Occupied - cities, towns, residential areas, etc. - minimum of 2 ha.
PP	Pipe Line
QU	Quarry (crushed rock, limestone)
RD	Road
RO	Rock Outcrop
RR	Railroad
TM	Transmission Line
WA	Water
LK	Lake
PN	Pond
ON	Ocean
RV	River
WL	Wetland

APPENDIX IV: PHOTOGRAPHS SHOWING BARE, FRINGE AND ADEQUATE AND FORESTED BUFFERS

APPENDIX V: RULEBASE FOR THE INTERPRETATION OF RIPARIAN ZONE STATUS

Riparian Feature	Adjacent GIS Environment Class	Status of Buffer	Composition of the Buffer	Infringement on Buffer (Within or 10m Adjacent)	Adjacent Landuse Class (within 100m)	Stream Order Wetland Order
Streams Lakes Wetlands	Forest	d. forested	a. Mature stand b. Regenerating Stand c. Plantation Stand d. Alder Shrub e. Adjacent Recent Silviculture f. Disturbed Buffer	a. Roads b. Trails c. Railways d. Gravel Pits e. Transmission Lines f. Camps g. Rural Residential h. Industrial i Recent Clear Cut j Partial Harvest Evident	a. Agriculture b. Urban c. Rural Residential d. Industrial e. Forestry	1. 1st Order 2. 2nd Order 3. 3rd Order 4. 4th Order 5. 5th Order
	Non-Forest	a. bare b. fringe c. adequate	*** no date entered for buffer composition in non-forest environment	a. Roads b. Trails c. Railways d. Gravel Pits e. Transmission Lines f. Camps g. Rural Residential h. Industrial i Agriculture j Urban	a. Agriculture b. Urban c. Rural Residential d. Industrial e. Forestry	1. 1st Order 2. 2nd Order 3. 3rd Order 4. 4th Order 5. 5th Order

APPENDIX VI: MICROSOFT EXCEL 97 – INTERPRETATION TABLE FOR THE ATTRIBUTES OF RIPARIAN ZONE STATUS

UNIQUE ID	WATER ID	STRM ORDER	L BUF WIDTH DE	L BUF WIDTH AC	LSTATUS	LNATURE	LINFRINGE	LADJLAND	STRM
0									
1	26721	5	30	30	FO	MT	NI	FO	
2	26721	5	30	0	BA	NN	AG	AG	
3	26721	5	30	0	BA	NN	AG	AG	
4	26721	5	30	0	BA	NN	AG	AG	
5	26721	5	30	0	BA	NN	AG	AG	
6	26721	5	30	0	BA	NN	AG	AG	
7	26721	5	30	30	AD	MT	NI	AG	
8	26721	5	30	10	FR	NN	AG	AG	
9	26721	5	30	5	FR	NN	AG	AG	
10	26721	5	30	30	FO	MT	NI	FO	
11	26721	5	30	10	FR	NN	AG	AG	
12	26721	5	30	20	FR	NN	AG	AG	
13	26721	5	30	30	FO	MT	NI	FO	
14	26721	5	30	30	FO	AL	NI	FO	
15	26721	5	30	10	FR	NN	LS	RU	
16	26721	5	30	0	BA	NN	RD	IN	
17	26721	5	30	30	AD	NN	NI	AG	
18	26721	5	30	10	FR	NN	AG	AG	
19	26721	5	30	10	FR	NN	AG	AG	
20	26721	5	30	30	AD	MT	NI	AG	
21	26721	5	30	0	FO	NN	RC	FO	

APPENDIX VII: DATABASE QUERIES

1. **Forested Status:**

   Both sides of the watercourse: ([Lstatus] = “FO”) and ([Rstatus] = “FO”)
   x number of selected records

   Left side of the watercourse: ([Lstatus] = “FO”) and ([Rstatus] <> “FO”)
   y number of selected records

   Right side of the watercourse: ([Lstatus] <> “FO”) and ([Rstatus] = “FO”)
   z number of selected records

2. **Forested and mature timber:**

   Both sides of the watercourse: ([LNature] = “MT”) and ([RNature] = “MT”)
   x number of selected records

   Left side of the watercourse: ([LNature] = “MT”) and ([RNature] <> “FO”)
   y number of selected records

   Right side of the watercourse: ([LNature] <> “MT”) and ([RNature] = “MT”)
   z number of selected records