Spatial GIS vegetation database and GIS Spatial modeling for the Jeremy's Bay Campground of Kejimkujik National Park and Historic Site

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Introduction

This technical report details the methodologies and issues that were encountered with a GIS project at the Applied Geomatics Research Group (AGRG) during the summer of 2004 that involved generating a spatial geographic database for Jeremy's Bay Campground of Kejimkujik National Park and Historic Site. High resolution aerial photography acquired from a previous AGRG aerial photography mission was used along with extensive data collected during a Rapid Vegetation Assessment survey and a detailed forest stand interpretation.

Kejimkujik National Park and Historic Site shown in figure 1, is located about 160 km west of Halifax in south western Nova Scotia between Liverpool and Annapolis Royal. The lakes and rivers of the park are habitat for many turtles, frogs and salamanders; Kejimkujik has more amphibians and reptiles than anywhere else in the Atlantic Provinces. The park is also home to many birds, especially common loons, and fish which include brook trout and white and yellow perch (Parks Canada Website, 2004). In Canada, National Parks are considered places where ecosystems and ecological integrity should be maintained and Kejimkujik National Park is no exception.

The project was divided into two main sections that were indirectly related to one other. The first major part of the project was the compilation of digital line work and the creation of a Geographic Information System (GIS) spatial database of forest stands found within the campground. The second part of the project was focused on generating a GIS spatial database of the vegetation found within each campsite that was collected during a Rapid Vegetation Assessment (RVA) Survey.

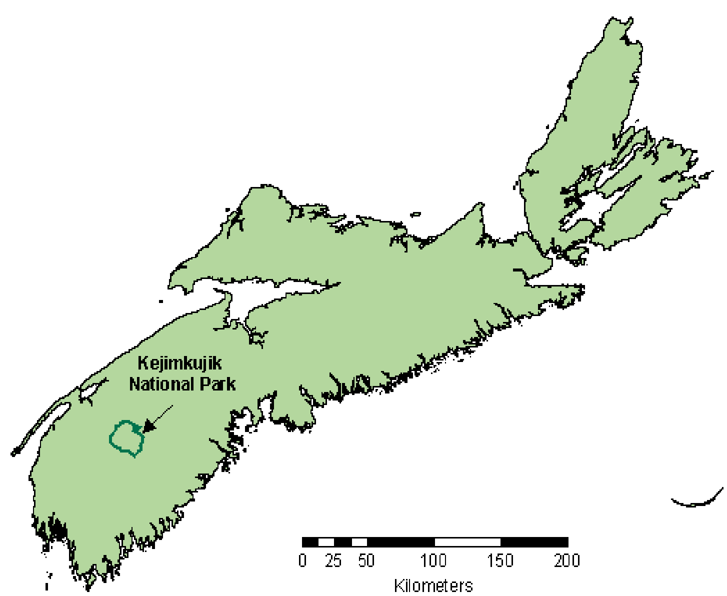


Figure 1 Kejimkujik National Park and Historic site is located approximately 160 km west of Halifax in the southern end of Nova Scotia.

Background

Ecological Integrity

Vegetation is one of the most important components in the Kejimkujik campground ecosystem as it provides habitat for many native species, privacy between campsites and a natural setting representative of the region. Vegetation health can be defined as the cover of vegetation from the ground to canopy, the health of the trees, the amount of vegetation removal, the creation of braided trails and the rate of regeneration of the forest community (O'Grady, 2004).

Impacts from park visitors on ecosystems can be serious and threaten the health and the integrity of the park. This is especially true in the campground section where human activities are highly concentrated and often lead to a variety of potential impacts on the environment. Several studies done in the past by researchers like O'Grady, Brooks and Vasseur have consistently documented visitor interactions and impacts to the campground. These impacts have covered a variety of issues such as tree mortality, soil compaction, and degradation of ground cover vegetation.

Several factors such as vegetation, soil characteristics, and microclimatic conditions as well as the type and history of visitor use can influence the degree of impacts occurring in a campground. In the past few years, there has been an increasing awareness of the degradation of the natural setting of the Jeremy's Bay campground. A few limited attempts were also initiated to assess the impacts and evaluate the potential for rehabilitation (Brooks and Vasseur, 2001).

Aerial Photography

Aerial photographs contain distortions, caused by terrain undulations and camera characteristics, which usually result in an inconsistent scale and displacement across the images. The photographs can really only serve as visual aids for interpretative purposes such as determining land use or deriving and interpreting contour interval data from.

An Orthophoto on the other hand, is an aerial photograph that has been completely orthorectified with all variations of scale and displacements due to terrain relief being removed. Ortho photography plays an enormous role in modern GIS because not only does it provide an informative rich background for otherwise monotonous GIS line work but it also serves as the basis of positional accuracy for all other layers on the map.

Resolution, a measure of the accuracy of the ability to determine between image values, is the easiest quality to recognize in digital photography. This is basically a measure of how much detail you can see in the digital image when you are zoomed in very closely. One meter resolution photography means that each pixel in the image is 1 meter wide. The smaller the pixel size is, the more detail you can see in the photographs. The AGRG flew an aerial photograph mission during the fall of 2003 and collected digital imagery with three different resolutions (1m, 50 cm, and 25 cm).

Unlike resolution, accuracy is not as easy to recognize. An uncorrected aerial photograph can have positional inaccuracies of up to several meters, but will appear perfectly normal when viewed by it self. The inaccuracy becomes more obvious when you overlay accurate GIS vectors or global positioning system (GPS) data on top of the photos. The inaccuracies will increase as you move away from the center point of the photo (MacKinnon 2003).

Once orthorectification has been performed, the orthorectified aerial photographs can then be used as a map whereas conventional aerial photographs cannot. The map will have scale and can be integrated with other GIS data sets. Now the visual aid or “pretty picture” has become a valuable tool to integrate and use with GIS.

Rapid Vegetation Assessment

The Jeremy’s Bay campground rapid vegetation assessment involved the identification and assessment of all vegetation located within a 15 m radius of the visual center of each individual campsite. The original assessment was done in 2002 and 300 of the 360 campsites were completed.

Due to limited resources, many studies have used vegetation rapid assessments because these methods are an effective way to evaluate impacts on the most valued and usually most affected component of the ecosystem.

The plots were laid out by determining the campground centre and placing two 30m tapes perpendicular to each other on a north-south, east-west axes. The centre of the campsite was determined by locating the centre of the driveway for the site and following a bearing to the approximate site centre. A handheld GPS unit was used to collect the approximate positioning of the center of the plot.

The center of the campsite was marked with a permanent steel stake that was buried to a depth of 5 cm below the surface. The steel stake was used so it could be relocated with a metal detector and a GPS. The digital camera was mounted on a tripod set at a height of one metre positioned over the center point. Photos were taken along the cardinal directions (N, E, W, S). The orientation of the photo was established using a hand held Silva Ranger compass. Photos were taken when the vegetation was flush (in foliage). Names were based on the campsite number and the directional transect (e.g 143N is campsite 143 and the North transect line).

Once the tapes were positioned, each quadrant was surveyed for seedlings, saplings, trees, and all herbaceous species inventoried. Vegetation damage, braided trails and trampling were also noted.

Digital photographs were used to visually record the vegetation within the four quadrants of each campsite, and all vegetation was measured and recorded into a spreadsheet. All of the vegetation within each quadrant was recorded and archived into the database management system at the Kejimkujik Ecosystem Science Centre. The assessment was to be done annually on a rotational basis. The researchers involved with the assessment concentrated on recording basic vegetation inventories and tree count data, as well as qualitative data such as vegetation damage, trampling and formation of braided trails.

Utilizing the data collected from the 2002 rapid vegetation assessment and incorporating it into a GIS will provide Park Biologists with tools to perform spatial analysis and recommendations, providing information for the management of ecological integrity within the campground.

Study Area

Jeremy's Bay Campground located within Kejimkujik National Park and Historic Site was the location of this project. The campground is located within the north-eastern section of the park. All data processing for the project was done at the AGRG (Applied Geomatics Research Group) research facility in Middleton, Nova Scotia.

The campground is comprised of 360 designated campsites and includes three different sections known as the Meadow loop, the Slapfoot loop and the Jim Charles loop.

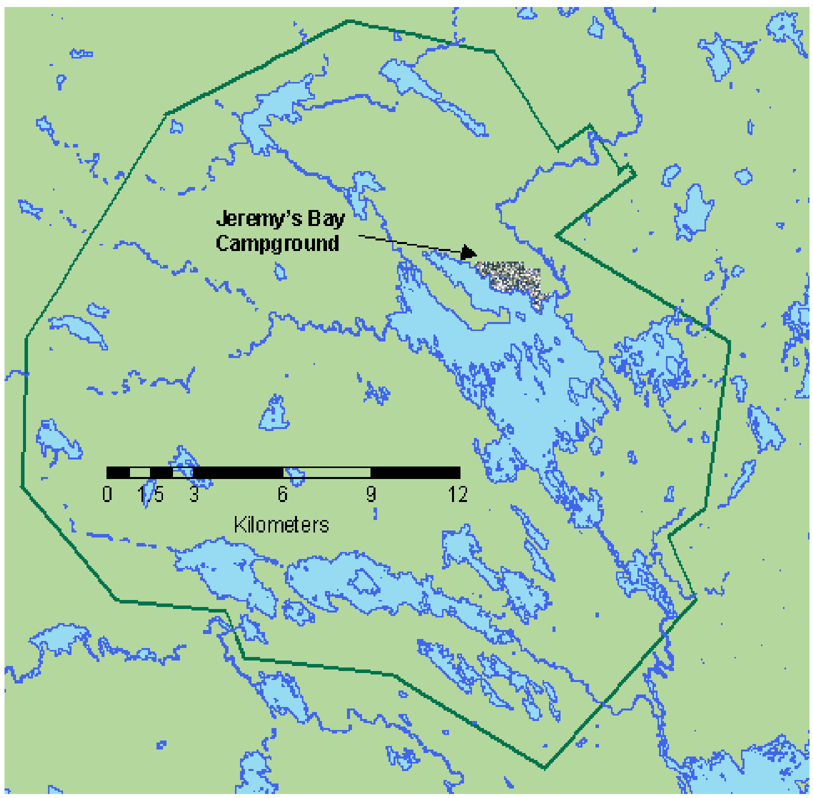


Figure 2 Jeremy's Bay Campground is located in the north-eastern section of the Kejimkujik National Park and Historic Site.

Objective

The main objective of this project was to create two spatial GIS databases that could be integrated with existing Park data and provided to Biologists and Botanists to be used as a valuable geomatics tool to derive spatially analysed decisions from. The spatial databases of the assessed collected data from the RVA work in 2002 and the forest interpretation from the 2003 aerial photography would be further analysed.

The spatial database will help assist in the action plan to develop and implement campground and trail rehabilitation protocols for assessing, monitoring and preventing human use impacts. The assessment will be documented through the use of digital mapping and a comprehensive database.

Methodology

Forest Interpretation Work

The AGRG images were captured during leaf-off conditions during the month of November with a Canon EOS 10 D digital camera as shown in figure 3. The 25 cm resolution digital air photos from the AGRG aerial flight missions in the fall of 2003 were enlarged to 8.5” x 14” and professionally printed. The hard copy photos were then supplied to a Forester who interpreted the various forest stands that made up the Jeremy’s Bay Campground. The stands were traced out onto the hard copy printed photos with permanent marker and the species and percentages of each type were supplied in paper format.

Figure 3 The camera used to collect the photography by the AGRG students was a Canon EOS 10 D digital camera, which was mounted with a level bubble and then placed on the out the side of a cargo hatch of a Cessna aircraft.

The aim of this part of the project was to utilize the supplied forest stand interpretation data and create a spatial GIS database from the sketched line work to accompany the Rapid Vegetation Assessment (RVA) Project. A student from the GIS class of 2004 (R. Garnett, 2004) at COGS was contracted to generate orthorectified mosaics of the three different resolutions from the digital air photos. The mosaics were created using PCI Ortho Engine software version 9.0, making use of a first order polynomial math model.

"A first order polynomial transformation was chosen over rectification based on the available coarse resolution of the digital elevation model (DEM). The DEM had a five metre resolution, which caused for a large Root Mean Squared Error (RMS) with the high resolution digital photos" (R. Garnett, 2004).

Figure 4 The photos for the project were supplied by the AGRG and collected with a Canon digital camera during the fall of 2003. The photo above represents one of the twenty eight photos that covered the campground. The resolution of the photo was 25 cm and the photo covered an area of 700 m by 500 m.

To create the 1m mosaic, Garnett used three of four available photos. Seven of twelve photos were used to create the half meter mosaic and only eleven of twenty eight photos were used to create the 25 cm mosaic. Vectors were used as the only source of ground truth for the 1 m mosaic, while the non-validated 1m mosaic was also used to help collect ground truth data to orthorectify the half and quarter meter mosaics. The vectors that were used were centerline and coastline files derived from 1:40k provincial aerial photography and had an accuracy of plus or minus 5 meters.

The photos were projected to UTM 20 T D04 (NAD83) where as all the vector data had been projected to UTM 20 T E012 (WGS84). All the data had to be projected and created using the same projection, therefore the orthomaps were re-projected into the same projection as the existing vector data already used by the park on previous projects.

Several sections of the three different resolution mosaics were inconsistent with one another, as could be easily identified when they were layered together with ArcMap and several vector layers of the campground. This brought up the question of which mosaic was accurate and were they accurate enough to collect digital line work from.

The majority of the campground had decent GPS derived vector data that was collected on previous AGRG field missions but there were still several sections that did not have accurate GPS data, and some of the GPS derived data that existed was questionable in respect to the accuracy of it. The Jim Charles loop was the most accurate mapped loop; the GPS for this loop was collected with a Leica RTK unit and a Total Station surveying unit by the AGRG during the summer of 2003. The best solution for the problem was to actually go to the park and collect GPS data to provide accurate line work for the areas that did not have any.

The AGRG had a vast inventory of GPS to select from thanks to its generous federal government funding over the past several years, however the availability of this equipment during the peak field research season was often very competitive. It was decided that the Trimble Pro XR unit with real time WAAS correction input was adequate enough to supply GPS data for this project. The more accurate Leica RTK system was not available at the time.

Figure 5 A Trimble Pro XR was used to collect GPS data to validate the orthomosaic. This model of GPS has a Windows CE based controller that allows the user to load imagery and data into prior to the mission to help make the field survey easier.

A full day was spent around the campground area of Kejimkujik National Park collecting GPS data for the areas of the mosaics that lacked good control and some GPS data was also collected in areas that had good control to validate the accuracy of the collected GPS data. Of most importance were the north eastern and the south western sections of the mosaic.

After the data was collected it, was exported from Trimble pathfinder office to ESRI shape format. The vector GPS shape file data was then used to attempt to correct the problems of the orthomaps. A new OrthoEngine project was created for the 25 cm resolution photos and a proper orthomosaic was derived using the aerial photography model. A second project was then completed using the output orthophotos from the first project but using the Thin Plate Spline math model.

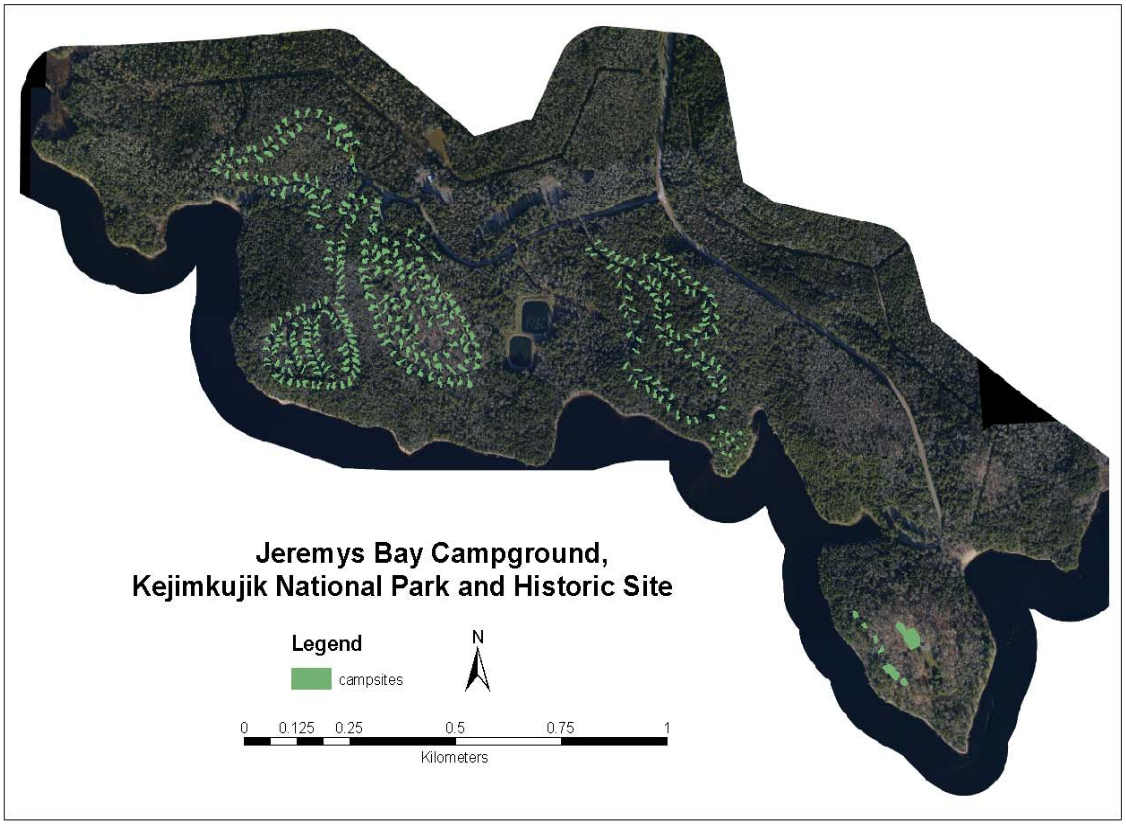


Figure 6 The mosaic used to digitize the forest polygons was created from 25 cm resolution 2003 AGRG digital photos. The campsites are shown on top of the photo to demonstrate the extent of the campground.

The roads and power line vectors were buffered to use as a uniform edge for the forest vector line work to connect to. This also helped to make cartographic display of the vector data visually more appealing as well. The roads were buffered at 6m and the power lines were buffered at 4m using ArcGIS. Separate shape files for the resultant buffered results were created.

Figure 7 The digitizing was done with ArcGIS 9x. Careful attention was given to ensure that all nodes snapped to existing nodes to avoid problems when creating polygon topology from the line shapefile.

A blank line vector shapefile with georeferencing defined to contain the forest line work was created using ArcCatalogue. All the lines from the forest stand interpretations drawn on the photos were then interpreted and digitized as vectors in the shape file. Snapping was initiated and careful attention was given to topology to ensure that all lines connected with existing nodes from other lines. After all lines from the photographs were digitized, they were double checked to ensure that none were missing. The line vector shapefile was then exported to ArcInfo coverage.

```
Usage: SHAPEARC <in_shape_file> <out_cover> {out_subclass} {DEFAULT |
          DEFINE}
Arc: SHAPEARC stand_lines.shp stand_polys
```

Equation 1 The SHAPEARC command was used to convert the line shapefile to a coverage; that was important for the generation of topology and the conversion of the vectors into the associated polygon shapes.

The Clean command from ArcInfo was used to convert the line coverage into polygon coverage with correct polygon or arc-node topology. The command allows

ARCINFO to edit and correct any geometric coordinate errors assembles arcs into polygons and create feature attribute information for each polygon or arc.

Usage: CLEAN <in_cover> {out_cover} {dangle_length} {fuzzy_tolerance}
{POLY | LINE}
Arc: CLEAN standlines standpoly # # poly

Equation 2 The clean command was used to convert the line coverage to polygon coverage and create topology.

The polygon coverage was then loaded into ArcGIS and compared with the line shapefile to ensure that the conversion was a success and that no lines or polygons were missing. The polygon coverage was then converted to a polygon shape file (2004-forest-linework.shp). A new field was added to the attributes of the polygon shapefile called POLY_ID. This was used as a key field to later combine the attributes of the polygons. The assigned numbers for each polygon from the photographs were entered into the POLY_ID attribute in the shapefile.

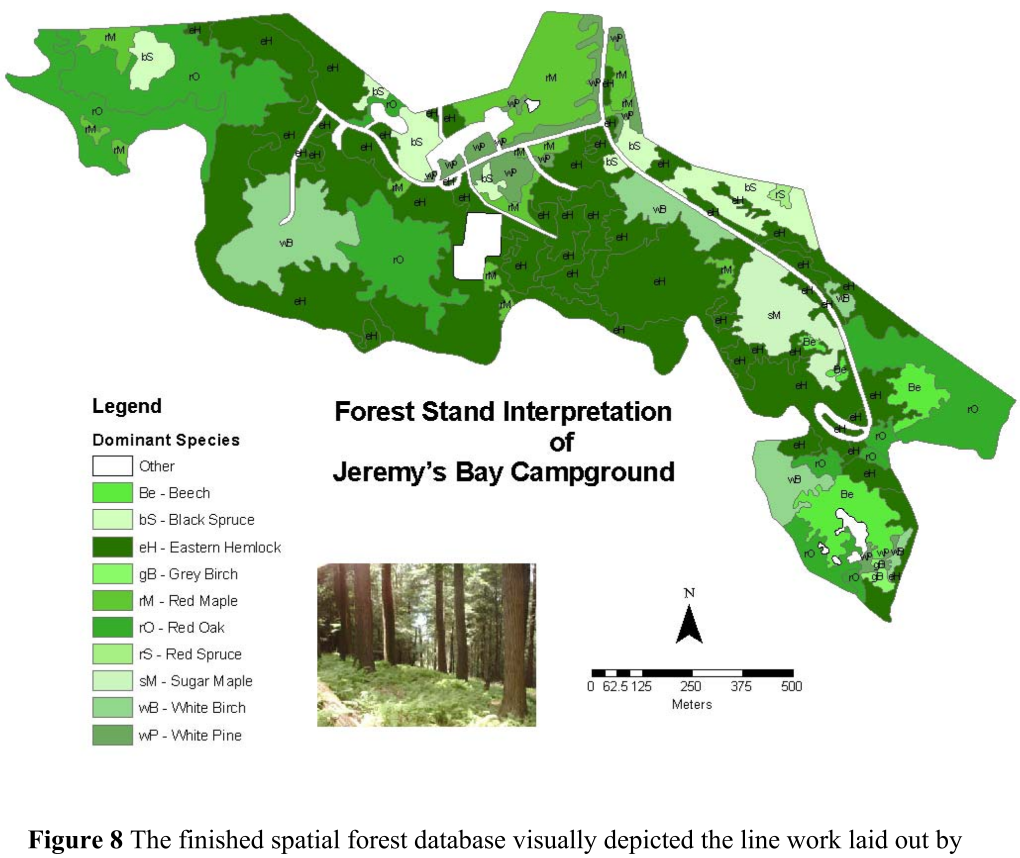


Figure 8 The finished spatial forest database visually depicted the line work laid out by the forester and contained all of the interpretive information as attributes of each polygon. Spatial analysis work could now be accomplished with the new dataset and the forest data could be incorporated with other GIS data from the campground.

The attribute data provided was entered into an excel spreadsheet and then exported to dbf format so that it could be attached to the polygon shape file. Each polygon had a unique number assigned (POLY_ID) to it so that it could be identified and used as a key field to append the attribute information with. The shapefile was loaded into ArcMap and then the dbf file was joined to the attributes of the shapefile.

The resultant polygon shapefile with the attached attribute data was examined a final time to ensure that no data was missing. An ArcGIS project file was created with the orthophotos mosaics and shapefiles. A final plot of the results was created and all data was compiled onto the final DVD to supply to Parks Canada as part of the final deliverables.

Rapid Vegetation Work

Each campsite was to include a 15 m radius around the center of each campsite and then be divided into four quadrants. The center points for the field component of the rapid vegetation survey, completed in 2002 were collected with GPS, however the accuracy of the GPS receiver equipment was not that precise. Therefore the shapefile containing the center point data was not accurate enough to clearly define the center points of each campsite.

Polygon shapefile of all 360 campsites of the park that were collected during 2 earlier GPS field surveys were used to generate centroid positions of each campground. Centroid coordinates were supplied for each campsite in excel format. This information was then exported into text files and then imported into ArcGIS as a point shapefile.

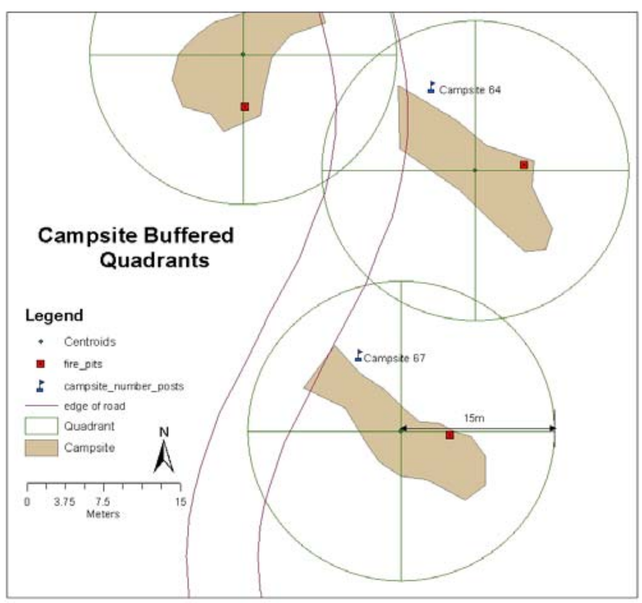


Figure 9 Each campsite was buffered 15m and then each buffered polygon was split into 4 equal quadrants, where all vegetation located within the quadrant was quickly surveyed.

The points in the shapefile were then buffered at 15m with the buffer option in ArcGIS. Each polygon was to be divided equally into 4 quadrants as shown in figure 10. In order to clip the polygons, the clip command was used, however to use this command you need to use polygons to split or clip the other polygons. So a polygon shapefile was created to use for the clipping. The spreadsheet with the centroids coordinates were used to compute coordinates for points that would be used to generate the clip polygons. Each clip polygon would use the campsite centroid coordinate as one corner coordinate of the clip polygon; the other three coordinates would have to be calculated. The buffer polygons had a 15m radius from the centroids so the clip polygon had to have sides that were greater then this so a 16m side was used. The result was that each campsite would now have coordinate pairs for 9 points that would define four equal sized square quadrants around the centroids position as shown in figure 10.

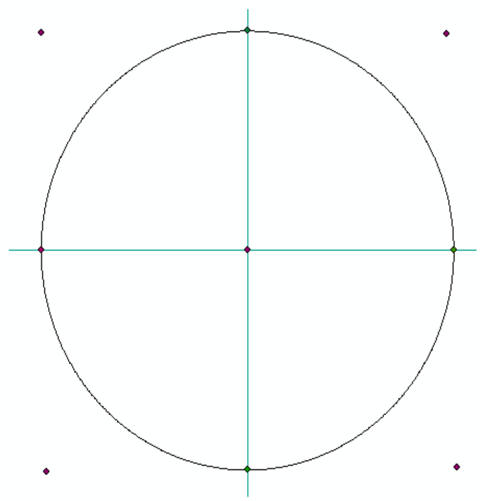
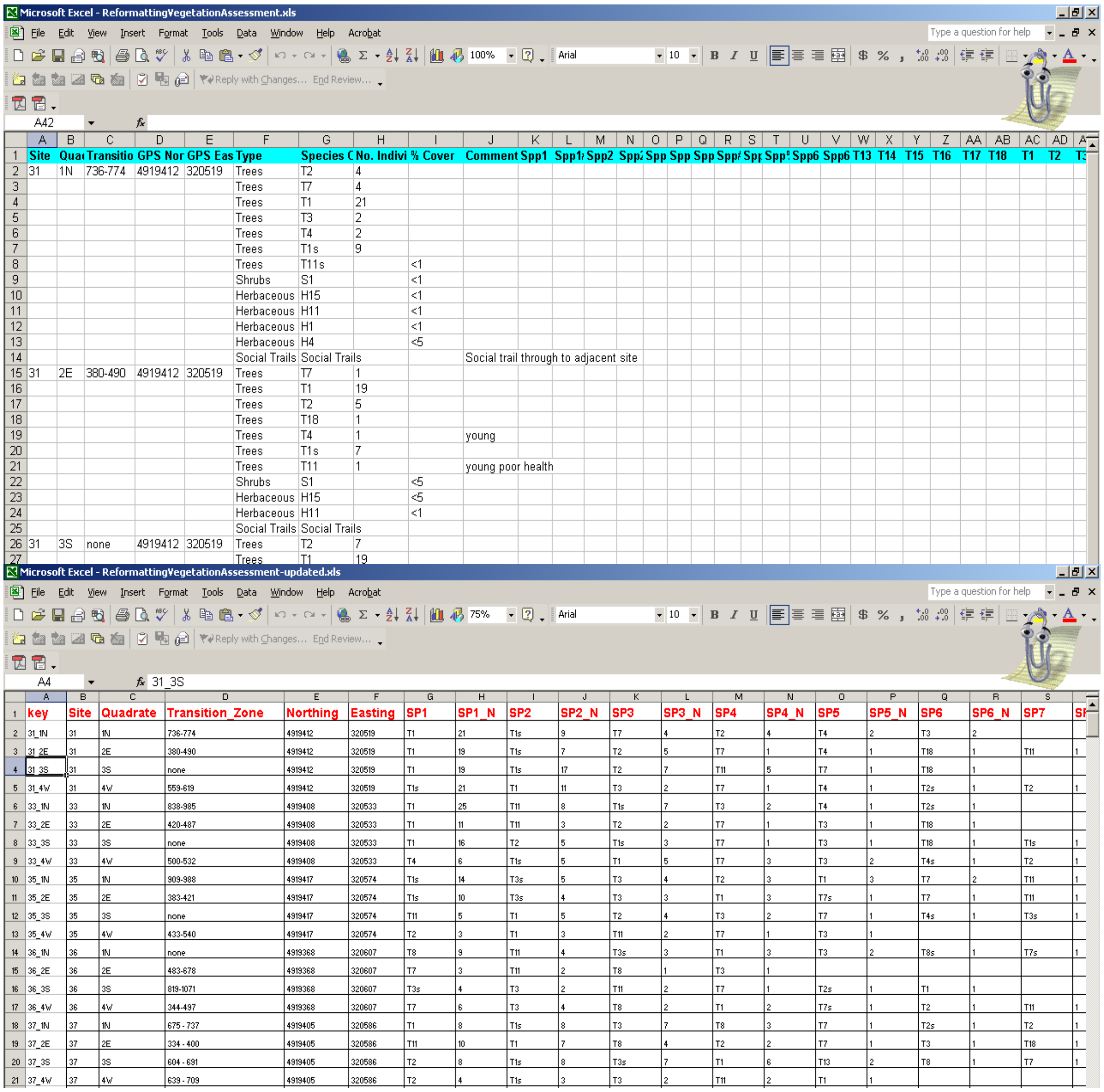


Figure 10 The centroids coordinates were utilized to generate new coordinates that were exploited to create points to generate clip polygons with.

The new points were then imported into ArcGIS and a point shapefile was created. A new polygon shapefile was created and then polygons were digitized from the points. The overlap of the campground quadrants caused confusion so the points in the point file were given unique colors to help identify them. The resultant polygon shapefile contained 4 equal sized square polygon quadrants for each campsite. The clip command from ARCGIS was then used to split the buffered campground polygons with the clip polygons created from the coordinate points.

Research was done on the internet to find other projects that were similar to this so that a better method could be found. The use of ArcView 3.3 was suggested because it has the ability to split polygons using lines. An avenue script was modified and then used to help automate the process. The square polygon shapefile was converted to a line shapefile and the lines from this file were then used with the modified avenue code to split the buffered polygons.

The data supplied in the spreadsheet contained about 11000 data records for the RVA and had to be reformatted in order for the data to be attached as attributes to the shapefile. Some research was done to find an easy solution for this task but none was found. Therefore tedious manual labour was used to reformat the approximately 11000 records down to about 1000 records into proper attribute structures to attach to the shapefiles.



Site	Quai	Transitio	GPS Nor	GPS Eas	Type	Species C	No. Indivi	% Cover	Comment
31	1N	736-774	4919412	320519	Trees	T2	4		
					Trees	T7	4		
					Trees	T1	21		
					Trees	T3	2		
					Trees	T4	2		
					Trees	T1s	9		
					Trees	T11s		<1	
					Shrubs	S1		<1	
					Herbaceous	H15		<1	
					Herbaceous	H11		<1	
					Herbaceous	H1		<1	
					Herbaceous	H4		<5	
					Social Trails	Social Trails			Social trail through to adjacent site
31	2E	380-490	4919412	320519	Trees	T7	1		
					Trees	T1	19		
					Trees	T2	5		
					Trees	T18	1		
					Trees	T4	1		young
					Trees	T1s	7		
					Trees	T11	1		young poor health
					Shrubs	S1		<5	
					Herbaceous	H15		<5	
					Herbaceous	H11		<1	
					Social Trails	Social Trails			
31	3S	none	4919412	320519	Trees	T2	7		
					Trees	T1	19		

Spp1	Spp1/	Spp2	Spp/	Spp	Spp	Spp	Spp/	Spp	Spp!	Spp6	Spp6	T13	T14	T15	T16	T17	T18	T1	T2	T

key	Site	Quadrate	Transition_Zone	Northing	Easting	SP1	SP1_N	SP2	SP2_N	SP3	SP3_N	SP4	SP4_N	SP5	SP5_N	SP6	SP6_N	SP7	SP
31_1N	31	1N	736-774	4919412	320519	T1	21	T1s	9	T7	4	T2	4	T4	2	T3	2		
31_2E	31	2E	380-490	4919412	320519	T1	19	T1s	7	T2	5	T7	1	T4	1	T18	1	T11	1
31_3S	31	3S	none	4919412	320519	T1	19	T1s	17	T2	7	T11	5	T7	1	T18	1		
31_4W	31	4W	559-619	4919412	320519	T1s	21	T1	11	T3	2	T7	1	T4	1	T2s	1	T2	1
33_1N	33	1N	838-985	4919408	320533	T1	25	T11	8	T1s	7	T3	2	T4	1	T2s	1		
33_2E	33	2E	420-487	4919408	320533	T1	11	T11	3	T2	2	T7	1	T3	1	T18	1		
33_3S	33	3S	none	4919408	320533	T1	16	T2	5	T1s	3	T7	1	T3	1	T18	1	T1s	1
33_4W	33	4W	500-532	4919408	320533	T4	6	T1s	5	T1	5	T7	3	T3	2	T4s	1	T2	1
35_1N	35	1N	909-988	4919417	320574	T1s	14	T3s	5	T3	4	T2	3	T1	3	T7	2	T11	1
35_2E	35	2E	383-421	4919417	320574	T1s	10	T3s	4	T3	3	T1	3	T7s	1	T7	1	T11	1
35_3S	35	3S	none	4919417	320574	T11	5	T1	5	T2	4	T3	2	T7	1	T4s	1	T3s	1
35_4W	35	4W	433-540	4919417	320574	T2	3	T1	3	T11	2	T7	1	T3	1				
36_1N	36	1N	none	4919368	320607	T8	9	T11	4	T3s	3	T1	3	T3	2	T8s	1	T7s	1
36_2E	36	2E	483-678	4919368	320607	T7	3	T11	2	T8	1	T3	1						
36_3S	36	3S	819-1071	4919368	320607	T3s	4	T3	2	T11	2	T7	1	T2s	1	T1	1		
36_4W	36	4W	344-497	4919368	320607	T7	6	T3	4	T8	2	T1	2	T7s	1	T2	1	T11	1
37_1N	37	1N	675 - 737	4919405	320586	T1	8	T1s	8	T3	7	T8	3	T7	1	T2s	1	T2	1
37_2E	37	2E	334 - 400	4919405	320586	T11	10	T1	7	T8	4	T2	2	T7	1	T3	1	T18	1
37_3S	37	3S	604 - 691	4919405	320586	T2	8	T1s	8	T3s	7	T1	6	T13	2	T8	1	T7	1
37_4W	37	4W	639 - 709	4919405	320586	T2	4	T1s	3	T3	2	T11	2	T1	1				

Figure 11 The data supplied in a spreadsheet was not in the proper format that could easily be attached to the shapefile, therefore a new spreadsheet with a different format was created. The image above is a screen grab of the original file and the bottom is a screen grab of the new format. Note that it is hard to show the whole file due to the 59 columns of the file. The original file had 10585 rows and 14 columns of data, the new reformatted file had 1039 rows and 59 columns.

After this process was complete, the data was double checked for consistency and then exported as a DBF file. The DBF file was then joined to the shapefiles. The final MXD file was created with several plots and the data files were burned onto DVD along with the data from above.

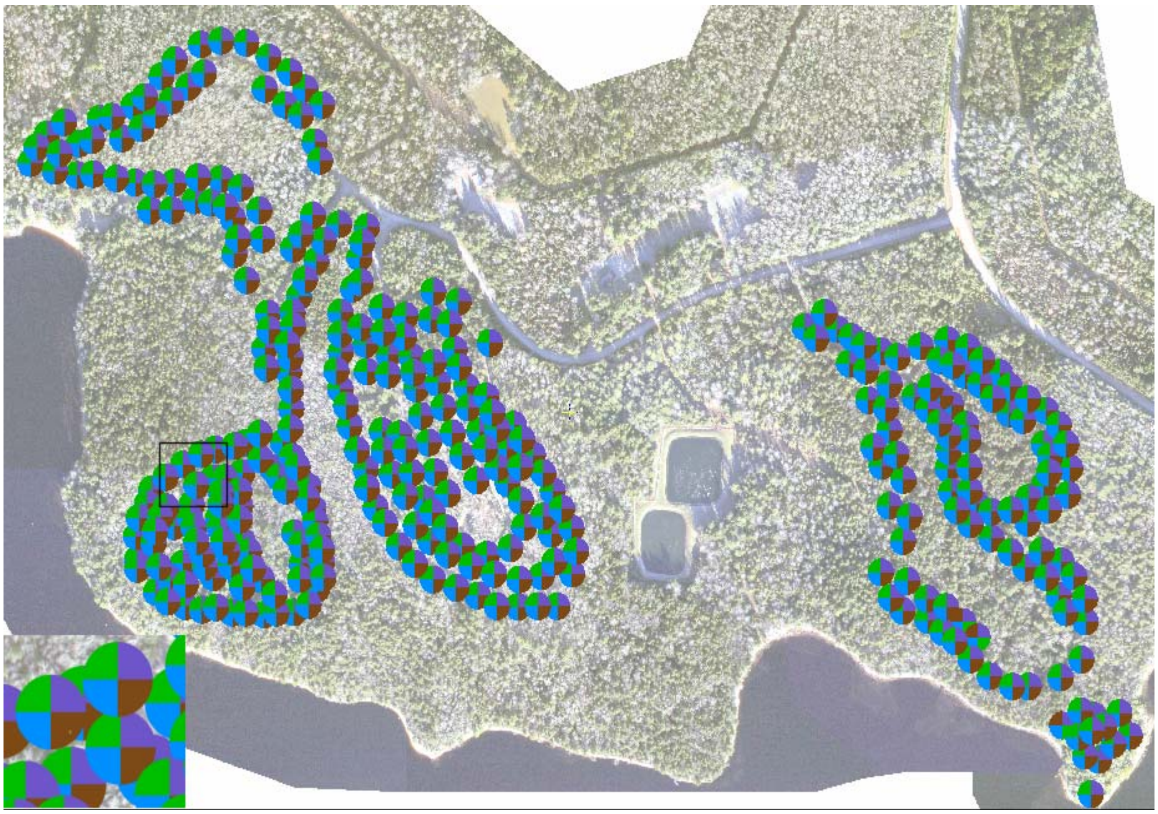


Figure 12 This map consists of the campground quadrants color-coded for easy recognition, which resulted from the second part of this project with an enlargement inset in the bottom corner. Note the abundance of overlap of the buffers that caused troubles with splitting the buffers into four equal quadrants. The image has been faded to avoid interfering with the GIS data and is about 1200 m by 900 m.

Results

The supplied mosaicked digital AGRG aerial photos, created at COGS during the spring of 2004, were never validated; therefore the accuracy of these orthomaps was never known. A quick comparison and visual validation of the three different resolution mosaicked images was necessary due to the known error that the AGRG photographic methods contained and were experienced during past missions.

After examining the mosaicked images in ArcGIS by simply loading all three images into the same ARCGIS project, it was easily noticed that the three images in fact were not orthorectified correctly, and that there were several questionable areas of the mosaics. It was hard to tell which mosaic was more accurate than the other due to the fact that all three differed spatially in certain areas. The main concern for this discrepancy was that in order to digitize accurate polygons for the database, the images would need to have a certain degree of accuracy as well.

It was then discovered that the mosaics also did not include all the available photos, which possibly lead to some of the distortion in the mosaic and the bad overall match between mosaics. To create the one meter mosaic, Garnett used three of four available photos to create the 1 m mosaic, seven of twelve photos were used to create the half meter mosaic and only eleven of twenty-eight photos were used to create the quarter meter mosaic. Garnett stated that the abundant images created redundancy in the image. He was correct with his statement however, what he did not realize was that this redundancy in aerial photography is necessary to generate true orthorectified images.

Vectors were the only source of ground truth data applied to correct the one meter mosaic, while the invalidated one meter mosaic image was also utilized to help collect ground truth data to create the half and quarter meter mosaics. A corrected image is a good method to help improve the results of creating mosaics, but it is important to ensure that the image source used has a relatively high degree of accuracy. The vectors that were used were centerline and coastline files derived from 1:40k provincial aerial photography and had an accuracy of plus or minus 5 meters. In R. Garnet's report, he seems to blame the difficulty and bad results directly on the AGRG photographers and not due to his inexperience of photogrammetry and remote sensing techniques.

The mosaicked photos were projected to UTM 20 T D04 (NAD83) but all the vector data had been projected to UTM 20 T E012 (WGS84), therefore it was decided that since the photo mosaics had to be redone anyway, that it would be easier to convert the projection of the photos to be consistent with the vectors projections then to reproject all the vector layers to match the photos. All new image products created from Ortho Engine were projected to UTM 20 T E012 (WGS84).

While the more accurate Leica RTK system was not available, the Trimble Pro XR unit with WAAS real time correction information was adequate enough to supply GPS data for this project. This GPS unit was used at the park for one day to collect GPS geographic information from the areas in the photo that were not consistent throughout the three different resolution images. Permission was obtained from the Park to enter restricted areas to obtain GPS information in areas west of the campground that were included in the forest interpretations. GPS was also collected along the coast since the coastline vectors were several years old and the accuracy of them was also uncertain.

A new OrthoEngine project was created for the 25 cm resolution photos and a proper orthorectified aerial photo mosaic was derived using the aerial photography model and then a second project was done with the orthos from the aerial photo math model but using the Thin Plate Spline method. All photos were included in the new Ortho Engine projects, as well as the collected GPS data.

The quarter meter mosaic was essential to have when digitizing the provided forest stand data so the digitization and design of the spatial data base could not begin until the photos were properly mosaicked and then validated to ensure that the results of the spatial database would also be accurate. ArcGIS was used to digitize the forest stand interpretations. Both the image and vector files were loaded together and the line work from the hard copy photos was then digitized into the appropriate shapefiles. The results of the line work generated was printed off from time to time and compared with the original interpretations to ensure that information was not missing or was incorrect.

The supplied written data was added into a spreadsheet in attribute format and then joined to the final cleaned polygon dataset. The resultant data was a polygon shapefile with all related attribute data for each stand attached and the proper projection defined. The forest data was incorporated with other park data to produce several hard copy plotted posters. The spatial database was also used to determine some general GIS spatial analysis of the data. Further analysis of the data would be accomplished in future projects.

No methodology was provided to aid in the process of creating the campground quadrants, so research was done to determine the best process. A quick general literature search and a broad internet search was completed to determine if any other projects were similar to this so that a better solution could be found. The search resulted in no similar projects

An attempt was made to split the buffered center point polygons using polygons created from the points defining each quadrant. The output polygons were not ideal and resulted in numerous slivers and very few buffers were actually split into four equal quadrants due to the large overlap of the campground buffers.

From several internet discussion groups, it was suggested that using ArcView 3.3 may be beneficial because it had the ability to split polygons using lines. An avenue script was found on the ERSI website and modified slightly to help automate the process. The square polygon shapefile was converted to a line shapefile and the lines from this file were used with the avenue code to split the buffered polygons. The result was a pie shaped polygon evenly split around into four quadrants and centered on each centroids position.

This process was much more tedious then would have preferred but seemed to be the best logical method to use without wasting too much time trying to find the easiest and quickest methods. The resultant quadrant shapefile resulted 1440 equal sized quadrant polygons, with the majority of them overlapping upon one another. Each polygon was given a unique key ID to be used to help join the attribute data with.

The data for this part of the project was supplied in a spreadsheet and contained about 11000 data records for the rapid assessment. The format which the spreadsheet was in, however, was not in a format that could easily be used to attach to polygons as attribute data and had to be reformatted in order for the data to be attached as attributes to the shapefile. Research was done to find an easy solution for this task but none was found. Therefore, tedious manual labour was used to reformat the about 11000 records down to about 1000 records into proper attribute structures to attach to the shapefiles.

This task exhausted the majority of the time resulting in no significant spatial analysis work done with the new GIS spatial datasets. Plans to hotlink the photos to the campsites in the ARCGIS MXD project file was also postponed due to the fact that the photos were never supplied. The final data was separated into an appropriate data structure, burned to DVD and then hard copy plots of the output with some basic analysis work displayed with the photos plotted off.

Conclusions

This project has been beneficial by continuing to contribute to the extensive geographic data that Kejimkujik National Park continues to collect and create. The joint effort between the Park and the AGRG maintains to help provide this synergetic relationship for creating value added products as well.

This project has resulted with two new GIS spatial databases that will become tools for future studies and continue to help provide environmental sound solutions for the park and the ecology.

All imagery that is to have line work digitized from is expected to be accurate and should be validated to ensure that the accuracy of the digitization can be defined.

Any data that is intended to be used in a GIS database should be recorded in a format that can easily be adapted to GIS format. A data dictionary would also help to keep improve process and the quality of the data.

The update of data from the next RVA should not take up as much time due to the framework that this project has created. The datasets can be easily duplicated and have the spreadsheets of the next assessment attached to it. After the next survey has been completed, extensive comparisons could be used to see what man-made effects are having on the campground.

More thorough comparisons between the forest database and the campground database with other GIS vegetation layers, imagery and datasets would be beneficial to the Park.

Public awareness of the project posted at the visitor center or on the internet would help people to take better care of the campground and may help educate the people on the importance of the study. Using maps of the studies will allow people to visually see the deterioration of the campsites may help as well.

References

Brooks K and Vasseur L (2001) Kejimkujik National Park Visitor Impact Assessment and Rehabilitation. Kejimkujik Fall Conference proceedings.

Garnett R, & Colville D (2004) Infested Hemlock Classification in Kejimkujik National Park and Historic Site: Using Digital Aerial Photography. Applied Geomatics Research Group unpublished report.

MacKinnon E (2003) Basic principals of creating Ortho Images with PCI Geomatica. Applied Geomatics Research Group unpublished report.

O'Grady S (2004) Terms of Reference – Rapid Vegetation Assessment and Photograph Analysis Jeremys Bay Campground Rehabilitation Project. Parks Canada unpublished report.

Appendices

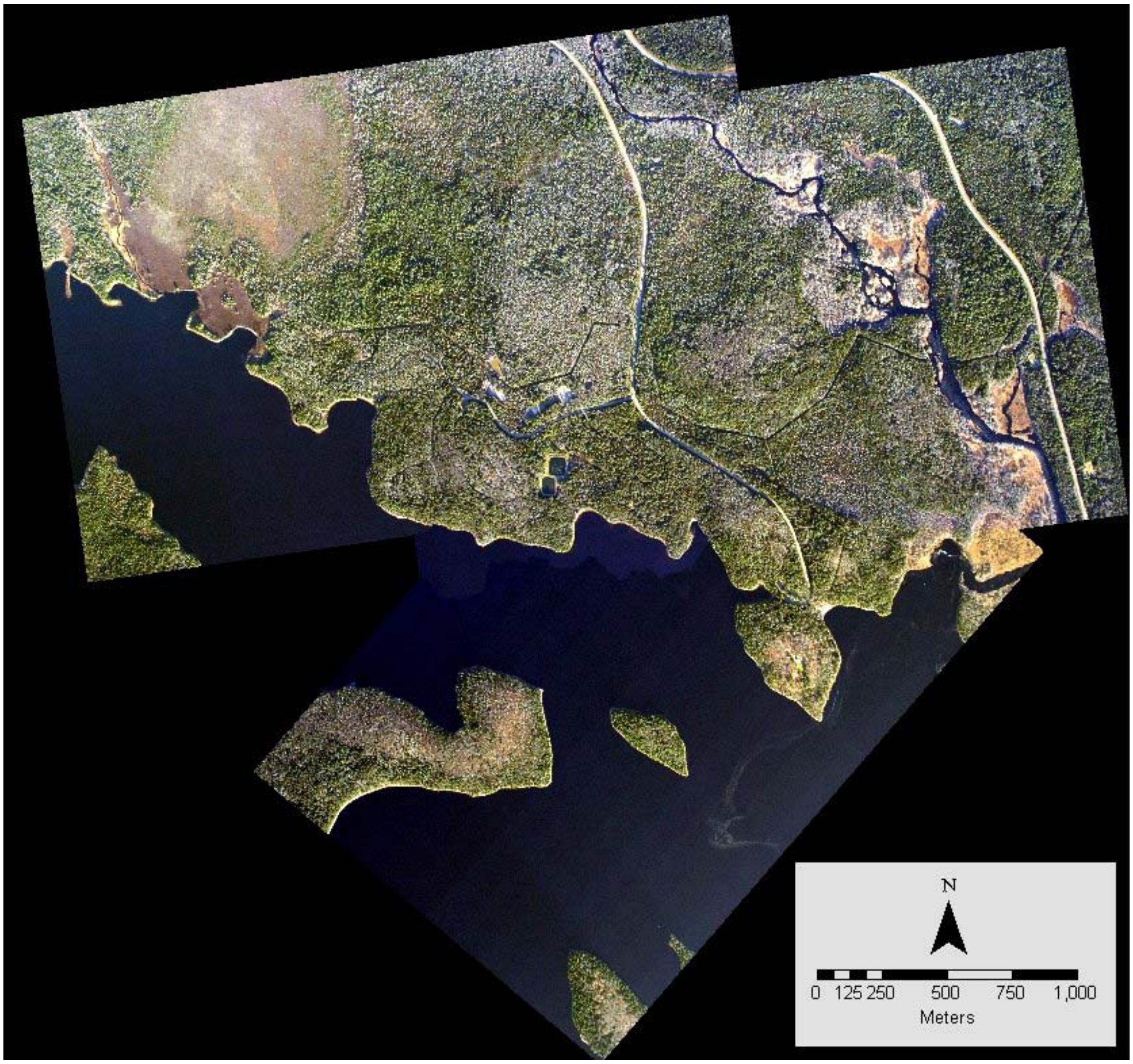


Figure 13 The supplied 1 m resolution orthomosaic was created from 3 of the 4 available digital photos.

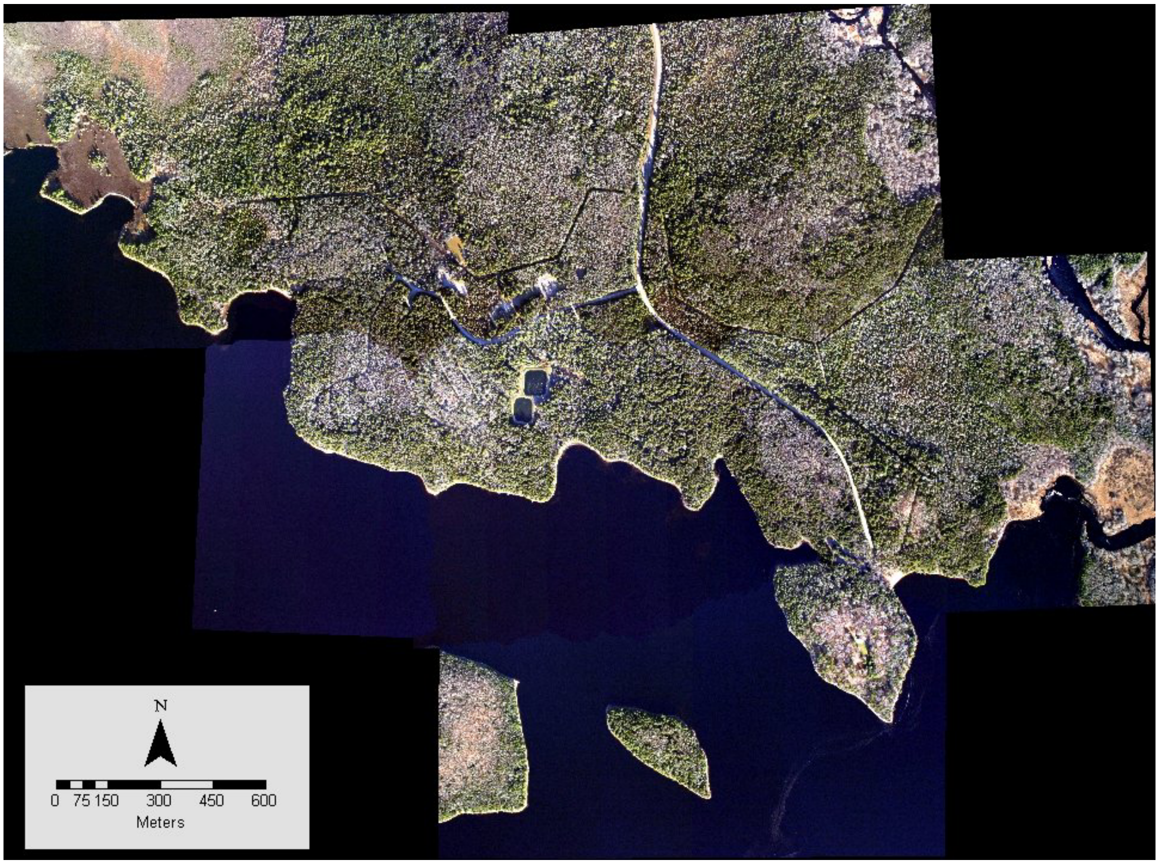


Figure 14 The supplied 50 cm resolution orthomosaic was created from 7 of the 12 available digital photos.

Figure 15 All three mosaics provided for the project are shown here layered ontop of one another with two of the major problem areas highlighted in red circles.

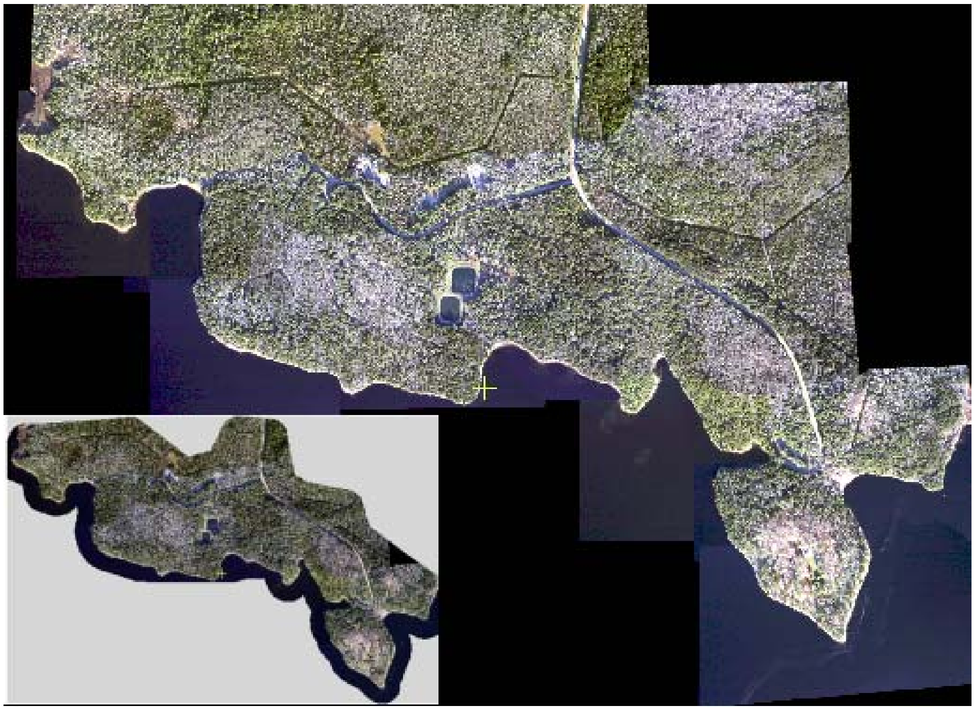


Figure 16 the new 25cm mosaic was created using all available photos, a boundary vector file was created for the study area using a combination of available vector data such as the coastline and the power lines. This study area boundary vector was then buffered, converted to a bitmap mask and then used with a PCI EASI script to model out the excess portions of the mosaic and make the image more appealing.

Figure 177 the two above images represent the original aerial photo (top) and then the orthorectified image with the vectors layered upon it to show the fir between raster image and the vector control.

```
!-------------------------------------------------------------------------------------------------------
! This simple script will clip the unnecessary excess portions of the mosaic file produced
! by OrthoEngine to an irregular buffered shape around the study area.
!
! The working file 'keji-25cm-mosaic.pix' has the existing mosaic image located in the
! first three channels,  an existing irregular shaped polygon bitmap located in the second
! segment and three empty image channels.
!
! %%3 is the bitmap mask of the clip polygon
! %1, %2, %3 are the RGB existing image channels
! %4, %5, %6 will be the new modeled RGB image channels
! the RGB value of 255, 255, 255 will set the background to white
!-------------------------------------------------------------------------------------------------------

MODEL ON "keji-25cm-mosaic.pix" OVER dbiw

 if %%3 = 1 then

   %4 = %1;
   %5 = %2;
   %6 = %3;

 else

   %4 = 255;
   %5 = 255;
   %6 = 255;

 endif;

ENDMODEL

!---------------------------------------------
! Export the resultant channels to a new file
!---------------------------------------------

FILI = "keji-25cm-mosaic.pix
FILO = "keji-25cm-mosaic-new.tif
DBIW =
DBIC = 4,5,6
DBIB =
DBVS =
DBLUT =
DBPCT =
FTYPE = "TIF
FOPTIONS = ""

RUN FEXPORT
!-------------------------------------------------------------------------------------------------------
```

Script 1 The above script is a PCI EASI script that was written to help clean up the mosaic.

```
*******************************************************************************
theView = av.GetActiveDoc
t = theView.GetThemes
splitTheme = msgbox.choice(t,"","Choose the line theme with the selected line")

theProjection = theView.GetProjection
theFtab = splitTheme.GetFTab
theShapeField = theFtab.FindField("Shape")

thebit = theFtab.GetSelection

  for each x in thebit
  aShape = theFtab.ReturnValue(theShapeField, x)
  if (theProjection.IsNull) then
    aGraphic = GraphicShape.Make(aShape.ReturnProjected(theProjection))
  else
    aGraphic = GraphicShape.Make(aShape)
  end
  if (aShape.Is(Polygon)) then
      msgbox.info("You must choose a line theme","Warning")
   end
end
theTheme = theView.GetEditableTheme

   if (theTheme <> nil) then
    theTheme.GetFtab.BeginTransaction
    theField = theTheme.GetFTab.FindField("Shape")
    theType = theField.GetType
    if ((theType = #FIELD_SHAPEPOLY) or (theType = #FIELD_SHAPELINE)) then
      theTheme.Split(aShape)
    end
    theTheme.GetFtab.EndTransaction
  end
  av.GetProject.SetModified(true)
*******************************************************************************
```

Script 2 The above Avenue code from the ESRI website was modified slightly and then used to split the campground polygons into four quadrants. Original code created: 5/25/2001 and obtained from http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=19409 on July 21, 2004.

POLY#	SP1	%SP1	SP2	%SP2	SP3	%SP3	SP4	%SP4	SP5	%SP5	OTHER	COMMENTS
1	rO	3	wP	3	rM	2	rS	2				
2	rM	6	rO	2	wB	2						
3	rM	10										
4	rO	3	rM	3	eH	1	wB	3				
5	rM	4	bS	3	wP	1	La	2				
6	bS	8	wP	1	La	1						
7	eH	7	rS	2	wB	1						
8	eH	3	rS	3	rO	2	rM	1	wB	1		
9	eH	7	wB	2	rM	1						
10	eH	7	rS	1	rO	1	wB	1			wS	
11	eH	6	rO	2	rM	1	wB	1				
12	wB	4	eH	3	rM	3						
13	eH	8	rM	2								
14	eH	8	rM	1	wB	1						
15	bS		rM									Open
16	rO	4	rM	3	eH	3						
17	eH	8	wP	1	rO	1						
18	eH	7	rS	1	rM	1	wB	1				
19	bS	6	rM	3	La	1						
20	eH	4	wP	3	rO	2	wB	1				
21	wP	4	eH	3	wB	1	Po	1	rM	1	rS	
22	rM	7	eH	2	rS	1						
23	rO	3	rM	3	Be	2	eH	2				
24	eH	5	rM	3	wP	2						
25	eH	4	rM	3	rO	2	wB	1				
26	rM	7	eH	1	rS	1	rO	1				
27	rM	5	rO	2	wB	2	eH	1				
28	bS	4	bF	4	rM	2						swamp
29	rM	4	eH	3	rS	2	bF	1				
30	eH	5	rS	2	wP	2	rM	1				
31	rM	4	Po	4	wB	2					rSwPeH	
32	wP	6	rO	3	rS	1					PoWBrMeH	
33	wP	7	wB	1	rO	1	rM	1				
34	rM	5	rO	3	wB	2						
35	eH	6	rS	2	rM	2						
36	rM		rS		bF		wP		eH			regen
37	eH	4	wP	4	rS	2						
38	wP	2	eH	4	rM	4						
39	bS	7	La	2	rM	1						swamp
40	eH	5	wB	2	rS	1	rM	1	Po	1		
41	eH	5	rM	2	rO	2	rS	1			wP	
42	eH	6	wB	2	wP	1	rS	1				
43	eH	6	rS	4							wP	
44	bS	8	wP	2								swamp
45	eH	6	rM	2	WB	2					rSwPrO	
46	bS	5	bF	4	wP	1						
47	eH	4	rS	3	rM	2	wB	1				
48	rS	4	wB	4	eH	2						
49	eH	7	bS	2	rM	1						
50	eH	5	rM	2	wB	2	rS	1				
51	eH	5	rS	3	wP	1	wB	1				
52	eH	6	rM	1	wB	1	wP	1	rS	1		
53	eH	8	rM	2							rSwB	
54	wB	6	eH	4								
55	eH	7	rM	2	wB	1						
56	rM	4	Be	3	wB	3						
57	eH	10										
58	sM	1	Be	4	rM	3	wB	2			yBIrO	
59	eH	5	rM	5								
60	eH	3	rM	3	rO	3	wP	1				
61	eH	6	rO	2	rM	1	wB	1				
62	eH	7	rM	2	rS	1						
63	wB	4	rM	4	rO	1	eH	1				
64	Be	4	wB	3	rM	3						
65	eH	4	wB	3	rM	3						
66	eH	10										
67	eH	5	wB	3	rM	2						

68	rO	4	rM	2	eH	2	wB	2				
69	Be	5	wB	2	rM	1	rO	1	sM	1		
70	eH	8	rM	1	wB	1						
71	eH	6	rO	2	wB	2						
72	eH	3	rO	3	rM	2	Be	1	wB	1		
73	rO	6	wA	1	wB	1	rM	2				open
74	rO	6	wA	1	wB	1	rM	2				closed
75	eH	4	wB	4	wP	2						
76	wB	5	eH	3	wP	2						
77	Be	4	rO	3	wB	3					wPwAsM	
78	rO	6	rM	2	eH	2						
79	eH	7	rO	1	rM	1	wB	1				
80	eH	4	rO	3	rM	2	wP	1				
81	wB	5	eH	1	rM	4						
82	wP	4	eH	3	rM	3						
83	gB		rO		rM		wP					regen
84	gB		rM		rO		wP					Alders & regen
85	rO	8	rM	2								
86	rO	5	wP	2	rM	1	wB	1	Be	1		
87												Picnic Area
88												Picnic Area
89												Recreation Area
90	wP	9	rO	1								
91												Sewage pond
92												Recreation Area
111	eH	6	rO	2	rM	1	wB	1				
120	eH	4	wP	3	rO	2	wB	1				
121	wP	4	eH	3	wB	1	Po	1	rM	1	rS	
124	eH	5	rM	3	wP	2						
131	rM	4	Po	4	wB	2					rSwPeH	
133	wP	7	wB	1	rO	1	rM	1				
134	rM	5	rO	3	wB	2						
159	eH	5	rM	5								
171	Be	4	wB	3	rM	3						
172	eH	3	rO	3	rM	2	Be	1	wB	1		
211	eH	6	rO	2	rM	1	wB	1				
221	wP	4	eH	3	wB	1	Po	1	rM	1	rS	
272	eH	3	rO	3	rM	2	Be	1	wB	1		
311	eH	6	rO	2	rM	1	wB	1				
321	wP	4	eH	3	wB	1	Po	1	rM	1	rS	
421	wP	4	eH	3	wB	1	Po	1	rM	1	rS	
521	wP	4	eH	3	wB	1	Po	1	rM	1	rS	

Table 2 Forest Attribute table created in Excel and then exported to dbf format to be attached with the shape file. The codes stand for tree species and the number stands for percentage of species per polygon. Note each unit is a unit of 10%.