Quantification of Spatial Change of the Natural Areas in NPCA Watershed from 1934 to 2010

AML Solutions

Project Manager: Hailey Gullett

GIS Analyst: Andrew Lipinski

Niagara Peninsula Conservation Authority

Client Representative: Tara Metzger

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nc Niagara College Canada

Executive Summary

Geographical Information Systems are very useful in determining spatial change, and quantifying spatial analysis (Johnston, Ver Hoef, Krivoruchko, & Lucas, 2001). The use of GIS will create a spatial inventory for 1934 of the changes that have taken place within the Niagara Peninsula Conservation Authority (NPCA) Watershed until 2010. This project has been requested to be completed by June 13, 2014, as requested by the Niagara Peninsula Conservation Authority. The project study will take place within the NPCA jurisdiction which includes all of the Niagara Region, part of the City of Hamilton and part of Haldimand County.

AML Solutions consultants are Hailey Gullett and Andrew Lipinski, and Dr. James Jiang will be the project advisor. AML Solutions is the ideal candidate for this project evidently from the past and current GIS knowledge and practice, educational experience, and a thorough background as a part of the NPCA. The goal of this project will be targeted on identifying changes in natural area using 1934 and 2010 orthoimagery. To ensure completion of this goal, objectives have been set that must be carried out. These objectives including creating and updating a spatial inventory of natural area habitat change, a report identifying areas and degrees of change by watershed, and maps with underlying statistics that identify levels of change.

The resources that will be necessary to the successful completion of the project are personnel, data, hardware, and software. Hardware, software and academic advisory will be supplied by Niagara College and the NPCA. These resources are necessary to complete the major tasks to be completed throughout which include project management, understanding the project, data acquisition, updating spatial inventory, performing GIS analysis, and finally a project summary. The tasks begin on October 4, 2013 and will be completed by June 13, 2014. The proposed methodology for completing these tasks requires the use of ArcGIS 10.1, Microsoft Office Suite 2010, 1934 and 2010 orthoimagery. The total cost of this project including mileage, a contingency estimate, and HST is $35,090.23.

The anticipation of risks and challenges are crucial for every project, some of the risks involved AML Solution foresees is the quality of the 1934 orthoimagery, properly functioning software and hardware, the issue that data may not cover the entire study area and therefore may result in data gaps, and finally the cooperation of ArcMap and orthoimagery provided. Finally, constraints on this project definitely include the time restraint of necessary completion by June 13, 2014, and the acquisition of consistent data throughout the project considering the lengthy time period being quantified.

Table of Contents

Table of Figures

List of Tables

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1.0 Introduction

AML Spatial Solutions has been given the opportunity to partake in a project involving the quantification of spatial change concerning natural areas within the Niagara Peninsula Conservation Authority's (NPCA) watershed. This is a study that will identify and quantify the spatial change of natural areas between 1934 and 2010 within the NPCA's jurisdiction. This study will involve the use of Esri's ArcGIS software with all data and previously created inventories supplied by the NPCA. AML Spatial Solutions is determined to complete a project that will greatly benefit the NPCA by providing scientifically defensible data for use in planning and policy development, identifying areas of habitat loss, gain and fragmentation as well as, allow for the development of greater environmental awareness within the community.

1.1 Niagara Peninsula Conservation Authority (NPCA)

The Niagara Peninsula Conservation Authority (NPCA) was established on April 30th 1959 under the Conservation Authorities Act. The NPCA serves roughly half a million people in a jurisdiction known as the Niagara Peninsula Watershed (Figure 1). When established the driving force behind the conservation movement was the organizations grassroots programs surrounding land stewardship and water quality and protection. Now, the Niagara Peninsula Conservation Authority's commitment to these grassroots programs is vital as it strives to manage the impacts of human activities, urban sprawl, habitat destruction and rural activities within its jurisdiction.

Figure 1: Niagara Peninsula Conservation Authority Jurisdiction

1.2 Study Area (NPCA Watershed)

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As mentioned above the Niagara Peninsula Conservation authority oversees a jurisdiction that serves roughly half a million people. This jurisdiction, known as the NPCA watershed will be the location of AML Spatial Solutions' study area. The Study area encompasses all of the Niagara Region, the southeast corner of the city of Hamilton and the Northeast portion of Haldimad County. The jurisdiction is broken up into sub watersheds which are based on the region's major bodies of water. The NPCA watershed and its Subwatershed can be seen in Figure 2 below.
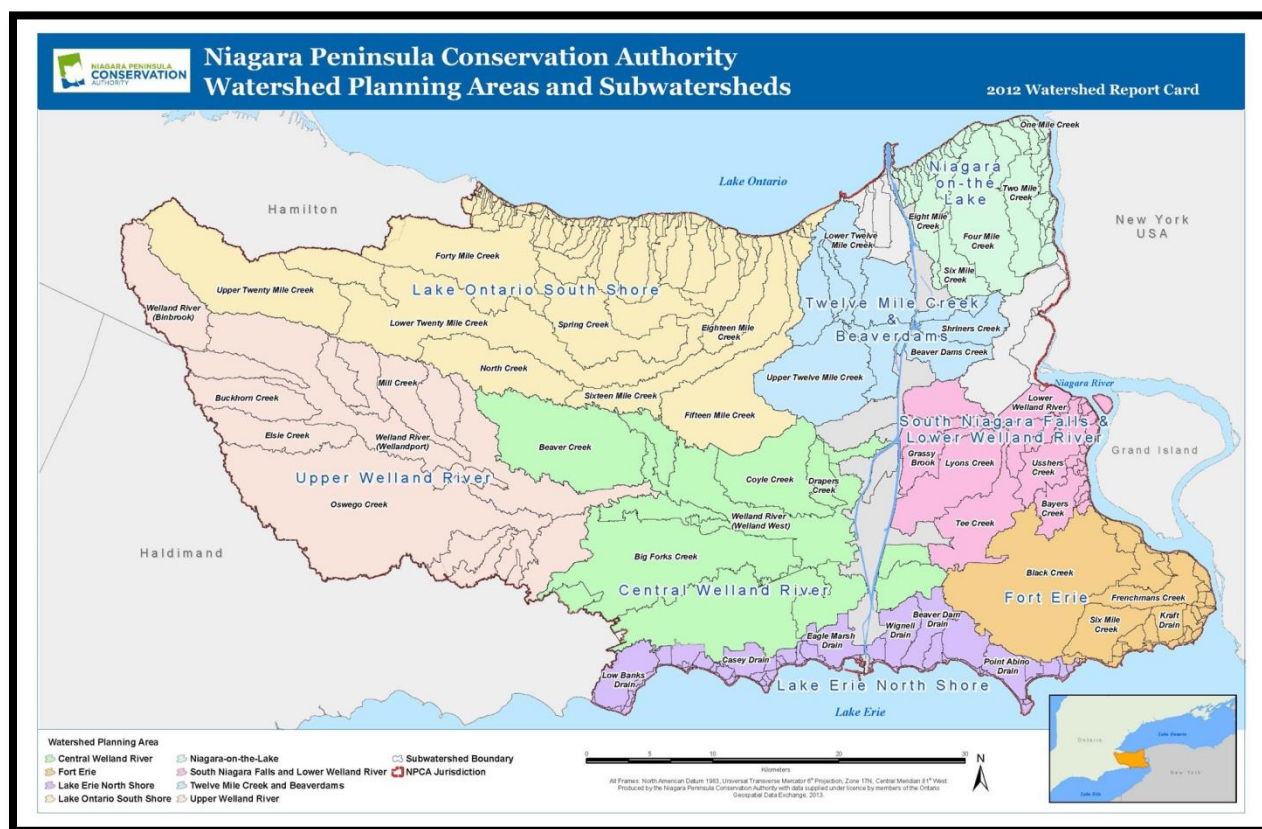
Figure 2: Niagara Peninsula Conservation Authority's Subwatersheds and Study Area

1.3 Project Understanding

In an attempt to increase environmental awareness within the community and build a database a database that would be open for public and private use the Niagara Peninsula Conservation authority, with help from naturalist clubs and municipalities undertook a Natural Heritage Areas Inventory (NAI). The project was conducted between April 2006 and December 2009 with a goal of identifying, classifying and mapping natural heritage areas within the NPCA jurisdiction (NPCA, 2010). The NAI was created with emphasis placed on following stringent industry standards and scientifically based protocol (NPCA, 2010).

42 Montgomery Road, Welland ON, L3C 2Y3

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The Niagara Peninsula Conservation Authority now requires a geodatabase that will contain layers of feature classes that display the spatial change and fragmentation of these natural areas between 1934 and 2010, the year the NAI was completed. This geodatabase will serve to help the NPCA quantify and better understand the changes that have occurred in their jurisdiction. Staff at the NPCA should be able to easily identify areas and the degree of natural areas change, actual and potential locations of old growth forest and finally habitat associated with at risk species.

1.4 Project Benefits
The leading benefits from performing this project include:

- An updated spatial inventory of natural areas
- Quantification of changes of natural areas from 1934 to 2010
- Identification of areas containing old growth forests within the NPCA jurisdiction
- Visual comparison of natural area changes from 1934 to 2010
- Identification of potential rare species habitat
- Assistance in planning and policy decision making
- Assistance in NPCA forestry department in guiding logging practices
- Supporting sustainable forestry practices
- Identification of potential areas for reconnaissance surveys

2.0 Goals and Objectives

2.1 Goal
The primary goal of this project will focus on creating a database containing a spatial inventory surrounding natural habitats within the NPCA Jurisdiction. The NPCA will possess statistics that quantify the levels of natural habitat change and fragmentation within the watershed using historical and current orthoimagery along with an updated natural areas inventory.

2.2 Primary Objectives
In order to satisfy the requirements of this project, critical objectives must be met. AML Solutions will take the time to create a spatial inventory of natural area habitat change from 1934 to 2010, report identifying areas of and degrees of change by municipality including nature of change (+,-, change in density), and create maps and statistics that identify the levels of change.

2.2.1 Create a Spatial Inventory of Natural Habitat Change from 1934 to 2010
This objective can be considered the main goal of the project. It consists of creating a spatial inventory that outlines the spatial change of natural areas between 1934 and 2010. This objective will be completed with the use of ArcMap and data provided to AML Spatial Solution by the Niagara Peninsula Conservation Authority.

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2.2.2 Report Identifying Areas and Degrees of Change by Municipalities

This objective complements the creation of the spatial inventory discussed above. It consists of determining and reporting on the areas that demonstrated a change in natural habitat from 1934 to 2010.

2.2.3 Identify Old Growth Forest Stands within the NPCA Jurisdiction

AML Spatial Solutions will create a spatial layer that will outline the areas of the jurisdiction that contain old growth forests. Data for this objective was provided by the client, the Bert Miller Nature Club, as well as, through research performed by the team. Also, areas of potential old growth forest will be determined using criteria provided by the Tara Metzger of the NPCA and the Bert Miller Nature Club.

2.2.4 Creation of Maps and Extraction of Statistic's Identifying Level of Change

This objective is twofold. First statistical data must be extracted from the habitat change inventories in order to report on the degree of change for each individual habitat type from 1934 to 2010. Secondly, logical and decipherable cartographic products must be created by the team in order to easily present the results of the project to the Niagara Peninsula Conservation Authority.

2.2.5 Creation of Final report

The last objective of the project will be the creation of the final product. This will be accomplished by creating a PowerPoint presentation and final report that will be presented to the client. Ultimately, this objective will be the most important as the culmination of all task and previous objectives will be presented here.

3.0 Summary of Proposed Major Tasks

4.0 Resources

4.1 Personnel

AML Spatial Solutions was established in September 2013 as a GIS consulting and solutions firm. With the skills and experience of its two founding partners, Hailey Gullet and Andrew Lipinski, AML spatial solutions seeks to undertake a client-based thesis project required in order to fulfill the Niagara College GIS-GM postgraduate curriculum. The team focuses on geospatial skills which includes the use of various mapping and analysis software used extensively in the geography discipline. The team also retains the consultancy services of Xinxia Jiang (Phd.) as an external project advisor

4.1.1 Hailey Gullett

Miss Gullett is the project manager for this project. Hailey holds a diploma in General Arts in Science from Niagara College, and since then has been studying Earth Sciences at Brock University. Currently she is a candidate in the GIS-GM postgraduate program at Niagara College.
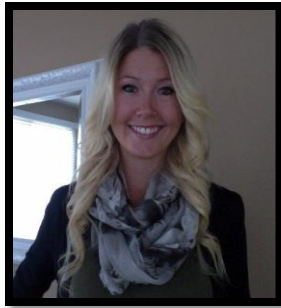
In her fifth year of postsecondary education, Hailey will combine her academic and practical experience to complete this project on time and at an extremely high quality. Her work experience and background within the NPCA will be extremely beneficial throughout this project as she is incredibly familiar with the organizations goals and policies.

4.1.2 Andrew Lipinski, BSc. ENVTech.

Mr. Lipinski is currently a candidate in the GIS-GM postgraduate program at Niagara College Canada and holds an Honors BSc. in Physical geography (Brock University, 2011) and an Environmental Technician Diploma (Niagara College Canada, 2006).

With Over 7 Years of educational experience, Andrew has been involved in many projects within the academic community which will undoubtedly aid in the execution and completion of the spatial inventory. Perhaps the most comparable project that Andrew has been involved with is the completion of an internship as a requirement for obtaining his BSc. Under the supervision of Dr. Tony B. Shaw of Brock universities Geography faculty Andrew completed a spatial analysis using Esri's ArcMap software outlining the location of potential vineyards in Norfolk and Haldimand County in Southern Ontario. While conducting this year long internship for Dr. Shaw Andrew was able to drastically improve his ability to use Esri Software, principally ArcMAP. Andrew also has a practical knowledge in VB programming, database design, Surveying with GPS and Total Stations and is proficient with ArcGIS 10.1, MapInfo and ERDAS.

Andrew will undertake the role of GIS Specialist for the duration of the Project. Andrew will be influential in every phase from initiation to completion.

4.1.3 Dr. Xinxia (James) Jiang - B.Sc., M.Sc., PhD
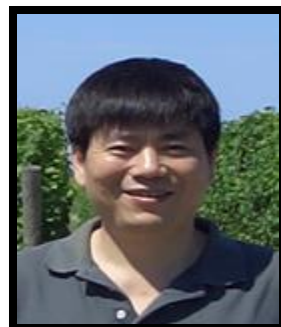
Dr. Xinxia (James) Jiang is a GIS Specialist and Professor of geomatics at Niagara College Canada. James received his B.Sc. in 1985 from Guilin Institute of Technology in China, his M.Sc. in 1988 from Central South University also in china and his PhD in 1998 From Southampton University in the United Kingdom.

His experience with similar projects is comprehensive. He worked as an assistant GIS and environmental management Professor at Windsor, Mount Allison and Brock Universities between 1999 and 2004. James' expertise lies in areas of GIS applications, geodatabase development, environmental management and assessment and urban planning. He has completed dozens of research and consulting papers and reports.

James will accept the role of project advisor, providing direction and expert judgment throughout the project duration. He will be involved as a consultant and will be compensated for his services according to his billable hours.

4.2 Hardware

The hardware required to complete this project includes Dell Precision T1650 Desktop Computers which are located at the Niagara College Glendale Campus, Niagara-on-the-Lake in rooms E308 and N202.

4.3 Software

The software required to complete this project include Esri's ArcGIS version 10.1, Microsoft Office Suite 2010, as well as 1934 and 2010 orthoimagery.

5.0 Methodologies

5.1 Work Breakdown Structure

The work breakdown structure of the NPCA quantifying spatial change of natural areas project can be seen in figure 3 below. The work breakdown structure is broken down into six main phases and the associated subtask that will be completed in order to successfully execute the project. These six phases include, project management, project understanding, data acquisition, update spatial inventory, perform GIS analysis and project summary. The following paragraphs will discuss in detail the six main phases.
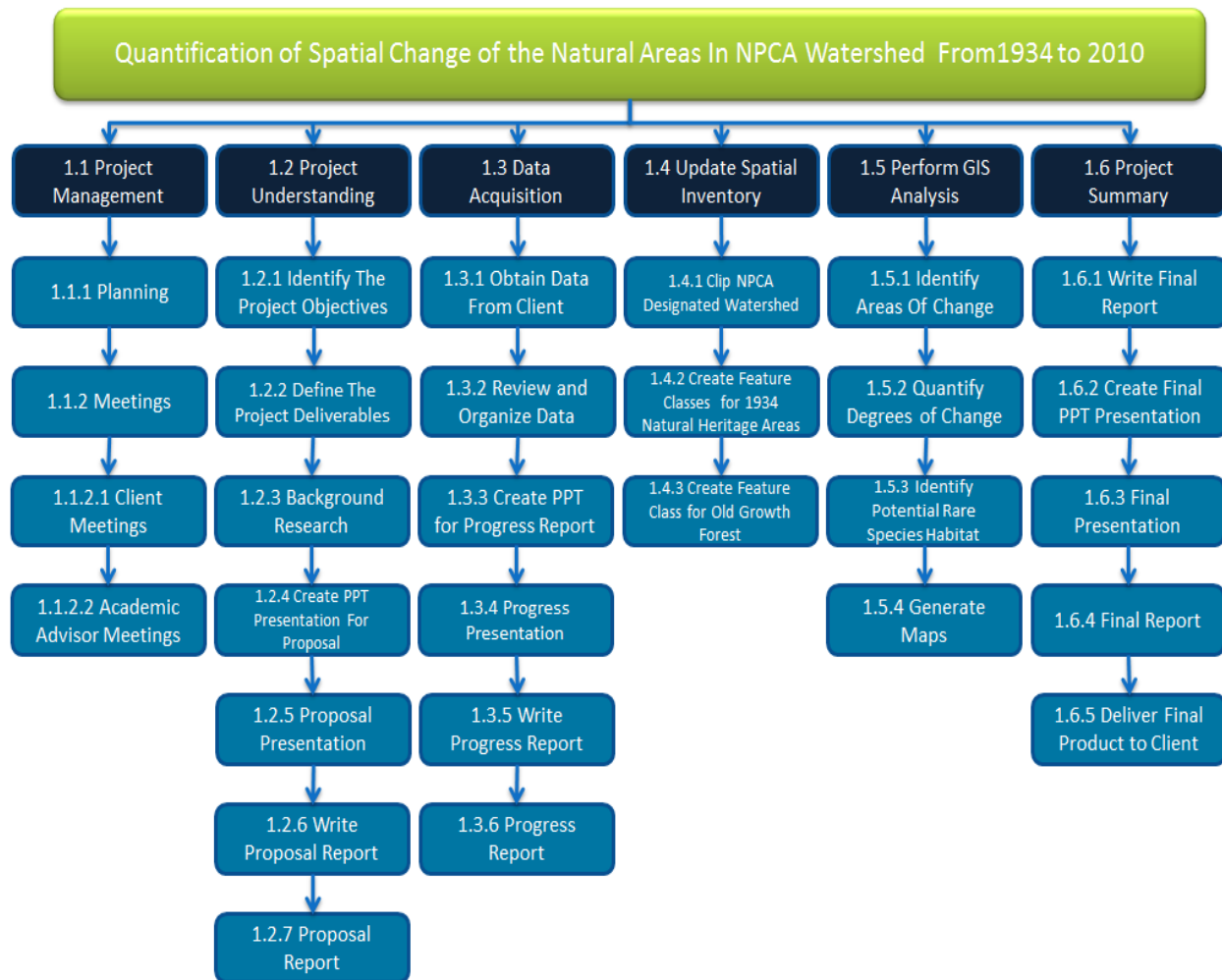
Figure 3: NPCA Quantifying Spatial Change of Natural Areas Work Breakdown Structure

5.1.1 Project Management

Project management is the first or initial phase of the project and will be ongoing throughout the duration of the study. This phase began on October 4th of 2013 shortly after the team's initial meeting with the client. Project management consists of two main subtasks, planning and meetings. The planning subtask has already been completed and entailed AML Spatial Solution determining a basic understanding of the project and identification of broad methods required for its completion. The second subtask involves meetings that will run the entire length of the project. Client meetings will occur monthly and discuss project progress as well as, to ensure that the project is meeting all of the clients required needs. Academic advisor meeting have been scheduled to occur bi-weekly and will utilize the resources of James Jiang in order to discuss reports on project progress that will be also be

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completed bi-weekly for James Jiang. Table 1 below outlines the proposed start and end date of the phase, proposed man hours and proposed cost.

Proposed Start Date	Friday October 4th, 2013
Proposed End Date	Monday June 9th , 2014
Proposed Time (Man Hours)	44 Hours
Proposed Cost	$3,750.00

Table 1: Project Management (Phase 1)

5.1.2 Project Understanding

Understanding the project is the second phase of the project. It consists of seven main subtasks that have been completed during this phase. These include, identifying the project objectives, defining the project deliverables, background research, creating a proposal presentation, writing the proposal report and finally, submission of the proposal report. Table 2 below list the start and end dates of phase 2 as well as, the proposed man hours and cost of this phase.

In order to determine the project life cycle AML spatial Solutions created a work breakdown structure and examined all of the tasks and subtask needed in order to successfully complete the project. The initial task was to identify the project objectives. These objectives were outlined in the original Project Overview Statement (POS) provided to us by Tara Metzger and the NPCA. A copy of this POS can be found in Appendix D. Next, the project teamed determined the project milestones which can be seen in table 3 below. The Three milestones comprise of the project proposal, project progress report and the report and presentation. Table 3 below outlines the major milestones and deliverables associated with each of these milestones. The next task, background research is an essential part required in order to understand the project. This was completed by researching various academic journals surrounding spatial analysis as well as, investigating the Natural Heritage Areas Inventory report provided to AML Spatial Solutions by Tara Metzger and the NPCA.

Finally, the remaining four tasks involved the team completing a proposal presentation and formal proposal report as required for successful completion of Phase 2.

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Proposed Start Date	Monday November 4th , 2013
Proposed End Date	Friday December 13th , 2014
Proposed Time (Person Hours)	42Hours
Proposed Cost (Labor and Materials)	$3,150.00

Table 2: Project Understanding (Phase 2)

Milestone 1: Project Proposal
• **Deliverable 1.1: Gantt chart.**
• **Deliverable 1.2: Project proposal.**
• **Deliverable 1.3: Proposal presentation.**
Milestone 2: Project Progress Report
• **Deliverable 2.1: Progress report.**
• **Deliverable 2.2: Progress report presentation.**
• **Deliverable 2.3: Maps of processed data.**
Milestone 3: Final Report and Presentation
• **Deliverable 3.1: Prepare maps of clipped area by city within the NPCA jurisdiction.**
• **Deliverable 3.2: Prepare maps which quantify spatial change and variations in natural areas within the NPCA jurisdiction.**
• **Deliverable 3.3:   Geodatabase with feature layer indicating areas of change.**
• **Deliverable 3.4: Final report and presentation.**

Table 3: Summary of Major Milestones and Deliverables

5.1.3 Data Acquisition

The data acquisition phase of the project began on Friday October 4th and coincident with the teams initial meeting with the client. This phase will run into the first few months of the new year and is estimated to cost $2,400.00 and require 32 man hours. Table 4 below shows the start and end date along with the proposed cost and man hours.

The first subtask of this phase was to obtain the data required for conducting the project. This initial data was provided to the team by the Tara Metzger of the NPCA at the initial client team meeting on October 4th 2013. Additional orthoimagery data was required in order to complete the goals and this was provided to the team after their proposal presentation from the client. The second subtask of phase three was to organize and review all of the data. This was completed by team members and required

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examining all of the data for errors, organizing the data into one easily accessible file and testing the data to ensure its use for the duration of the project. During this phase it was determined that the JP2 file format of the 2010 orthoimagery is inherently flawed when attempting to create pyramids in Esri's ArcMap platform. The team will need to determine a methodology to correct this problem through additional research. The next four subtasks of this project will be the creation of a powerpoint presentation and progress report that will outline the progress of the project. This will determine if the project is on budget, on time and fulfilling the client's needs. The presentation and progress report will be delivered to Tara Metzger and the Niagara Peninsula Conservation Authority the third week of March.

Proposed Start Date	Thursday October 31st, 2013
Proposed End Date	Thursday May 29th, 2014
Proposed Time (Person Hours)	22.5 Hours
Proposed Cost (Labor and Materials)	$2,045.00

Table 4: Data Acquisition (Phase 3)

5.1.4 Update Spatial Inventory

Phase four, updating the spatial inventory and its three subtasks will be vital in order to successfully accomplish the goals of the project. This phase is not only the most labor intensive but also the most costly. Table 4 below outlines the proposed start and end times of this phase along with the proposed man hours and cost.

The first task of this phase of the project will be to create new layers that represent the various watersheds within the NPCA's jurisdiction. This task will be completed by clipping the watershed boundaries and exporting the results to create a new layer. This will be essential for not only allowing both members to simultaneously update the spatial inventory but more importantly allows for the accurate statistical representation of spatial change within each of the NPCA's watersheds. The second task of phase four is perhaps the most important task that must be completed in order to achieve the primary goals of this project. This task involves updating the spatial inventory in order to be able to determine the areas and degree of spatial change within the study area. This will be completed by exploring the 2010 natural area inventory data provided by the NPCA and comparing natural heritage areas present in 2010 to natural heritage areas present in 1934. The 2010 NAI is composed of thousands of polygon which outline the various natural areas of the study area. These polygons will be edited in order to visually represent the changes that occurred between the natural areas of 1934 and 2010.

The last task of phase four will be the creation of a layer in order to visually represent old growth forest and potential old growth forest within the NPCA's jurisdiction. This will be completed by generating a

polygon feature class that represents current areas of identified old growth forest. These areas are known as data regarding representing these areas was provided by the client through the Bert Miller Nature Club. Also, AML spatial solution obtained more extensive data of an updated Bert Miller Nature Club document outlining areas of old growth forest during the project understanding phase. The team will also attempt to outline area where old growth forest is likely to be present. The methodology involved in this is rather simple. The client stated to AML Spatial Solutions that old growth forests generally represent areas that have remained untouched from human processes for a duration of at least 100 years. Thus, any stands of forest that appear to be well established in 1934 and remain in 2010 signify a stand of forest where old growth is possible.

Proposed Start Date	Thursday October 31st, 2013
Proposed End Date	Thursday May 29th, 2014
Proposed Time (Person Hours)	22.5 Hours
Proposed Cost (Labor and Materials)	$2,045.00

Table 5: Update Spatial Inventory (Phase 4)

5.1.5 Perform GIS Analysis

Phase five of the project, like phase four which it complements, is also a vital stage in order to provide the client with the goals and objectives required to successfully complete the project. This stage involves the analysis of the updated spatial inventory created in the previous phase. Table 6 below outlines the start and end date of Phase 5 and the proposed cost and man hours required for the completion of this stage.

Phase five will begin with identifying the areas of natural heritage habitat change by comparing the various layers created for the 1934 spatial inventory to those of the 2010 NPCA NAI. The second subtask of this phase will be to quantify the amount of change within each subwatershed of the NPCA jurisdiction. This will be accomplished by extracting statistical totals of each natural heritage area for both the 1934 and 2010 layer. The difference between the statistical totals of both the 1934 and 2010 layers respectively, will easily demonstrate whether there existed a positive or negative change between the natural areas from 1934 to 2010. It is hypothesized by AML Spatial Solutions that the sub watersheds within the jurisdiction, despite efforts by the NPCA and grassroots organizations, will exhibit a net decrease in natural habitat areas from 1934 to 2010. This can be attributed predominantly through urban growth of major centers and land use changes within the jurisdiction. Also, areas where extreme change has occurred will be highlighted and examined in more detail. Next, species at risk habitat will be identified. This will be completed by determine which species in the jurisdiction face the most risk from habitat change by examine the original Natural Heritage Areas Inventory's criteria on the species at risk

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and their habitat within the jurisdiction. These areas will be highlighted and reported in the final product. The last stage of this phase will be to create logical, decipherable and cartographically sound maps that display the results from the tasks previously discussed.

Proposed Start Date	Thursday October 31st, 2013
Proposed End Date	Thursday May 29th, 2014
Proposed Time (Person Hours)	22.5 Hours
Proposed Cost (Labor and Materials)	$2,045.00

Table 6: Perform GIS Analysis (Phase 5)

5.1.6 Project Summary

The project summary is the last phase of the project and involves AML Spatial Solution preparing a final product that will be delivered to the client. The first subtask of this phase will be to create a formally writing final report that will provide all of the required deliverables and objectives to the Niagara Peninsula Conservation Authority. The second task will be to create a final presentation. This will be formally presented to the client on the specific date give. Table 7 below outlines the start and end dates of phase six, along with the proposed man hours and cost.

Proposed Start Date	Thursday October 31st, 2013
Proposed End Date	Thursday May 29th, 2014
Proposed Time (Person Hours)	22.5 Hours
Proposed Cost (Labor and Materials)	$2,045.00

Table 7: Project Summary (Phase 6)

6.0 Schedule

Table 8 summarizes the major tasks within the project, the date they begin on, end on and the number of person hours spent on each task. The value for person hours represents both team members and any additional human resources used.

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Major Task	Start Date	End Date	Person Hours
Project Management	10/4/2013	6/9/2014	44
Understand the Project	11/4/2013	3/10/2014	42
Data Acquisition	1/6/2014	3/21/2014	32
Update File Geodatabase	3/17/2013	4/30/2014	184
Perform GIS Analysis	5/5/2014	5/20/2014	36
Project Summary	5/21/2013	6/13/2013	29

Table 8: Project Schedule

7.0 Cost Estimate/Budget

The budget for all major tasks is outlined in Table 8. The total cost for the team to carry out all of the major tasks was calculated at $27,975.00. Additionally, mileage was calculated at $0.50 per kilometer and consists of each AML Solutions team member going to the NPCA main office 6 times. These meetings will take place biweekly and begin in January. Another cost included in the total budget is a Contingency Estimate which allows for any unexpected costs that arise throughout the project. HST is also included within additional costs at 13%, giving the project a proposed budget of $35,090.23.

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Major Task

Task	Cost	Total Cost
Project Management	$ 3,750.00	
Understand the Project	$ 3,150.00	
Data Acquisition	$ 2,400.00	
Update Spatial Inventory	$ 13,800.00	
Perform GIS Analysis	$ 2,700.00	
Project Summary	$ 2,175.00	
		$ 27,975.00

Travel

Km/Trip	Cost	Total Cost
46.8km @ 12 trips	$0.50/km	$ 280.80

Additional

Condition	Assessed Price	Total Cost
Contingency Estimate	10%	$ 2,797.50

Total Project Cost

Sub-Total		$ 31,053.30
HST (13%)		$ 4,036.93

Total

		$ 35,090.23

Table 9: Budget Outline

Figure 7 is a pie graph showing the breakdown of the entire project budget. The majority of the cost is clearly going into updating the spatial inventory (file geodatabase). The other costs within the project completion are roughly 10% of the budget respectively. The smallest portion of the budget is mileage as soon in Figure 7. AM Solutions thought that a 10% contingency estimate is accurate as this is the first project the company has undergone and would like to ensure the project is not completed over budget.
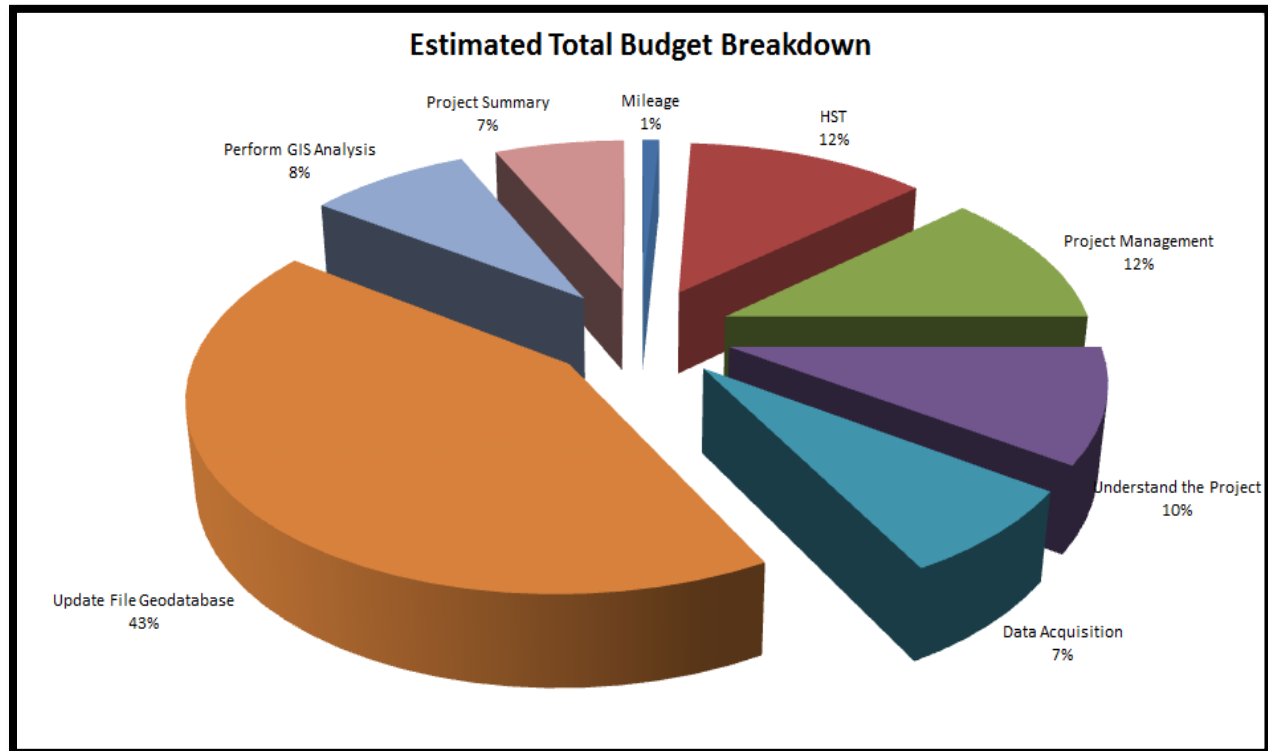
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Figure 4: Pie Chart Project Budget Breakdown

The project budget displayed in the prior chart and pie graph has been created for educational purposes, the client is not responsible for these costs. The expenses of this project are provided to the NPCA by student consultants, Niagara College, and the staff advisor.

8.0 Risk Assessment and Constraints

While undertaking a project, it is important to foresee any risks that may occur during the process. It is possible that the data and imagery provided by the NPCA is fit for use, the orthoimagery is from 1934, and has been georeferenced by an unknown source it may become difficult to compare 2010 orthoimagery if the georeferencing is of a low quality. It may be encountered that the data may not cover the entire study area and therefore may result in data gaps. Data quality checks will be applied to ensure this is recognized. It is possible that there may be issues with the functionality and performance of software and hardware throughout the duration of the project. The usage of a few large images in a *.jpg2 format do not open within Esri's ArcGIS 10.1 regarding a failure to build pyramids, however this is a known issue to Esri and they have workaround steps on their help website to conquer this problem.

There are also some constraints with this project, most importantly the deadline by which the project must be completed by. The program ends on June 13, 2014, so all aspects of the project absolutely must be completed by this date. An additional constraint is the acquisition of consistent data throughout the project considering the lengthy time period.

9.0 Conclusion

AML Solutions will play a critical role in determining the levels of change of natural areas within the NPCA watershed, which will be beneficial in determining natural habitat changes, identification of potential rare species habitat, as well as the ability to identify areas containing old growth forests within the NPCA jurisdiction. This project will be completed by June 13, 2014 as requested by the Niagara Peninsula Conservation Authority. The project study will take place throughout the Niagara Region, and partially the City of Hamilton and Haldimand County as well.

The Quantification of Spatial Changes within the NPCA Watershed from 1934 to 2010 will aid in planning and policy decision making at the Conservation Authority as well as assist their forestry department in guiding logging practices as well as supporting sustainable forestry practices. The total cost of the project including, including mileage, a contingency estimate, and HST is $35,090.23. It is important to mention that there are risks associated with every project; however AML Solutions will do their best to diminish these risks.

AML Solutions is passionate about GIS, and has extensive experience with project work where the implementation of GIS is involved. The team is also familiar with the NPCA, their goals and their values. These assets paired with their up-to-date knowledge of GIS techniques and methods will ensure this project is carried out successfully on time and on budget. AML Solutions is looking forward to working on this project, and achieving the expectations of the client.

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Appendix A – Terms of Reference

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Appendix B – Curricula Vitae

Appendix C – Gantt Chart

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Appendix D – Project Overview Statement

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