Archaeological Overview of Northeastern British Columbia: Year Three Report

Muskwa Plateau from Pink Mountain

Prepared for the
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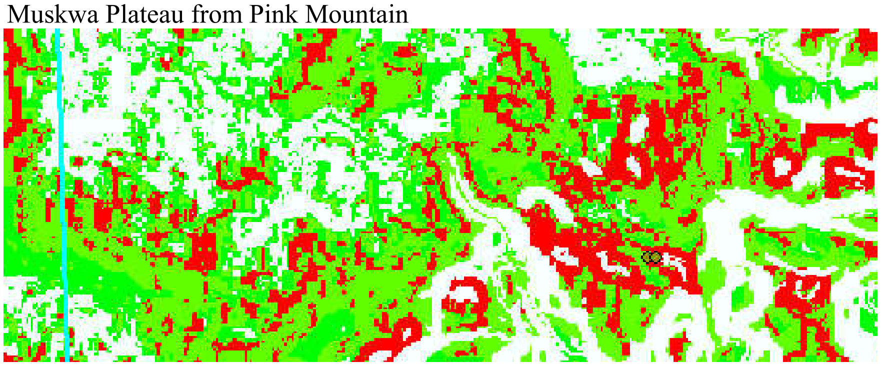
Submitted to the following First Nations
The Fort Nelson First Nation
The Halfway First Nation
The Dene Tha'
The Blueberry River First Nations
The West Moberly First Nations
The Doig River First Nation
The Acho Dene Koe
The Saulteau First Nation
The Treaty Eight Tribal Association



Millennia Research Limited
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Management Summary

Year three of the NE BC archaeological predictive modelling was focussed on two main topics: identifying terrain, and using smaller geographic sub-areas as a basis for creating more specific and robust models. Both endeavours were very successful and the models created this year are major improvements, in both statistical performance and sophistication, over last year's versions.

A terrain model was created in recognition of the fact that archaeological potential is strongly correlated with terrain features, especially in areas where the usual indicators are less effective (i.e. large tracts of black spruce muskeg). Field survey was undertaken mainly to test the terrain model. This survey included identifying terrain features on the map and determining whether or not they existed on the ground; and, identifying terrain features on the ground and determining whether or not they existed on the map. Archaeological potential was recorded for all these features. Six archaeological sites and one CMT site were found during survey. Most terrain features were not shovel-tested and it is likely undetected archaeological sites occur at some of these locations.

Site location checks continued into this year, and many more sites were moved to a closer location using 1 meter-resolution orthophotos. These precisely corrected site locations have provided data for model creation and testing, and greatly increase the precision of the models. A problem with site inventory form mapping continued, with the lack of mid-scale maps making it impossible to verify the location of many sites.

A strong focus this year was the creation of ecosection-specific models. This was identified in the Year Two report as an appropriate method of dealing with ecological diversity within the study area. A new model was created for each ecosection. In every case, the model's performance increased. The strongest improvements occurred for the two ecosections that had terrain models created for them.

New variables were included in this year's modelling process, and involved new uses of updated forest cover data as well. Terrain Ecosystem Mapping and Predictive Ecosystem Mapping (TEM/PEM) data was investigated for possible use next year.

Meetings were held after the Clear Hills ecosection mapping was completed to liaise with some First Nations and Oil and Gas Commission staff.

The tasks proposed for next year include terrain modelling the remainder of the study area. TRIM II mapping has recently become available for virtually the entire study area, and will be incorporated. More extensive fieldwork is planned for the coming year to address ground truthing.

In August 2002, project and contract management duties, as well as chair of the Steering Committee, were transferred from Ministry of Energy and Mines to the Oil and Gas Commission.

Acknowledgements

Numerous individuals have assisted with the development and refinement of the Year Three deliverables for the NE BC Archaeological Overview. These include:

Vera Brandzin, Heritage Conservation Program Manager and Tom Ouellette, Director of Aboriginal Relations and Land Use, at the Oil and Gas Commission (OGC) offices in Fort St. John. Vera provided extensive help and direction and we particularly thank her.

Dan Klassen of the Fort Nelson First Nation; Bernice Lilly of the Halfway River First Nation; Debbie Apsassin of the Blueberry River First Nation; Dolly Apsassin of the Doig River First Nation; and, Dave Caldwell of Prophet River First Nation all met with our staff to arrange field work or to discuss the model mapping results. Thanks to all for their time and effort.

James Pike, Planning and Assessment, Archaeology & Forests Branch of the Ministry of Sustainable Resource Management is our Project Officer; Chris Spicer, Senior Business Analyst, Business Application Services, who assisted with our acquisition of ortho-photos used for site corrections.

Julie Smith, Todd Christensen, and Keary Walde at Heritage North are thanked for all the help in the field in 2002; and Keary for his help reviewing the model and palaeo site locations in "spring" 2003.

Remi Farvaque and Ken Schwab of Big Pine Heritage Consulting are thanked for their time examining the Clear Hills model mapsheets in "spring" 2003.

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Introduction

This report presents the third year results of the NE BC Archaeological Overview Assessment. Millennia Research was awarded the five-year contract by the Ministry of Energy and Mines (MEM) to complete an AOA in northeastern BC for the MEM and the BC Oil and Gas Commission (OGC). In this endeavour, Millennia Research has partnered with Timberline Forest Inventory Consultants Ltd, who provide Geographic Information System (GIS) support, and with Heritage North Consulting Ltd, (this year) as our study area specialists. The Year Two report for the AOA outlined the general terms of the AOA, datagaps analysis and survey, and preliminary modelling.

The NE BC AOA covers a large continuous area is bounded to the north by the British Columbia border with Northwest Territories, and to the east by the border with Alberta. It is approximately 380 km from north to south, and between 120 and 230 km east to west, close to 78,000 square kilometres in area. It includes parts of the Fort Nelson and Fort St. John Forest Districts and falls within NTS map sheets 94O, 94P, 94J, 94I, 94H, the eastern half of 94G, and the northern half of 94A (Figure 1).

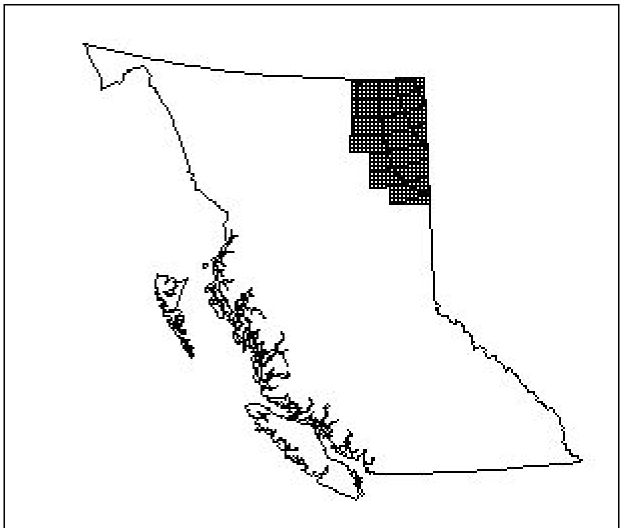


Figure 1. Study Area.

This report spans the period of April 1, 2002 to March 31, 2003. The report outlines the Year Three objectives, and describes meetings with First Nations, survey coverage mapping, site checks, trail and palaeo site research, it includes a discussion of mid-stage model development, summarizes improvements made in terrain identification, and presents fieldwork results. The final section of the report outlines areas of further research and model refinement to be undertaken in the third year of the project.

This report doesn’t follow the suggested AOA report layout as much of the guideline material is covered in the Year 1 and Year Two reports (which have both been included on the attached CD). This report focuses on areas of research and concern for this year alone. Other files included on the CD are the Adobe Acrobat Reader program, which may need to be installed to read the reports, the Appendix 1 (variable analysis printouts), and this report. **Please use the digital version of the report to see all figures in colour.** The electronic version also allows for quick and easy searching for terms and fast browsing of pages using the 'Thumbnails' on the left of the screen.

Project Review Committee

Overall project direction is the responsibility of the Project Review Committee. The current Committee consists of Tom Ouellette (OGC), James Pike (Archaeology and Forests Branch), Mary Viszlai-Beale (Ft. Nelson Forest District), Dr. Quentin Mackie (University of Victoria) and Vera Brandzin (OGC).

Year Three Objectives

The Terms of Reference (TOR) identified specific tasks for each of the five years of the project.

Year Three tasks include:

- Fieldwork
- Mapping of newly recorded archaeological sites
- Inventory of new archaeological survey data
- Testing and refinement of model
- Reporting

Discussions with First Nations

While conducting fieldwork in late September and early October, 2002; Kristi Benson and Rob Vincent (representing Millennia Research Limited) met with Dan Klassen of the Fort Nelson First Nation regarding the project and future directions. Following model completion for the Clear Hills Ecosection in February, example mapsheets were the focus of meetings with representatives from the Doig, Blueberry, Prophet River, and Fort Nelson First Nations. At each meeting the model was discussed and the maps examined. The very different look to the maps compared to previous products generated considerable interest. All meetings were positive. Preliminary talks regarding the next round of field testing were discussed at some meetings.

Predictive Model Development and Upgrade Overview

Data Used in Analysis

The updates to the NE AOA model were based on several types of data: updated data (such as orthorectified site locations and new forest cover data) and new variables. Both are described below. In addition, these data were used in new ways to create models. The study area was broken down into ecosections which each had a separate model made. And the combination of relevant variables was manipulated to determine if particular combinations increased model performance. A complete list of data used in the modelling process is presented in the Year Two report; only new or changed variables are discussed in this report (Eldridge, et al. 2002). **The Year Two and Year 1 reports are also included on the CD attached to this report.**

New Data

The main group of new variables are terrain variables, the concepts of which were discussed in the Year Two Report and created and used for the Year Three model (Eldridge, et al. 2002). The process of terrain modelling is described in detail later in the report. It is based on a moving window consisting of a central cell and surrounding cells. The cells, for our purposes, contain elevation data. Cells surrounding the central cell are compared for elevation differences and recorded in a new output cell layer (or grid).

ArcView GIS was used to examine the cells or square polygons created by the moving window technique (see the Year Two report) to identify ridges and breaks-in-slope. Areas of high potential due to topographic features such as eskers, knolls, terraces, etc were examined to determine the values of the variables to find combinations that were unique to these cells. When viewed in ArcView using the 3D Analyst extension, it is relatively easy to determine whether or not the technique is effective (see for example Figure 10). The cell values were used to select both breaks-in-slope and microtopographical features. Multiple grid cell sizes, and multiple combinations of topo-elevation variables were used in the modelling.

Aspen stand variables were also included in both the CLH and MUP ecosection models. Buffering of distance to polygon (stand) boundary was also included. Next year, aspen stands throughout the study area and MUP pine stands will be analysed in this manner to strengthen the model's performance.

Updated Data

More site location corrections occurred in Year Three, although this was not a focus. Orthorectified air photos were used to precisely plot the location of sites, which provides a degree of accuracy superior to the use of TRIM data alone. At the time of reporting, 79 % of site points in the model database are now recorded as having their locations corrected using orthophotos.

Another dataset that was updated for this year's model creation was forest cover. In January it became apparent that forest cover data was inaccurate and outdated beyond what we had understood earlier. Newer forest cover data was integrated into the Clear Hills and Muskwa Plateau ecosections.

As recommended last year, this year's model database was modified slightly. Two smaller ecosections (MUF, the Muskwa Foothills in the western portion of the study area, and PEL, the Peace Lowland in the far south of the study area) had the number of random (grid) points doubled in the model database. This allowed for a more robust statistical analysis of these study areas. PEL only was present on a few partial mapsheets, and the CLH model was extrapolated to these areas during the modelling.

Another small change was the boundary variable, which went to the biogeoclimatic zone boundary last year, but this year went to the ecosection boundary.

Variables Used

The following table, provided by Timberline, lists and describes the variables used in creating and updating the model. In addition, the 'Analysis' column describes how the variables were created, and the 'Differ' column indicates whether or not the variables are new or changed from the 2002 model.

Table 1 Variables Used in 2003 Model

VARIABLE	DESCRIPTION	ANALYSIS	DIFFER*
expect	numeric potential value assigned by model		
exp_class	character potential class assigned by model		
recnum	borden number + unique id for site points		Y
surv_num	survey number + unique id		Y
grid_num	1 or 2 km grid point - unique id		N
type	site, survey, grid		Y
trails	major trail	near to	N
tbrln	timberline defined by Alpine Tundra bgc zone	near to	N
eskers	eskers	near to	N
lakevs	lakes < 5 ha	near to	N
lakesm	lakes > 5 ha and < 100 ha	near to	N
lakemd	lakes > 100 ha and < 1000 ha	near to	N
lakelg	lakes > 1000 ha	near to	N
wetsm	wetland < 5 ha	near to	N
wetlg	wetland > 5 ha	near to	N
rv_dbl	double line river	near to	N
rv_int	intermittent or indefinite river	near to	N
rv_sgl	single line river	near to	N
sites_nr	nearest neighbouring phrd site	near to	N
bdy	study boundary	near to	Y
sel1	20 m 7 by 7 selected cells (ground-truthed)	near to	Y
sel2_d	50 m 9 by 9 selected cells (ground-truthed)**	near to	Y
sel3a	select 3a grid cells (significant hilltops)	near to	Y
sel3b	select 3b grid cells (significant hilltops)	near to	Y

sel3c	select 3c grid cells (significant hilltops)	near to	Y
bgc_zone	biogeoclimatic zone	identity	N
subzone	biogeoclimatic subzone	identity	N
eco_sec	biogeoclimatic ecosection	identity	N
in_lkrv	in lake or double line river	identity	N
wetsm_id	wetland < 5 ha	identity	N
wetlg_id	wetland > 5 ha	identity	N
in_wet	in wetland	identity	N
agecls	projected age class of forest stand (all species)1	identity	Y
hghtcls	projected height class of forest stand (all species)2	identity	Y
lpine_id	Lodgepole pine present in stand	identity	Y
lpind_p	percentage of Lodgepole pine in stand	identity	Y
birch_id	Birch, Common paper and Alaska birch present in stand	identity	Y
birch_p	percentage of Birch species in stand	identity	Y
aspen_id	Aspen present in stand	identity	Y
aspen_p	percentage of Aspen in stand	identity	Y
wspr_id	White spruce present in stand	identity	Y
wspr_p	percentage of White spruce in stand	identity	Y
bspr_id	Black spuce present in stand	identity	Y
bspr_p	percentage of Black spruce in stand	identity	Y
cotton_id	Cottonwood present in stand	identity	Y
cotton_p	percentage of Cottonwood in stand	identity	Y
lt_id	Tamarack present in stand	identity	Y
lt_pct	percentage of Tamarack in stand	identity	Y
l_id	Larch present in stand	identity	Y
l_pct	percentage of Larch in stand	identity	Y
fir_id	True fir, Alpine fir, and Amabalis fir present in stand	identity	Y
fir_pct	pecentage of Fir species in stand	identity	Y
s_id	Spruce present in stand	identity	Y
s_pct	percentage of Spruce in stand	identity	Y
aspensize	size of dissolved aspen mapstand (ge 50% for CLH, > 0% for MUP)	identity	Y
aspennear	distance from within of dissolved aspen mapstand to polygon boundary	near to	Y
count7	count of positive difference values for 20x20m, 7x7 window	identity	Y
count9	count of positive difference values for 50x50m, 9x9 window	identity	Y
positive7	sum of positive difference values for 20x20m grid, 7x7 window	identity	Y
positive9	sum of positive difference values for 50x50m grid, 9x9 window	identity	Y
negative7	sum of negative difference values for 20x20m grid, 7x7 window	identity	Y
negative9	sum of negative difference values for 50x50m grid, 9x9 window	identity	Y
slope	slope (degree) for 20x20m grid	identity	Y

sel1id	select 1 grid cells (positive7 ge 80 and negative7 ge -75)	identity	Y
sel2id	select 2 grid cells (positive9 ge 200 and negative9 ge -100)	identity	Y
sel3aid	select 3a grid cells (count9 77-79 and positive9 ge 750)	identity	Y
sel3bid	select 3b grid cells (count9 = 80)	identity	Y
sel3cid	select 3c grid cells (count9 = 80 and positive9 ge 800)	identity	Y
x_coord	UTM northing coordinate	N/A	N
y_coord	UTM easting coordinate	N/A	N
mapno	TRIM mapsheet number	N/A	Y
orthophoto	orthophoto corrected phrd site	N/A	N
borden	Borden number	N/A	N
chin_type	indicates 'point' or 'poly' phrd site	N/A	N
paleo	phrd site typography	N/A	N
rise	phrd site typography	N/A	N
knoll	phrd site typography	N/A	N
ridge	phrd site typography	N/A	N
terrace	phrd site typography	N/A	N
hilltop	phrd site typography	N/A	N
hillside	phrd site typography	N/A	N
featureless	phrd site typography	N/A	N
esker	phrd site typography	N/A	N
break	phrd site typography	N/A	N
<100m	phrd site typography	N/A	N
revised	phrd site typography	N/A	N
not_mappable	phrd site typography	N/A	N
near_water	phrd site typography	N/A	N
not_enuf_info	phrd site typography	N/A	N
flag	phrd site type	N/A	N
precontact	phrd site type	N/A	N
historic	phrd site type	N/A	N
lithic	phrd site type	N/A	N
trail	phrd site type	N/A	N
cmt	phrd site type	N/A	N
subsistence	phrd site type	N/A	N
habitation	phrd site type	N/A	N
cultural_mat	phrd site type	N/A	N
burial	phrd site type	N/A	N
earthwork	phrd site type	N/A	N
landform	*physiographic regions*	DEFERRED	
strandln	*contours for glacial lakes*	DEFERRED	

* Y = Coverage differs from 2002 model or coverage/variable is new for 2003 model

** sel2_d coverage is a dissolved coverage, therefore, the near-to distance for points within the polygons are not necessary accurate; points outside the polygons are accurate. This was done in an effort to expedite the processing as only sites outside the polygons were of interest.

Traditional Use Data

Traditional Use (TUS) data from the Treaty 8 region were provided to Millennia through a data sharing agreement (Interim Data sharing Agreement between the Treaty 8 First Nations and the Government of British Columbia) . Prior to receiving this data, we anticipated that the files would be very useful for modelling purposes, especially in the MUP (Muskwa Plateau) ecosection where trails are the most predictive variable. However, the TUS data for the MUP ecosection was disappointing from a modelling viewpoint: it was only points (except for large linguistic polygons), and all of these points were previously recorded archaeological sites. In the southern portion of the study area, more trails are evident in the TUS data. Next year, these trails will be incorporated into the Clear Hills model (which was already built when the TUS data arrived). Other sources of TUS data will also be sought out.

Site Location Corrections

Site location corrections continued into Year Three, although this was not a major focus in Year Three. As explained in the Year Two report, this process is integral to modelling as even a 50 m error in site location can make many sites fall outside high potential zones. Prior to the updated model database being created by Timberline mid way through Year Three, 79% of the site points in the database were recorded as being orthocorrected (i.e. corrected with 1 m pixel size orthorectified airphoto). However, we continued to have problems confidently placing most site locations because lack of mid-scale (e.g., 1:5000) maps on site forms, and many site locations remain tentative. Site corrections were initiated immediately after the Year Two report was completed and continued sporadically until January, with some further site corrections as a result of flagged data in the model database. In July 2002, updated boundaries were provided to the Archaeology and Registry Services Branch as a shapefile so their records could reflect new boundaries. Updated boundaries will also be provided next year.

Examples of Corrections

One impetus for orthocorrections was that swamps are 'zeroed' in our model, that is, after all other variables are calculated; anything within a swamp is set to zero and thus low potential.

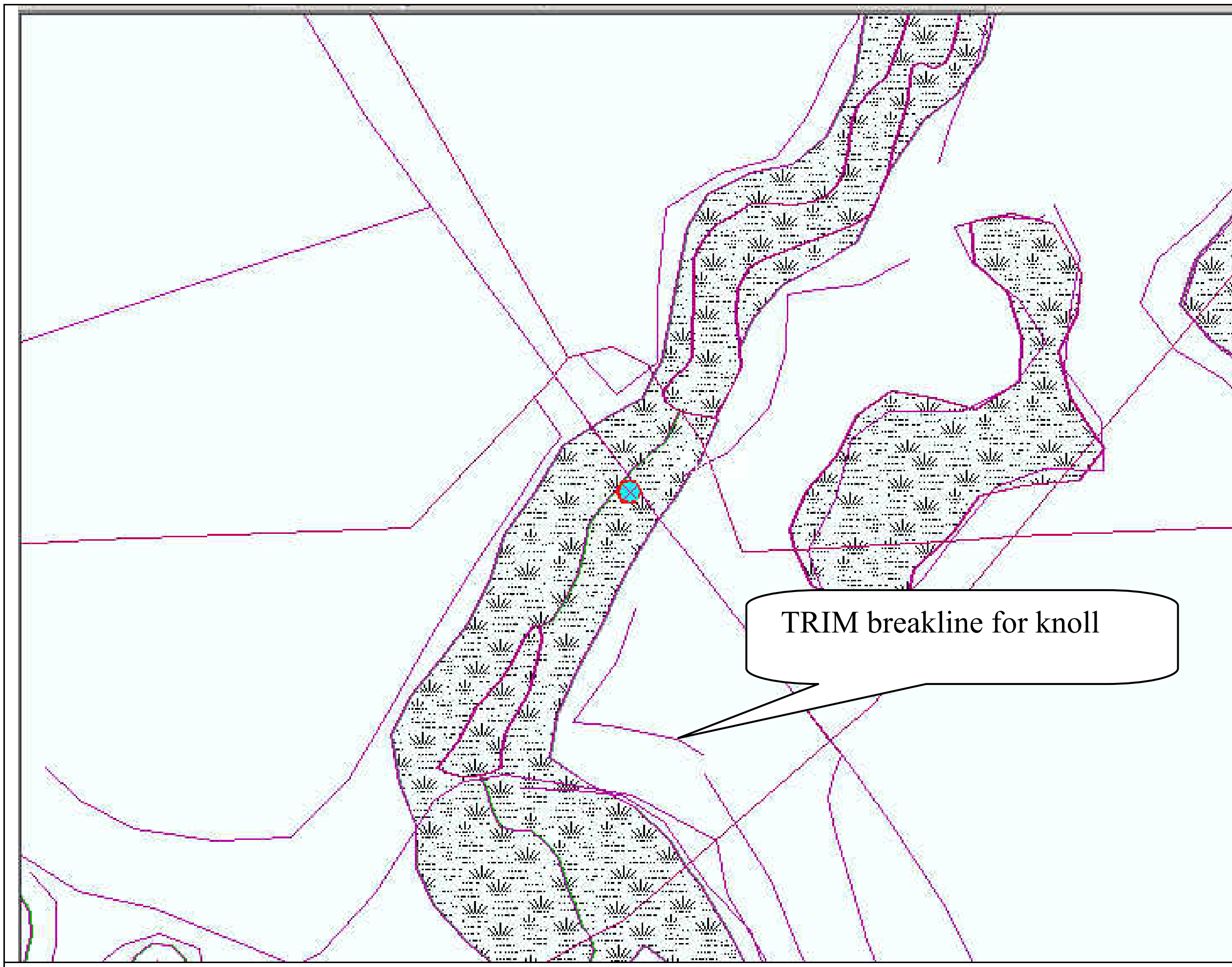


Figure 2. HgRd-001, as mapped in HRIA.
Archaeological site HgRd-001, displayed with TRIM base.

We were noticing that some sites seemed to be within swamps and were wondering if this was a mapping problem, or if sites indeed were found in swamps. If it were a mapping problem, it could be in one of two dimensions: that the location of the site is correct and the TRIM/Forest Cover swamps are wrong, or that the site is mapped in the wrong location. After checking several sites that were indicated as occurring in swamps, it was decided that the majority were mapped incorrectly. For example, HgRd-001 was corrected using TRIM but the orthophoto made it much easier to place it extremely accurately (see Figure 2, Figure 3, Figure 4, and Figure 5).

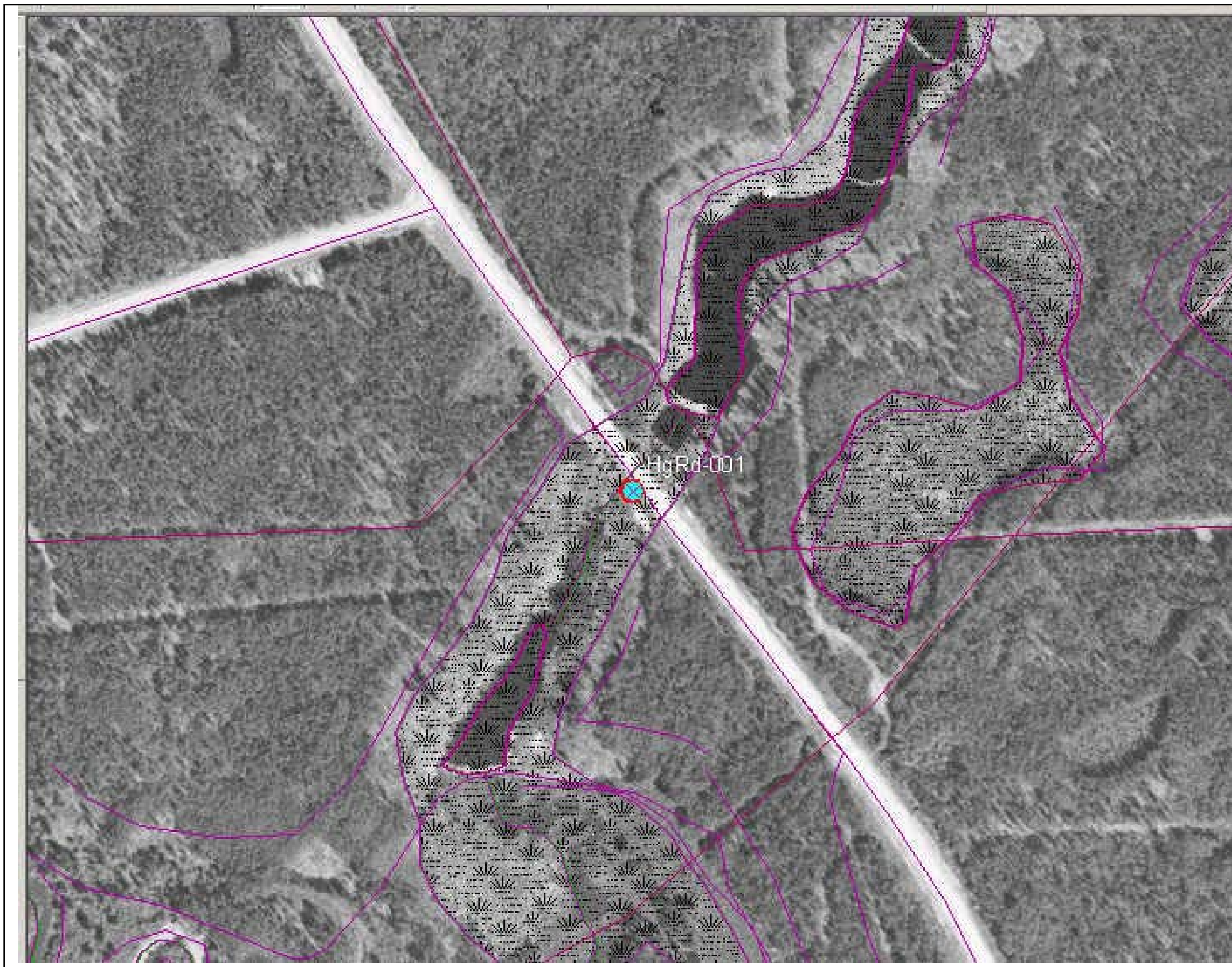


Figure 3. HgRd-001, with Orthophoto.
The same site with orthophoto turned on. It is immediately apparent that it is too close to the stream. With the orthophoto layer turned on, it is much easier to see actual dimensions of road, etc. to compare it to the sketch map (Figure 5).

The location of this site in the swamp was incorrect and would cause two types of problems in the modelling process. The incorrect location would skew the buffering numbers, i.e. appear that sites are closer to streams than they are. Also, because it was mapped in a swamp, it would appear as though the site itself was caught in low potential even though its actual location would be classified as a higher potential region.

Figure 4. HgRd-001, Orthocorrected.
The site has been moved to the knoll where it is mapped in the sketch map. The L-shaped breakline under the site can be seen as a treeline extending north (Figure 5).

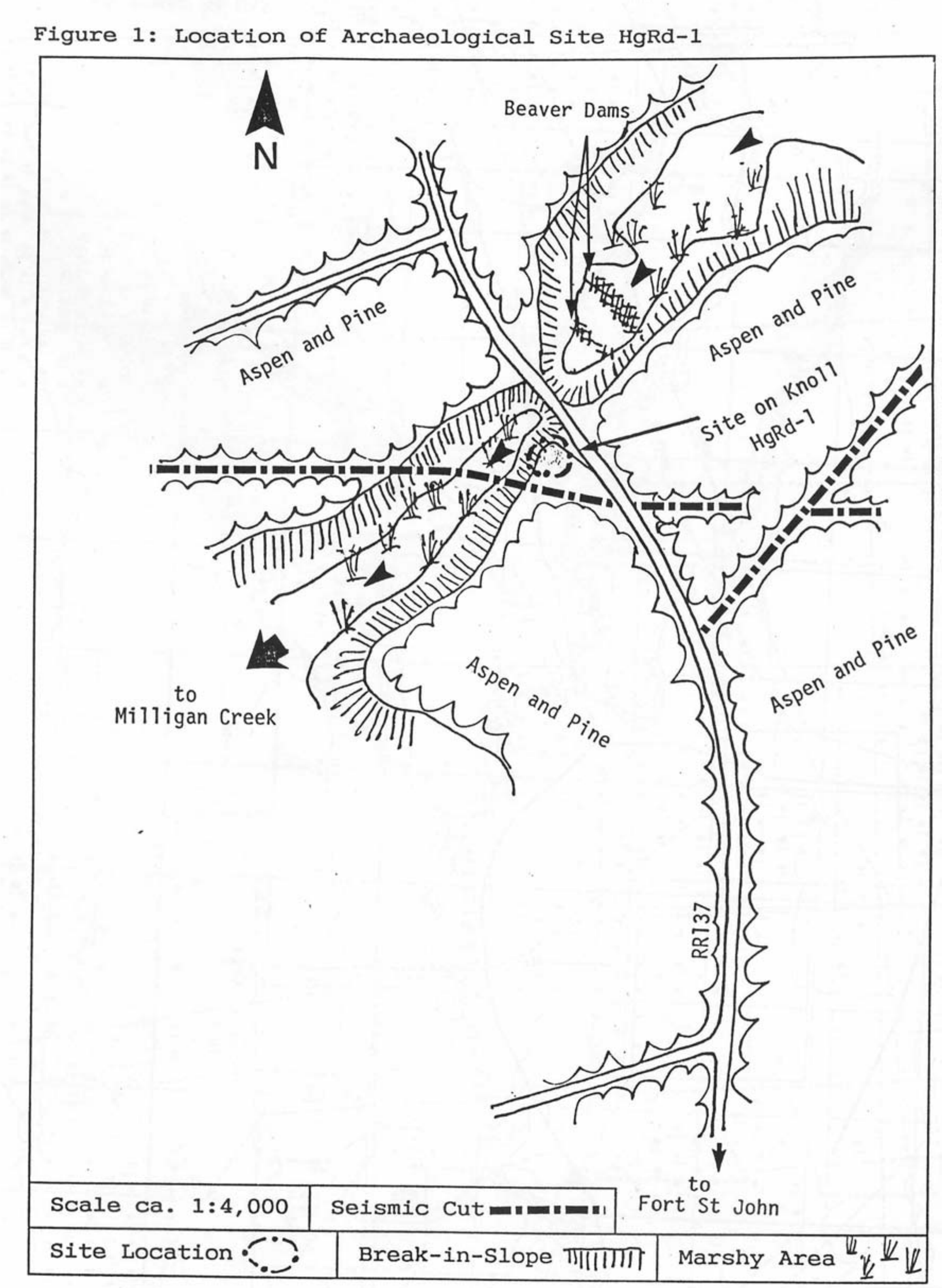


Figure 5. HgRd-001, Sketch Map.
The sketch map accompanying the site form was used to locate the site properly, with the aid of the Orthophoto and TRIM. The site location was moved about 40 m.

Changing Points to Polygons

Also, some sites need to be changed to polygons because although they were originally provided as points, site dimensions are larger than the 10 m cut-off. HhRr-003 is a good example, as it was both moved and changed to a polygon. Figure 6 displays the old and new locations of this site over the orthophoto.

Figure 6. HhRr-003, Previous and New Locations.
The red dot is where the site was originally mapped as a point. The yellow polygon indicates how the location and dimensions were modified to include the main polygon and the isolated artifact. Scale is approximately 1:7000; the distance between the sites is about 540 m.

This site was obviously in the wrong location. The sketch map (Figure 7) indicates that it is just north of the crossing point of two seismic lines, themselves north of another, east-west running seismic line. The difference in location between the two sites is more than half of a kilometre! As well, the site as displayed in the sketch map consists of a site area and an isolated artifact nearby. As the site area itself is about 50 m long (including the isolated artifact south of the seismic crossing), this site should be a polygon and not a point.

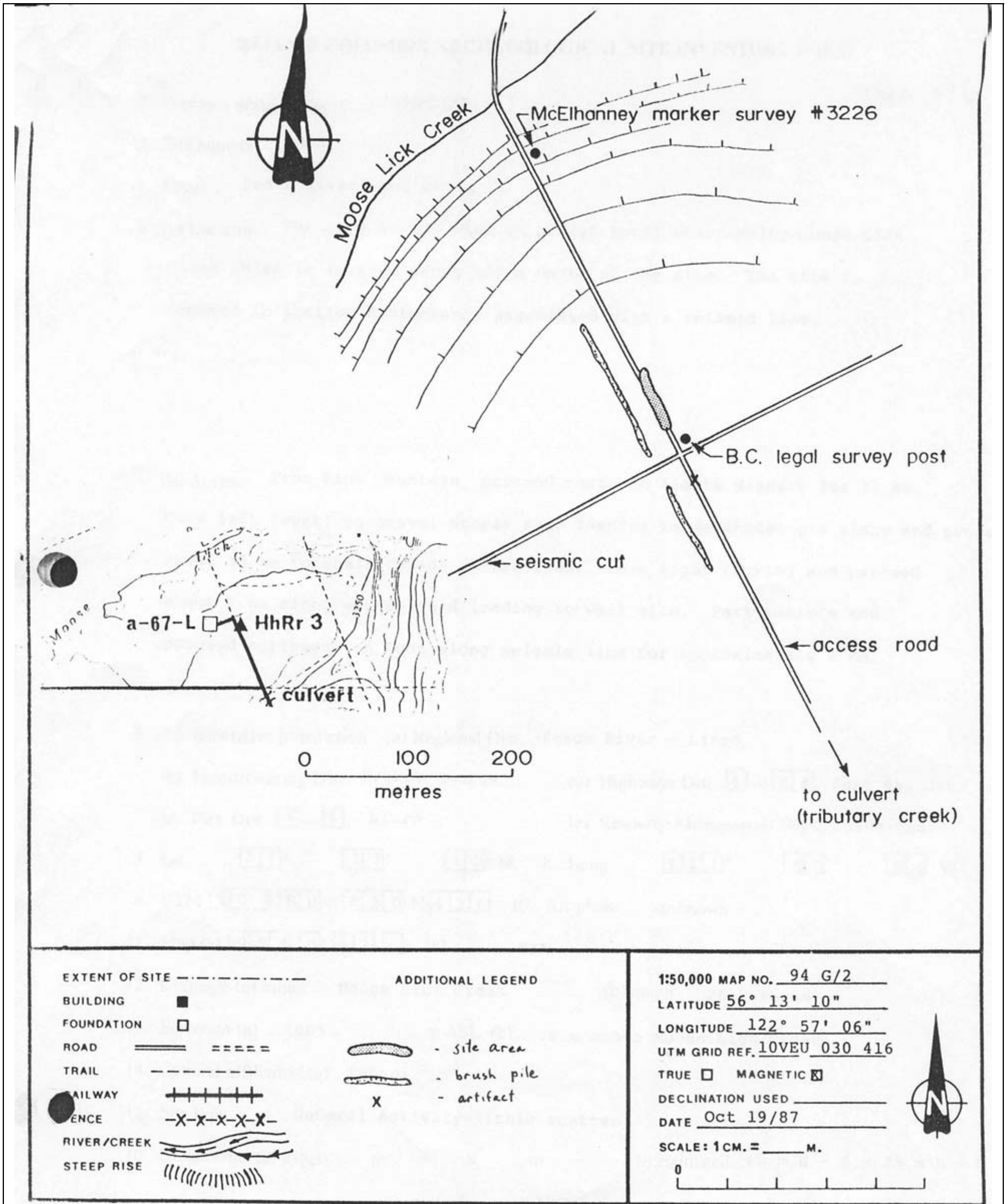


Figure 7. HhRr-003, Sketch Map.
The site sketch map shows clearly that the site is located at the crossing of the two seismic lines, with a region of the site to the north and an artifact to the south. The two seismic lines correspond to the pair used in Figure 6 to properly locate the site.

Noticing Site Boundary Problems

Sites that are represented as polygons instead of points are included in the model database as a series of points, placed around the boundary of the site. Checking the model for site points against slope led to an examination of several site points occurring on steep slopes. It was realised that if a site is mapped even slightly out of place, the points on the boundary aren't as appropriate to model for as points closer to the centre would be. Next year, we will attempt to create a model database that has SITE points within a site polygon, not only around the boundary. As an example, site HdRc-011, HdRc-012, and HdRc-013 are polygonal archaeological sites in very close proximity to each other. All three were captured in higher potential in the model database, except for two points of HdRc-012. It was determined that steep slope was the reason these two points were not considered high, and the three sites were displayed with the orthophoto underneath. Even though these sites had been orthocorrected and were very close to the correct spot, the east boundary of the HdRc-012 polygon crossed over the bank of a small gully even though it is likely that the site itself does not. These points would, when using the model database, make it appear that the amount of site points in a low potential category was higher than it actually is. Although the boundary of this site was corrected, other instances of a similar type of problem may also exist.

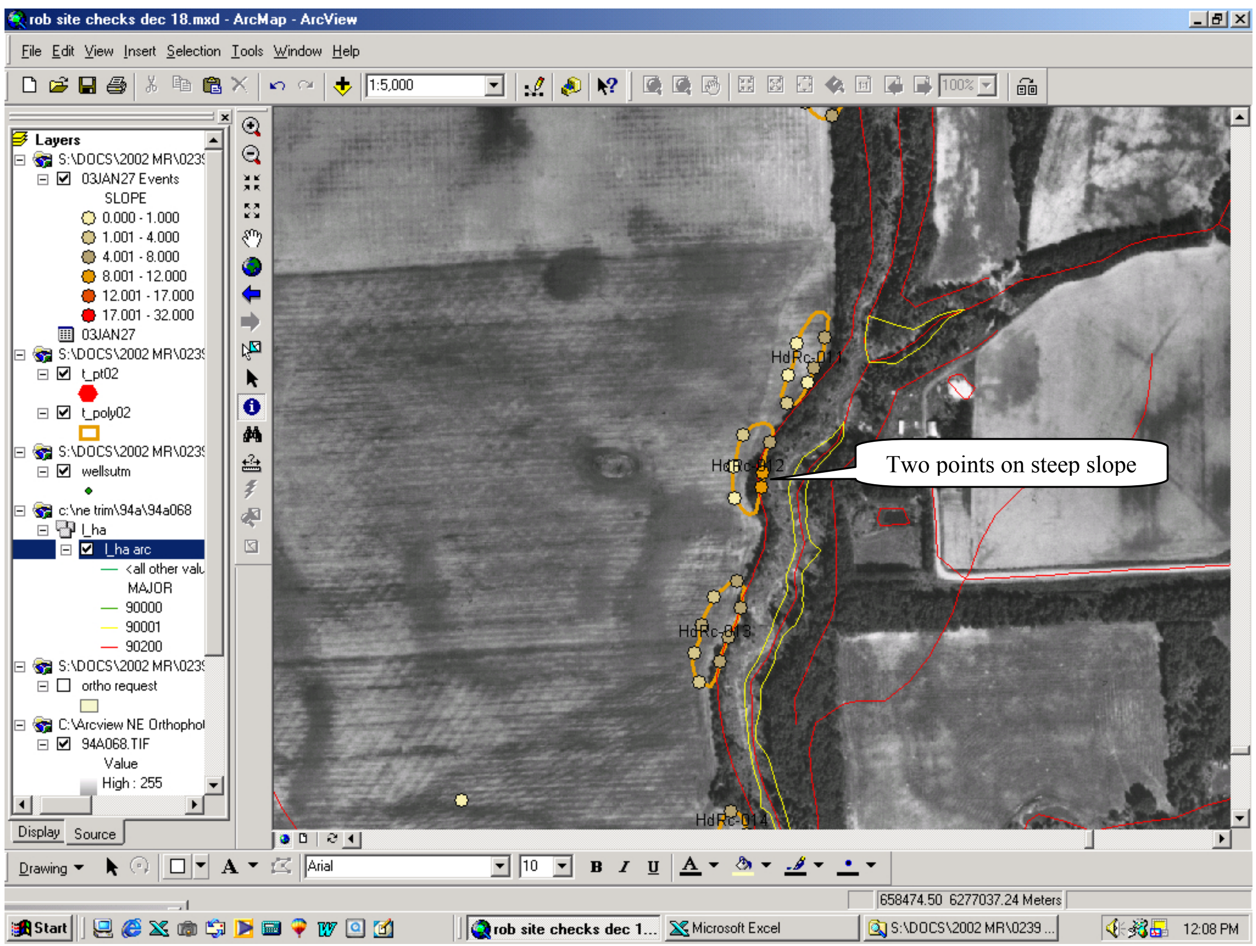


Figure 8. HdRc-011-013 Polygon Boundary and Slope Problem.
The orange coloured points along HdRc-012's boundary are incorrectly located on a steep slope.

Orthocorrections will continue into the next year as new site data will be available and the remaining 21% of the sites need to be checked. The updated site location information will be used in the model and will be provided to the Archaeology and Registry Services Branch to ensure that other archaeologists or land managers have access to it.

Identification of Topographic Features

As identified in the Year Two report, and by several authors referenced therein, the major contributor to archaeological potential in the northeast is terrain (Eldridge, et al. 2002). Identifying and modelling for terrain was identified as key to the success of this model from its inception. Much of the area is swamp and marsh, so an appropriate location to camp or extract resources in the northeast is often based on raised terrain. In very flat areas, any 'bump out of the muskeg' might contain an archaeological site. In areas with more variable terrain, it is terrace edges, rises, and high, aspen and pine-covered features that seem to have archaeological potential, based on previously recorded site locations and consultation with other contracting archaeologists. Millennia developed a novel technique for the selection of terrain based on relative elevation, as initiated in the Year Two report (Eldridge, et al. 2002). This terrain identification technique was the focus of this year's work on the northeast potential model.

As reported last year, digital elevation models (DEM), a digital representation of the earth's surface, offer hope of identifying areas of interest. Previous attempts to use DEM for the northeast had not been successful. The DEM for the northeast was built by Timberline from TRIM DEM spot elevation points and breaklines. The elevation model was interpolated by Timberline using a TIN or triangulated irregular network. Each point of the spot elevation was connected to its closest neighbours to form a triangle, which has a particular slope, elevation range, and aspect. In building the TIN, hard and soft breaklines were used, which are definite changes in the contour direction adding precision to the digital surface. For example, rivers, roads and railways could all be added as breaklines to make the surface model more precise. Cultural breaklines were not used in the modelling to try to avoid modelling for modern influences on the landscape.

A problem that was anticipated with using the northeast DEM was accuracy. As with any computer-created model, the accuracy of the northeast DEM would depend on the quality of the elevation data and the 'fit' of the algorithm used to both the data and the anticipated use of the model. Digital spot elevations and breaklines for the region came from TRIM. TRIM provides spot elevations or DEM points in an irregular grid about 50-100 m apart; with additional breaklines to increase the precision of the DEM. 'Spot' elevations were derived from stereo aerial photographs and TRIM standards state that "90% of all discreet spot elevations and DEM points shall be accurate to within 5 m of their true elevation" (Ministry of Environment Lands and Parks Geographic Data BC 1992). Elevations are given to the nearest metre, however, and relative elevation changes of one or two metres are commonly observed and appear to be accurate relative to each other. Millennia and Timberline were concerned that the fine resolution needed to identify small terrain features (for example, a knoll 3 meters above surrounding terrain) was not available in TRIM. Millennia archaeologists feel that although there are problems inherent in the data, it is acceptable for selecting out topographic features of even quite small dimensions and most identified features appear real. Field examination of selected mapsheets bore out this supposition (see below).

In the second year of the project, a DEM created from TRIM was used by Timberline to attempt to extract terraces, ridges, and other terrain features. These features were extracted using the ArcINFO VIP command. Please see the Year Two report for a critique and explanation of the VIP command (Eldridge, et al. 2002). The VIP algorithm attempts to identify major terrain features by examining the surface locally using a 'window.' For these purposes, a 'window' is a small program which in essence 'moves' across a digital surface. The VIP program assumes that each point has 8 'neighbours', which form 4 diametrically opposite pairs, i.e. up and down, right and left, upper left and lower right, and upper right and lower left. The software examines each of these pairs of neighbours for each point, connecting them with a straight line. It then computes the perpendicular distance of the central point from this line diagram from the other points. VIP then averages the four distances to obtain a measure of "significance" for the point and deletes DEM points in order of significance, eliminating the 'least significant' points first. One major problem was found to be that all 'high points' were considered significant no matter what their size. Unfortunately, the VIP algorithm was designed principally to be able to *reduce* the complexity of the terrain models. In the northeast, we were looking to use the full range of complexity and detail available in the data available.

As the DEM by itself or the VIP command was not extracting the detailed topography hoped for, the idea of a moving window, with the ability to access localized terrain differences, was exciting to Millennia archaeologists. Based on this concept, a new 'moving window' technique was conceived. The moving window technique used a grid of elevation data to identify both small and large terrain features. Timberline wrote an AML (Arc Marco Language) script to automate the moving window process, run in ArcINFO's GRID extension, so it could easily be applied to the entire study area in an efficient manner. The Year Two report discusses the moving window concept in detail (Eldridge, et al. 2002). The moving window technique returns a new grid for each variable calculated. The variables are based on the relative differences between the central cell and surrounding cells. The smallest possible analysis unit used was a 3x3 window, with a central cell and eight bordering cells. Because it is important to compare the elevation of the cell with cells two, three, and four neighbours away, 5x5, 7x7, and 9x9 windows were also calculated. As the window 'moves' from cell to cell, it assigns the desired value (see below) as the value of the cell in the new, output grid. That is, the number calculated by the software is stored as a non-spatial variable in a table associated with the spatial file. Two cell sizes were used: a 50 m cell and a 20 m cell. The elevation of these cells was interpolated from a lattice. Although the 20 m cell involved a higher level of interpolation, ground inspection of both 20 m and 50 m cells indicated that they were reasonable. Running the technique again with better data (more accurate and denser spot elevations) can probably identify smaller features, if better data becomes available.

Four variables were calculated. They were:

(1) **positive** (the sum of the differences in meters elevation between the central cell and all cells lower than the central cell);

(2) **negative** (the sum of the differences in meters elevation between the central cell and all cells higher than the central cell);

(3) **absolute** (the sum of absolute differences between the elevation of the central cell and all other cells in the window), and;

(4) **count** (a count of the number of cells lower than the central cell).

Although each variable was calculated into a separate grid, it became obvious after working with the output grids that the power of the moving window method is its ability to combine these variables and thereby very precisely control the type of feature identified.

In essence, as the window moves from cell to cell, it calculates the difference in elevation between each of the cell's nearest eight neighbours (cardinal directions and NW, NE, SW and SE). For the 'positive' grid, the moving window method added up all the differences in elevation that are positive (i.e., the central cell is higher). For example, a cell that was 1 m above each of the eight surrounding cells would have a positive value of +8. The same process is used to obtain the 'negative' variable, except that the negative elevation differences (total difference in meters of the cells that are above the central cell) are assigned as an attribute to the cell. For the 'count' variables, a count of the number of neighbours the cell is above is recorded.

The values assigned to the 'positive' and 'negative' cells vary drastically, especially in the 7x7 and 9x9 moving windows. The 9x9 moving window positive and negative values add the elevation differences for 80 of the cells' nearest neighbours. Therefore the 'positive' value can be in the thousands, although the count variable can only be a maximum of 80. A count of 80 would indicate that this cell was above every single cell for 450 m out north-south and east-west. A high count combined can be combined with the positive number to identify hilltops of varying sizes. The 'absolute' values added up the absolute difference in elevation between nearest neighbours as an indicator of topographic variability. This function was not found useful for modelling for archaeological sites.

The grids can be displayed in ArcView or ArcMap and queried using the Spatial Analyst extension. The results of map queries are also grids, and can be saved for later viewing and comparison. When viewed using GIS, the results of the queries were impressive. The basic query used the positive and negative values. The assumption is twofold:

1. sites occur in places slightly elevated above nearby ground (i.e. there is a high positive value);
2. sites tend not to occur in places where there is even higher elevation nearby (i.e. there is not a large negative value - it is not below surrounding terrain, midway down a slope, at the base of a ravine, etc). They also occur on the slope breaks above major coulees and river valleys, or near the edges of terraces – all of which tend not to have higher elevation.

Positive and negative grids were combined to answer to both of these assumptions. Figure 9 displays an early attempt at using the results of the moving window to indicate terrace edges. The blue cells are shown 'draped' over the TIN, which is stretched 2 times its height to emphasise slope. This early attempt demonstrates that selected (blue) grid cells aren't quite capturing the breaks in slope. Many are 'running down' the slope or down ridges.

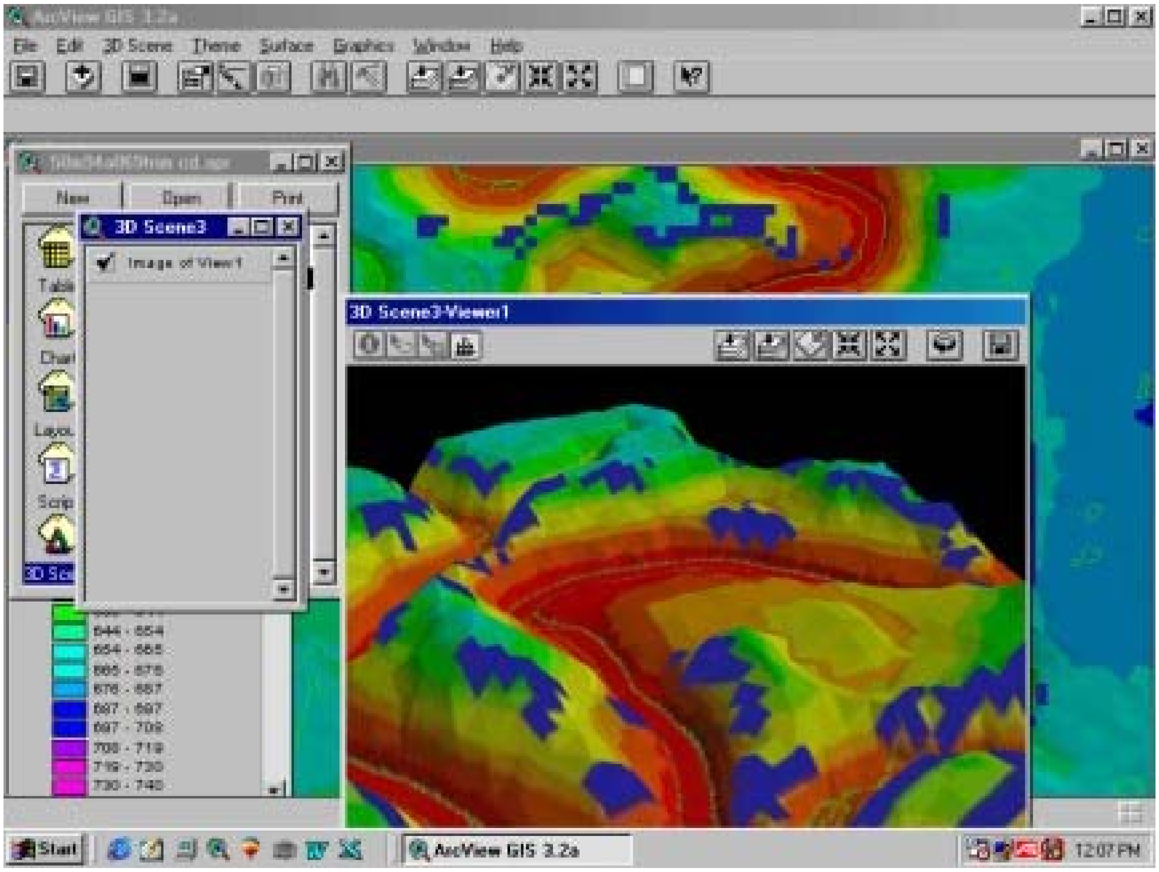


Figure 9. Developing the moving window in ArcView to use it to find breaks in slope (Beatton River).

Each refinement of the equation used to join the positive and negative grids moved towards the goal of selected cells being on top of areas where potential exists to find archaeological sites, and no selected cells occurring outside of these areas. Ridges, low rises, most scarps, and breaks-in-slope above approximately 4 m are caught by the moving window used in TRIM by manipulating the numbers chosen to select cells.

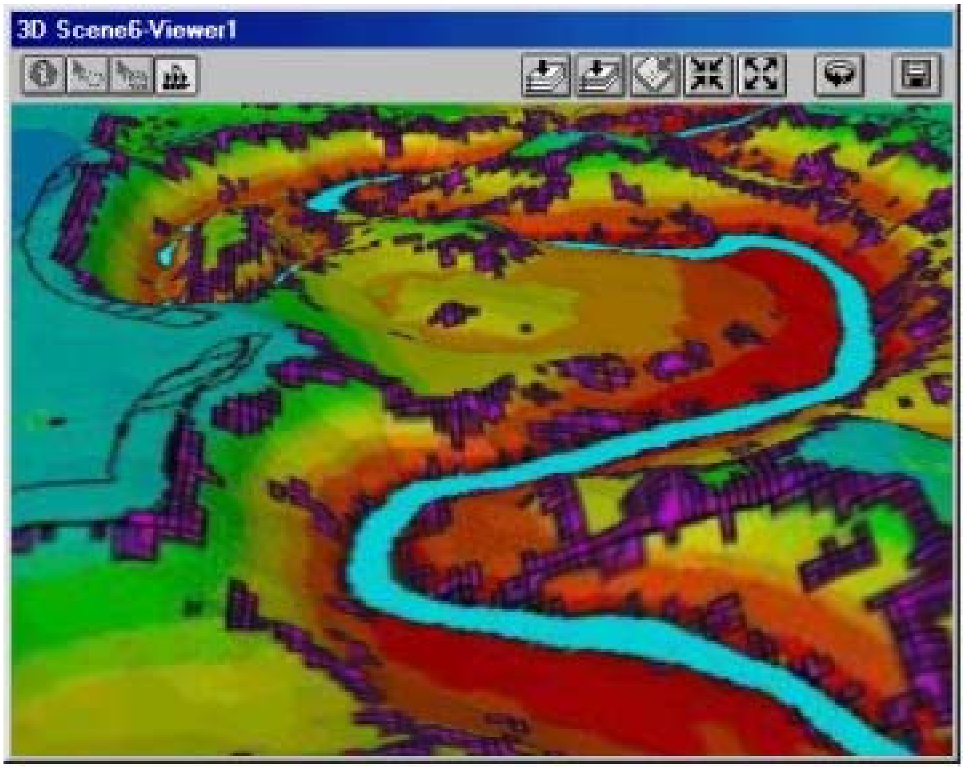


Figure 10. Using the 20 meter grid for analysis.

During analysis it was determined that hilltops were relatively easy to identify using the Count variable. A count of 8 indicated that the central cell was the highest location in a 3x3 window, while a count of 80 shows the central cell contains the highest point in a 9 x 9 window. This can be a substantial hilltop, considering that a 9 x 9 window on cells that are 50 m along each side is 450 m wide. To include lower hilltops and ridges, Counts such as >75 will work.. Using the Spatial Analyst extension, different grids (such as positive, negative, and slope) can be queried concurrently to produce a grid where complex specifications are met, such as:

Positive > 100, negative > -100, slope >10%

A broad variety of techniques were used to try and find the best method to select terrain that has archaeological potential. This included using a formula like the one above, using formulas that only used positive and negative, buffering around cells selected with stringent positive and negative cell selection equations, and 'clipping' out higher slopes on broader equations. The model for the Clear Hills eventually used positive and negative equations and buffering these locations. As each ecosection has different terrain, it is expected that not only will different numbers be important, but different types of equations will be important as well.

Once a combination of filters seemed appropriate, they were displayed in 3D using the 3D Analyst extension of ArcView. The basis for the 3D image was the TIN, with an orthorectified air photo 'draped' over it, that is, with the digital orthophoto displayed as though it were a 3D surface. The grids, when displayed on top of the 3D orthophoto, were easily judged to capture the regions known from our previous research as having higher potential. These were ridge features, terraces, and other breaks-in-slope. However, as the grids were created from the TINs, the 'fit' of the terrace edges and the display of the 3D image could easily become spurious, and many areas were selected for ground-truthing.

The technique worked beyond expectation. The following series of screen captures display how the 'selected cells' worked at picking out topography and even microtopography.

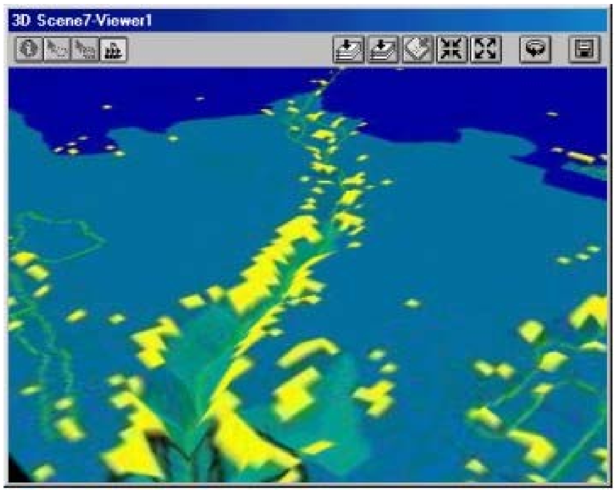


Figure 11. Microtopography with the 20 meter cell size.
This small stream valley (relief magnified 5 times) is in an area of subdued topography.

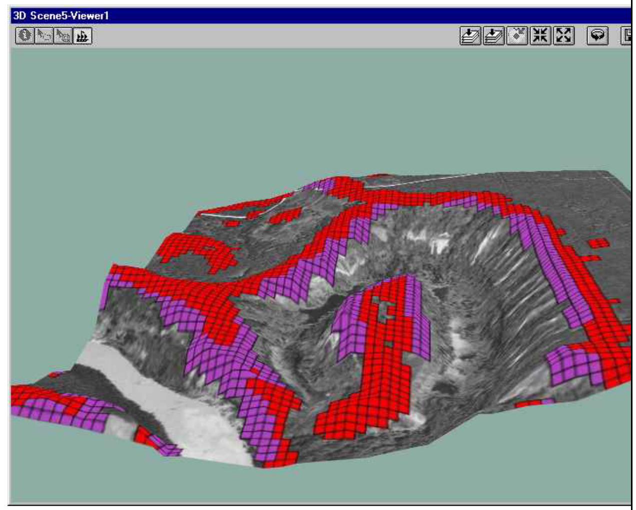


Figure 12. Terrace edges along medium river valleys.
This image displays two separate steps in the process: the purple cells represent an equation that was too liberal: the grid cells are falling down the slope. The red cells are a much better representation of terrace edges.

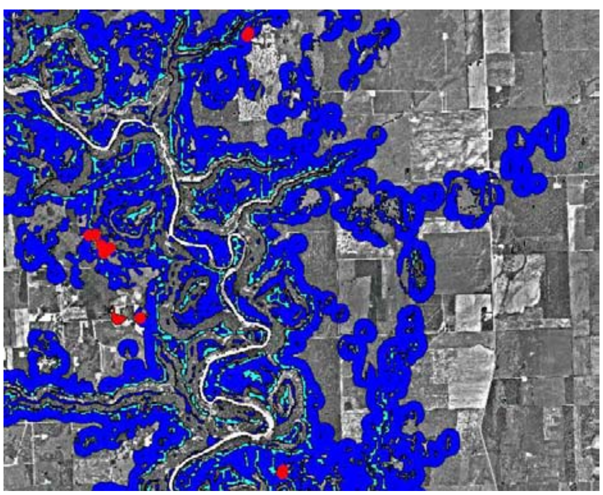


Figure 13. Buffering breaks-in-slope.
A 200 m buffer of breaks-in-slope identified by the moving window technique. Archaeological sites in red. 90% of the 33 sites on this mapsheet occur in the blue zone.

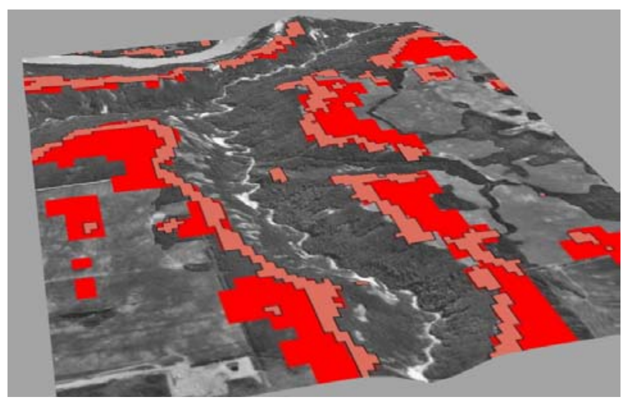


Figure 14. Using a 7 x 7 20 m grid and 9 x 9 50 m grid.
A 9x9 window on 50m grids gave the potential to reach several hundred meters back from the terrace edge slope breaks, where sites are often located.

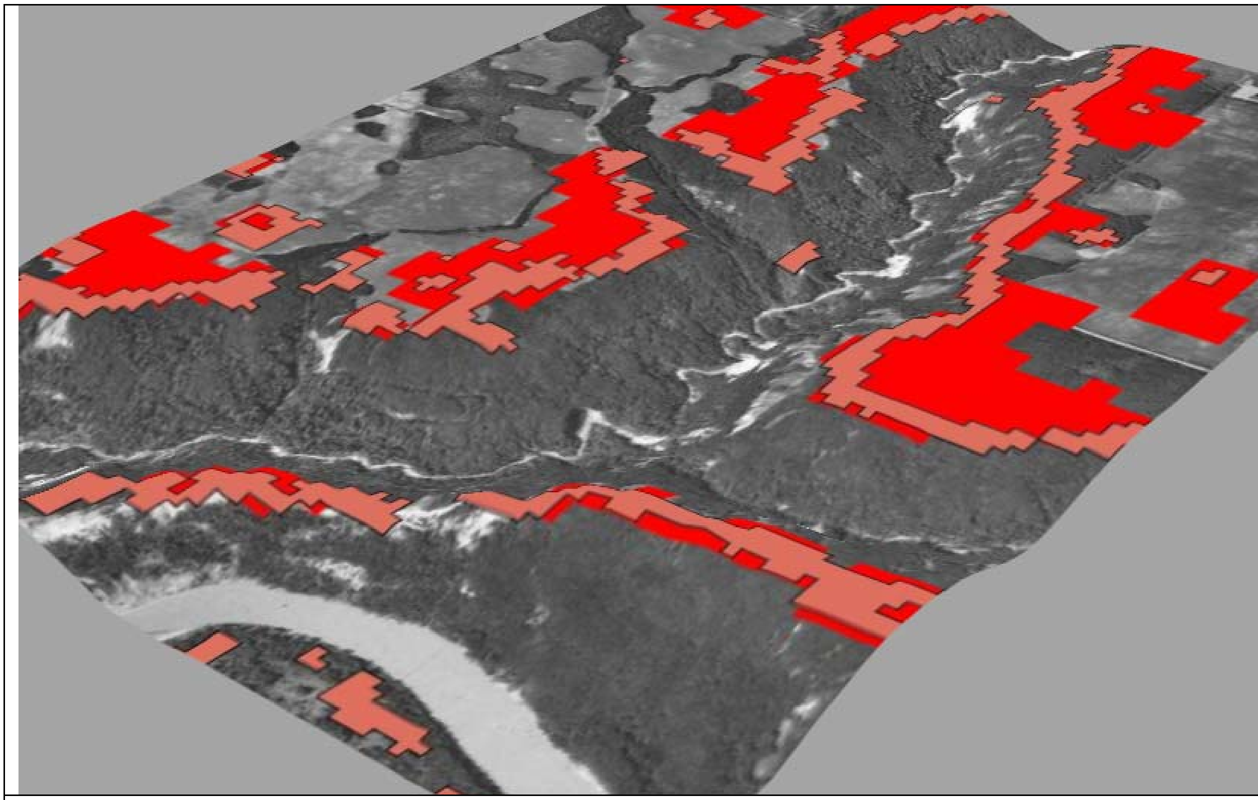


Figure 15. Small river, large landform.
This small river flowing from the upper right was mapped in TRIM as 'single line', although the terraces above this river are similar in proportion to those typical of double-line rivers. Note also low hills are captured. Little land except for remnant terraces is captured in the river valley itself.

Intensive ground-truthing of the preliminary terrain-identification algorithms found them to be generally very effective. A discussion of the field season and the results of the initial terrain modelling is provided in the AIS section.

Additional discussion of landforms that are identified through the modelling process and appear on the potential maps is provided in the section regarding map interpretation.

In early November, 2002, Millennia received the near-to and identity analysis of the selected cells from Timberline for the Clear Hills and Muskwa Plateau ecosections. The 'selected cells' were identified from the positive and negative values of the moving window technique, and indicated ground that was above surrounding land but not below surrounding land. Two main themes emerged in the analysis of the near-to and identity analyses: the topographic cell selection system (the terrain model) is effective at capturing sites (and further, sites co-vary with terrain). Also, the numbers used to create the selected cells that were ground-truthed were perhaps too discriminatory in selecting cells, rather than too broad.

The original selected cells perform well capturing archaeological sites without also capturing a large amount of non-site area. Therefore, although only 33% of the sites were captured in the selected cells, these cells only represent 9% of the ground surface, a Kvamme's gain statistic of 0.73, which is very good for a single variable. These numbers were calculated using the 2 km random grid points compared to the site points; archaeological sites may each have more than one point (if the boundary is a polygon). Table 2 displays the breakdown of the two types of selected cells.

Table 2 Selected Cells and Archaeological Sites

Cell Type:	#Sites	%Sites	# Grids	%Grids	Kvamme's Gain:
20 Meter Grid (Select1)	93	18%	115	4%	0.77
50 Meter Grid (Select2)	110	22%	186	6%	0.73
In either or both grids	165	33%	256	9%	0.73
Total within/out of selected cells	503	100%	2905	100%	

The numbers of site sample points selected is virtually identical to the number of actual sites selected, 62 sites of 196 total, or 31.6%.

As noted by field staff during the ground-truthing stage, often the selected cells did not encompass enough of any one land feature. In other words, the numbers used to select the cells were considered to be too limited in scope. The buffer analysis program bore this supposition out. Ideally it would be more meaningful to change the selected cell numbers rather than use a straight buffer as buffering would capture much of the terrain the program was attempting to miss such as steep slopes. However, as an exercise to determine how close the selected cells were to archaeological sites, a 10 m Buffer program was executed. These Buffer programs were run with a filter to remove grid and site points that fell directly *within* the selected cells (see Table 3 and Table 4). The buffer program indicates that a slight (10 to 20 m buffer) around existing cells would increase the site capture substantially.

Table 3 Selected Cells with 10 m buffer

Cell Type:	#Sites	%Sites	# Grids	%Grids	Kvamme's Gain:
20 Meter Grid (Select1)	236	47%	305	10%	0.79
50 Meter Grid (Select2)	200	40%	430	15%	0.63

Table 4 Selected Cells with 20 m buffer

Cell Type:	#Sites	%Sites	# Grids	%Grids	Kvamme's Gain:
20 Meter Grid (Select1)	284	56%	415	15%	0.73
50 Meter Grid (Select2)	253	50%	430	15%	0.7

However, increasing the site capture probably didn't need to increase the area in such a dramatic way. Instead, the positive and negative numbers were analysed and the appropriate combination of cells was used to create the model. The selected cells were also used in both the Clear Hills and the Muskwa Plateau models (see Model Building section below).

Archaeological Inventory Study (AIS) – Year Three

As identified in the Year Two Report (Eldridge, et al. 2002), and following the BC Archaeological Inventory Guidelines (BC Archaeology Branch 2000), the goal of Millennia Research's archaeological inventory assessment (AIS) is to "identify and record physical evidence of past human activities in a defined study area" by gathering representative data regarding "site distribution and density from varying physical environments". The Guidelines identify the following characteristics of a successful AIS:

- it must address a specific research or resource management objective;
- it must have a clearly defined scope;
- it must use an appropriate, thorough survey method; the methodology should be directly linked to the program objectives;
- it must be conducted as a field survey;
- it should provide accurate data results; and
- it should provide a summary of previous archaeological investigations.

An initial summary of previous archaeological investigations was presented in the Year 1 report. The Year Two report details the archaeological investigations undertaken by Millennia Research during the 2001 field season.

The following sections outline the results-to-date of the AIS in meeting the remainder of these general goals.

Scope and Objectives

The year three AIS had one main objective: to ground-truth the terrain model developed by Millennia Research Limited. This involved gathering macro- and micro-topographical data and recording field-assessed archaeological potential for these features. Also, the efficacy of a terrain model in the differing regions of the study area was evaluated. In the future stages of modelling, terrain models will continue to be refined using field gathered data.

This data was to be gathered through field survey in the general area of Ft. Nelson, Tetsa River, Pink Mountain, Fort St. John, and north of Fort St. John regions (see Figure 16).

Survey Sampling Design

Consideration was given to the following characteristics in selecting map sheets and survey areas:

- access and proximity to a settlement (as determined by looking at orthophotos and maps);
- the presence of highpoints, ridges and terrace edges identified by the terrain model and differing in size, location in relation to other topographic features, shape, and frequency from other mapsheets selected;
- within the Muskwa Plateau (MUP) and Clear Hills (CLH) environmental zones (ecosections) selected for study this year;
- presence of known sites.

With these considerations in mind, map sheets 94G.009, 94G.010, 94J.061, 94J082, 94O.022, and 94O.031 were selected within the MUP environmental zone, and map sheets 94A.067, 94A.076, 94H.028, and 94H.078 were selected within the CLH environmental zone (Figure 16).

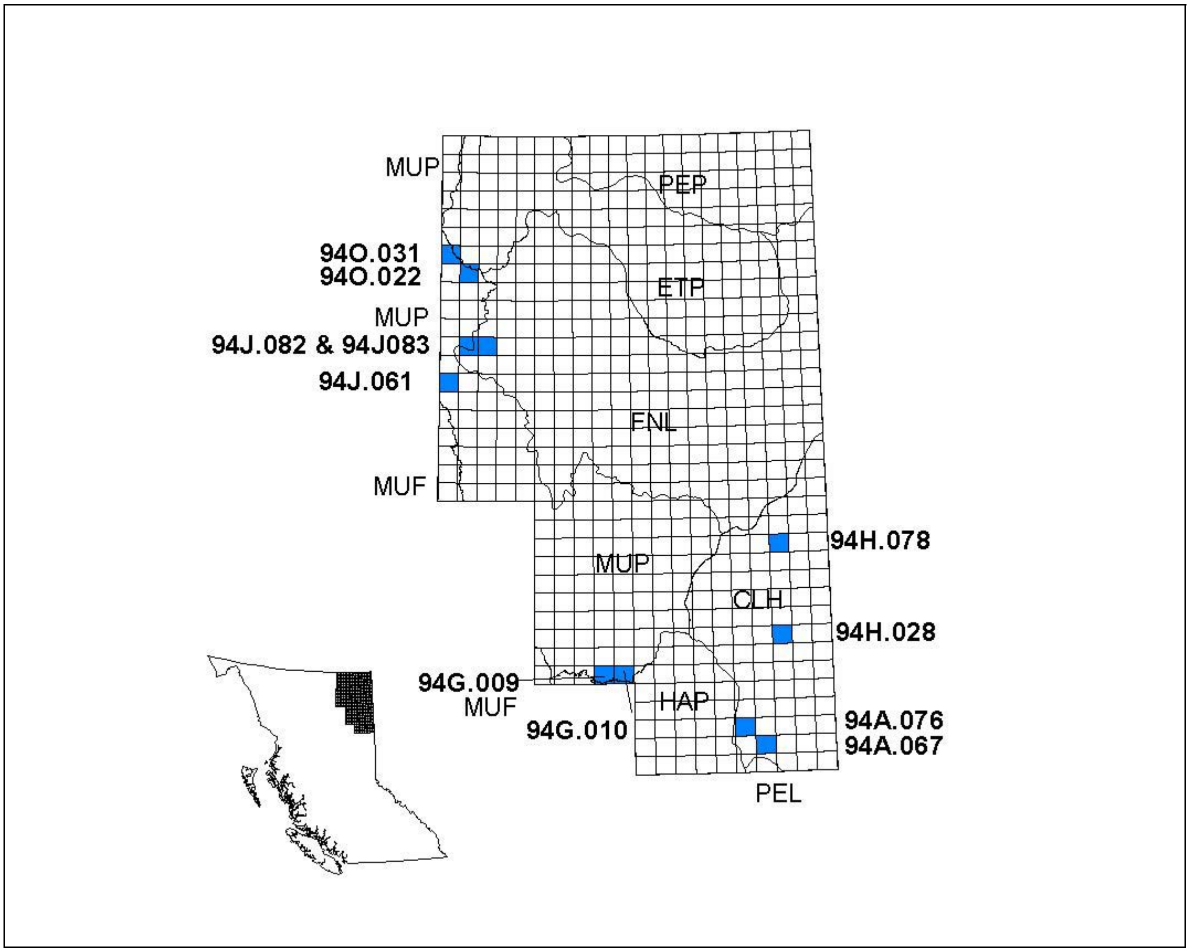


Figure 16. Mapsheets where AIS survey was conducted.

Terrain Model Testing

The terrain model (both 20 meter grid cell size and 50 meter grid cell size iterations) was plotted on the 1:20,000 maps used in the field. Once a general area of survey was selected, mapped highpoints, ridges, and terrace edge co-ordinates were located in the field via GPS. Terrain features encountered during survey which were not identified on the map were also recorded. Photos and notes were taken of these features.

The following information was recorded as survey points when terrain features (or lack thereof) were encountered:

Mapsheet	UTM	MapRate	Grnd Rate	Notes

where the MapRate was the terrain model potential rating from the map, and the Grnd Rate was the archaeological potential assigned to that location in the field based on all available data such as ground cover, forest cover, slope, visibility factors, water, etc.. Notes included reasons why the location was ascribed its potential rating, if testing occurred, if a site was found, ground cover, forest cover, slope, elevation, and approximate dimensions, as appropriate.

In addition to seeing if the model was picking up the landforms, it was also tested to see if it was accurately depicting their extent. This was achieved by crew members walking along the edges of the features and seeing if it correlated with the maps.

Survey Methods

Fieldwork was carried out September 17-19, 2002 and September 23 to October 6, 2003. Crew members included Kristi Benson, Morley Eldridge, and Rob Vincent from Millennia Research; Todd Christiansen, Julie Smith, and Keary Walde from Heritage North Consulting; Richard Apsassin from the Blueberry River First Nation; Richard Resener and Robert Needlay from the Fort Nelson First Nation; and, Edward Achla from the Halfway River First Nation. An assistant from the Doig River First Nation was not available. Work was carried out under Permit 2001-270, issued by the Archaeology Branch, Ministry of Sustainable Resource Management.

Survey consisted of a combination of controlled and judgemental survey to find areas of increased potential. For the controlled survey, the UTMs of terrain features, as determined from the maps, were entered as waypoints into GPS units which guided the crews to those areas. The judgemental survey was usually secondary to the waypoints, and occurred while accessing the pre-determined waypoints. Survey was conducted by foot, helicopter, all-terrain vehicle (ATV), or horse, and made use of existing roads, seismic lines, and paths. Generally crews consisted of one archaeologist from Millennia, one archaeologist from Heritage North Consulting, and one First Nation assistant. When two crews were working simultaneously, one crew would use ATVs and one crew would conduct pedestrian survey. The selection of survey waypoints depended on the type of access. It should be stressed that management decisions on the basis of prior survey should not be made on the basis of the survey conducted during this project. In many cases, areas of potential were identified, but not shovel tested, and can not be considered to have been adequately surveyed.

Several features each day were selected for sub-surface testing due to their high potential for archaeological sites as indicated by the archaeologists from Heritage North Consulting. These features, such as knolls, hilltops, terrace edges, and ridges were tested intensively, up to 45 tests per feature. Shovel tests were approximately 35 x 35 cm in size and were excavated to sterile deposits, usually associated with the ‘C’ horizon. Matrices were trowel sorted or screened using a ¼ inch mesh. Terrain features exhibiting good surface exposures were examined for evidence of archaeological sites, including but not limited to structural remains, lithic scatters, rock art sites, burials, and historical refuse.

In forested areas containing pine or aspen, the trees were inspected for cultural modification.

When a site was found, its location was established using a GPS unit, and its boundaries delineated through a series of shovel tests. Photos were taken and maps drawn as required. Artifacts were recorded and then reburied at the site except when the specimens needed further analysis to determine if they were cultural or not, or in one case when it was indicated by Heritage North that the projectile point base should be collected for a reference collection.

Results

Seven new sites were recorded as a result of fieldwork, and 300 survey points, to be used in the analysis of the terrain model, were collected.

Newly Recorded Sites

HeRf-007

A single artifact was collected from this site, consisting of the base of a side notched projectile point, made from a black chert. The point was found on the surface of a cultivated field on top of a hummocky knoll. It is thought to belong to the Middle Plains Archaic period, which dates from 3000 – 5000 BP (before present). No subsurface testing occurred a this site.

Figure 17. Knoll where HeRf-007 was located.

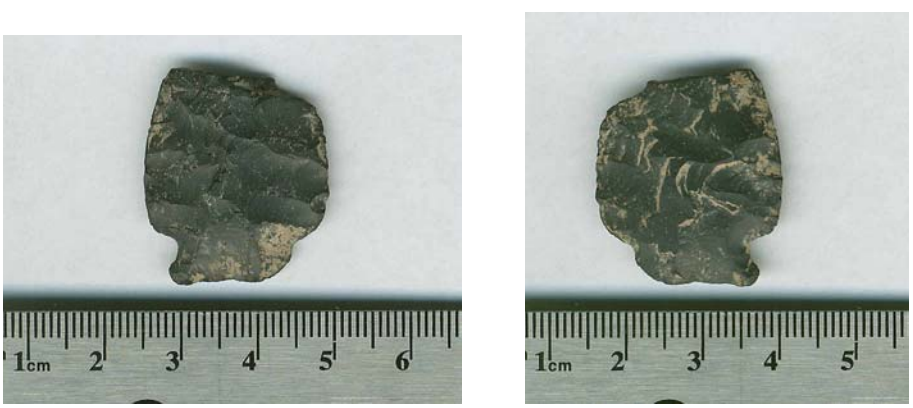


Figure 18. Projectile point base collected from HeRf-007.

HeRf-008

This site consists of an isolated chert flake, found on the surface off the side of a road on the side-bank of a hill (Figure 18 and Figure 19). The area has been significantly disturbed, most likely related to road construction, and machine tracks were visible on top of the hill. No sub-surface testing was conducted at this site.

Figure 19. Area of Site HeRf-008.

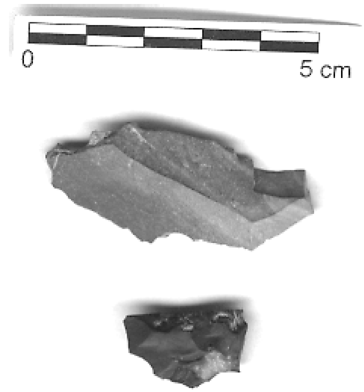
Figure 20. Flake recovered from Site HeRf-008.

HgRm-006

This site is situated at the south-east (SE) end of a ridge running NW/SE, overlooking an oxbow to the east. Swamp and muskeg is found both to the north and west. Two chert flakes, one cobble tool, and FCR were found at the site, at depths of 7-10cm DBS. All artifacts were re-buried at the site.

IeRx-002

This site is located on a small terrace along a stepped ridge feature between Gardner Creek and an unnamed tributary (Figure 21). Two chert flakes were recovered, one in a shovel test, the other on the surface (Figure 22). Both were collected.

	
Figure 21. Area of IeRx-002.	**Figure 22. Flakes recovered at IeRx-002.**

Site M1

This site consists of two chert flakes: one late-reduction stage flake and one piece of shatter. The site is situated near the slope break of a low ridge feature in an agricultural field that is probably the result of peri-glacial land formation, and possibly a shoreline scarp of Glacial Lake Peace. This site has not yet been assigned a permanent Borden number.

Site M2

This site is situated on top of a knoll feature, beside a major slope break above the Beatton River. Both flakes were found on an oil/gas related disturbance, and were not collected. Two chert flakes were observed: one late-reduction stage flake and one pressure flake. This site has not yet been assigned a permanent number.

Site CMT1

This site is located on a small terrace, overlooking a drainage to the southeast. A single lodgepole pine CMT was recorded here, which is thought to post-date 1846 due to the tree size and healing lobe size (Figure 23). This site has not yet been assigned a permanent number.

Figure 23. CMT recorded at Site CMT1.

Survey Points

Over the course of field work, 300 survey points were collected to assess the efficacy of the terrain model. Four types of data were sought:

1. locations where the map indicated a terrain feature and it existed on the ground (YY);
2. locations where the map indicated a terrain feature and it did not exist on the ground (YN);
3. locations where the map indicated no terrain features and this was the case on the ground (NN); and,
4. locations where the map indicated no terrain features when in fact there was a terrain feature on the ground (NY).

It soon became apparent that the terrain model was doing an excellent job of capturing the terrace edge and ridge features situated along major creeks and rivers, so subtle topographic features were targeted for survey.

Table 1 below summarizes the survey points for each ecosection, and a representative sample of the different types of points are presented in Figure 24. Ten of the points fell outside the study area, for which there was no terrain model data, and have not been included in the analysis.

Table 5. Summary of Data Points by Ecosection.

	Clearhills Ecosection (CLH)		Muskwa Plateau Ecosection (MUP)		Total	
	# of Points	%	# of Points	%	# of Points	%
YY	60	40	65	46	125	43
NN	14	10	18	13	32	11
YN	11	7	17	12	28	10
NY	65	43	40	29	105	36
Total	150	100	140	100	290	100

For those data points which equalled 'YY' or 'NN', the model is working – it is accurately predicting the presence (YY) or absence (NN) of terrain features. Where the points equal 'YN' or 'NY', the model is not working (or GPS errors are sufficient to cause an apparent miss). In the case of 'YN', the model may be over-representing significant terrain features by predicting features which aren't there. For those points which equal "NY", the opposite is true – the model may be missing significant land features which in fact exist. Of greatest concern is the latter case, where terrain features with the potential for archaeological sites may not be captured.

The terrain model performed better than expected at picking up the smaller, microtopographic features given that survey focused primarily in areas of low topographic relief, away from the large terrain features, such as river terraces and long ridges. This is encouraging for extrapolating the modelling to the Fort Nelson Lowlands ecosection, where there is very limited topographic relief. However, there did not appear to be any clear pattern as to what was getting captured and what was not. Terrain models were also substantially improved between the time of fieldwork and the model production.

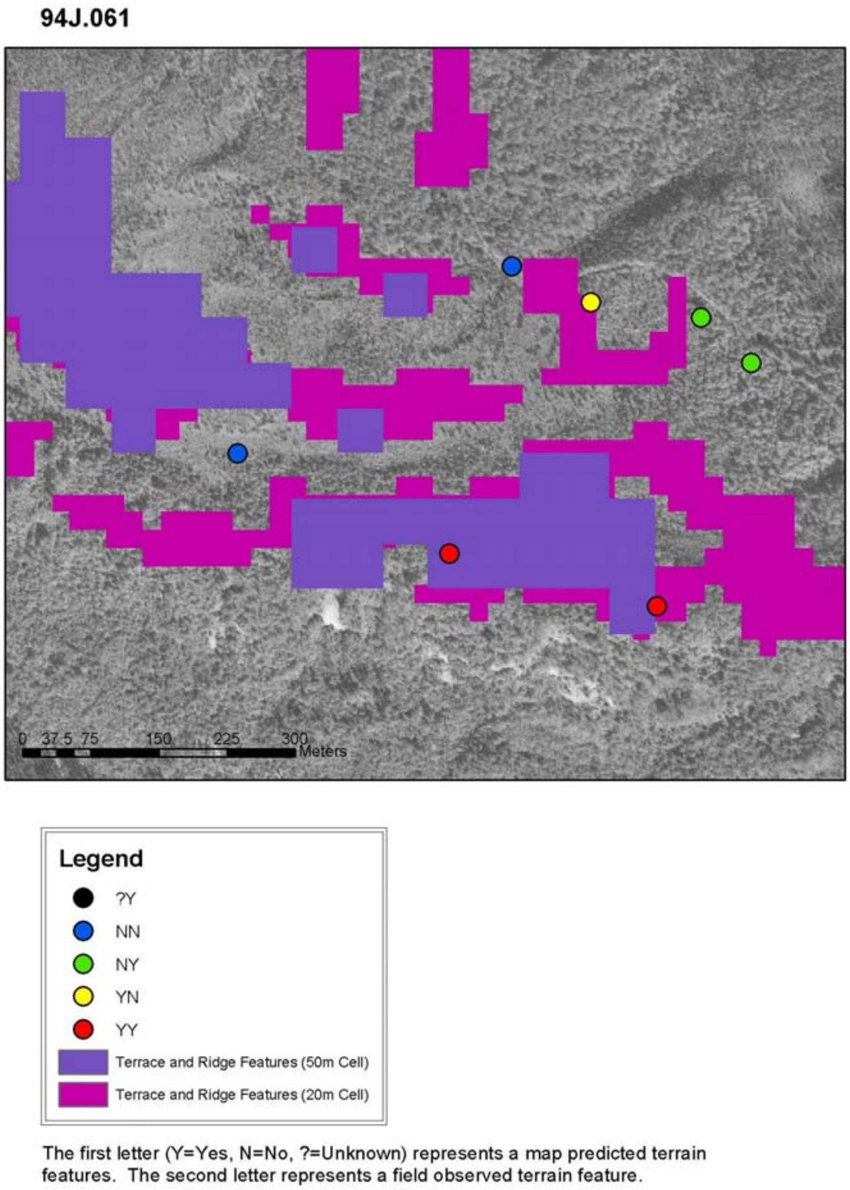


Figure 24. Representative Sample of Data Points.

In the field it was observed that the 20 m and 50 m grid caught different features. The 50 m analysis tends to catch the major features, while the 20 m catches small features, and the edges of terraces or ridges right at the slope break. This is shown in Figure 25 and in Figure 26.

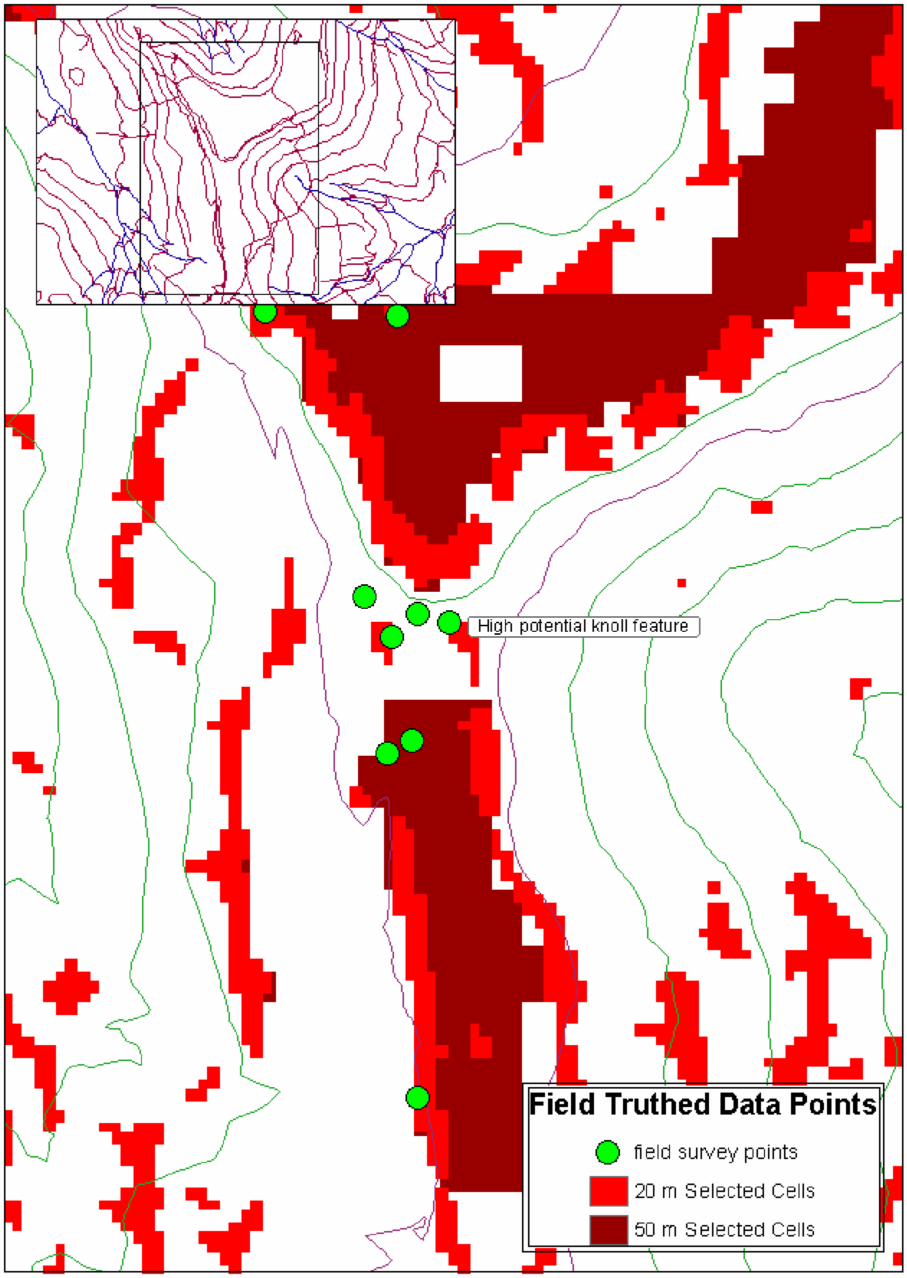


Figure 25. Map showing high elevation ridge feature identified by 50 and 20 m cells, with two small knolls in the saddle (see Figure 26).
Inset map 1:50,000 scale, part of 94G009. Survey points are all colour coded the same.

Figure 26. Microtopographic feature caught by 20 m cell analysis.

This small knoll is located on the saddle of a ridge, and was assessed on the ground as having moderate to high potential. The surrounding area had low potential.

Looking at the CLH ecosection, for which we can compare the terrain model with the archaeological potential model, of the 65 points which were missed by the terrain model (NY), all but eleven were captured by the potential model. Further, all eleven of these points were less than 20 m from a moderate or higher potential zone in the original terrain model. This distance is considered insignificant as this is less the resolution at which the model is produced, and may also be a result of inaccuracies inherent with handheld GPS units. Finally, the terrain features are so close that they would (hopefully) be noticed by crews surveying in the adjacent areas picked up by the potential model.

Newly Recorded Sites vs. Potential Model and Terrain Model

Site #	Terrain Model	Archaeological Potential Rating	Comments
HeRf-007	YY	M	~9m away from MH rating
HeRf-008	YY	MH	
HgRm-006	NY	n/a	Arch. model not available
IeRx-002	YY	n/a	Arch. model not available
Site M1	YY	MH	
Site M2	YY	L	~3.5m from MH rating
Site CMT1	YY	n/a	Arch. model not available

Six of the seven sites recorded were on topographic features picked up by the terrain model, evidence of the association between sites and such features. Four sites were recorded within the CLH ecosection, two of which were captured by the potential model, while the remaining two are situated within 9 m of a moderate or higher potential area, an example of which is shown in Figure 27. That the two points were not captured by the model is not of great concern for the same reasons described above.

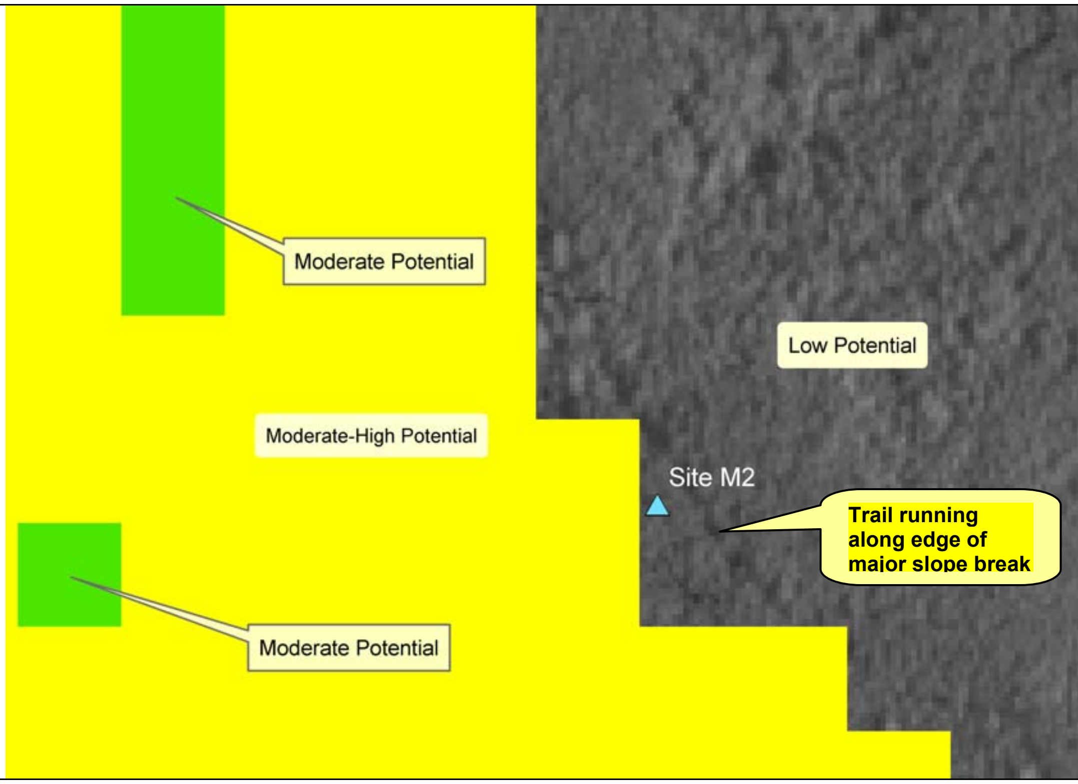


Figure 27. Site M2 in relation to Potential Model, showing an insignificant error.

Evaluation of Field Assessed Potential vs. Model Assessed Potential

During fieldwork, a potential assessment was assigned to each survey point based on field observations. Once the archaeological potential model had been developed for the CLH ecosection, we were able to compare the field assessed potential against it. The two assessments were in agreement approximately 72% of the time (109 out of 151 survey points), with some leeway given to the field assessed potential due to its subjective nature (if it was within one potential rating of the model's assessment, the two were considered to be in agreement, except where the model assessed an area as low and the field assessment was moderate or higher).

Of particular concern were areas which were assessed as low by the potential model but were assessed as moderate or higher in the field – as was the case for 12 of the 151 points or 8%. However, all of the points were within 16 m of areas assessed as moderate or higher, and these results should not be of concern for the same reasons described above. In fact, most of the errors can be attributed to data points GPS errors greater than the mapping resolution of the model.

Conclusions

Fieldwork was successful in achieving its main objective, which was to ground-truth the terrain model developed by Millennia Research. Seven new sites were also recorded in the process. Further, the information gathered while ground-truthing the terrain model was also helpful in assessing the archaeological potential model for the CLH ecosection, which was developed subsequent to the fieldwork.

The terrain model accurately captured virtually all of the terraces along major rivers and creeks, and most of the terraces along their tributaries. In addition, many of the hilltops, knolls, and ridges were also captured. Areas where it was found to be working less effectively, though still better than expected, included hummocky land, swamp edges, and areas with largely undifferentiated terrain.

There were many instances where the terrain model failed to identify topographic features which were identified in the field. Fortunately, these features are virtually all caught by the potential model, of which updated terrain models are modified by many variables. This is discussed in the section on model development.

Model Building

Model Building in Year Three focussed on terrain modelling and creating models for each ecosection. Last year the decision was made to separate the study area into ecosections to better model for different ecological diversity. A new model was created for each ecosection. A terrain model was created, run, tested, and incorporated into several of the models. These models, without exception, perform better than the model created last year (Eldridge, et al. 2002). In the two ecosections where terrain variables were available, the difference is startling.

The basis of the modelling process, both for the current year and for all previous models, is the near-to and identity analyses completed by Timberline and the buffer program. The near-to and identity analyses were analysed using the Buffer Program (described below) to determine if each variable and some combinations of variables indicated potential. The Buffer program statistically assesses the difference in distribution between sites and non-sites, and can be used to assess the difference between random points and surveys. The model database has three types of points: SITE, GRID, and SURV points. SURV points indicate the location of survey where no site has been found and these were used extensively in testing datagaps in Year Two. SITE points indicate archaeological sites: one point for each archaeological site that is represented as a point spatially (such as an isolated lithic find) and several points for polygonal sites. These points were extracted from the polygon boundary. GRID points are random and represent the landscape. In most ecosections GRID points are placed on a systematic grid every 2 km.

For modelling purposes, the Chi-square statistic is used to determine the difference between the Observed number of site points is different than the Expected number of site points. Expected values are derived from a ratio of the points within and outside of the buffers. For instance, if 1/10th of the grid points were within 200 m of trails, a random distribution of sites would allow that about 1/10th of the site points also be found within 200 m of trails. Often, this is not the case, as archaeological sites pattern around certain variables and thus are <u>not</u> random. The Chi-square statistic (which in the Buffer Program assumes two degrees of freedom and a critical value of 2.71) assesses the difference between expected and observed and indicates the likelihood or probability that the difference could be expected by chance. The chi-square is calculated as:

$$\text{Chi-square} = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

This formula totals the expected numbers inside each specific buffer distance with those outside this buffer. To determine the optimal buffer size, which is in turn used to determine the parameters used to build the model, the chi-square statistic was calculated for set intervals from the feature. Hence the name, 'Buffer Program.'

For example, if a 50 m interval is chosen (the program asks for this information each time it is run), starting at 0 m, then the number of sites between 0 and 50 m was added up and compared to the number of random grid points between 0 m and 50 m. Secondly, the number of sites NOT in this interval was compared to the number of grid points not in the interval. These calculations are carried out for each buffer as requested by the user. Often, an area up to 2000 m divided up into buffers of 100 m was executed. If the numbers indicated that a finer or broader pattern is visible, then the buffer program was executed again on the same variable with smaller or larger iterations. After all intervals have been calculated, a new chi-square is calculated for the overall interval from 0 m to the last significant interval, although interpretation of the graph is considered to be just as important. In some cases the appropriate buffer began at some point away from the variable (like ephemeral creeks, where the first 50 m is low potential but from 100 to 200 its high). The Chi-square statistic determines how likely the observed values would happen by chance, the higher the Chi-square value, the less likely the distribution is random.

Appendix 1 has all the variable printouts used in creating the model. Due to the large size of this appendix, it has not been printed but is provided on the accompanying CD. The variable printouts are the output of the buffering programs used to identify the parameters of each variable useful for modelling purposes. A copy if the Year Two report is also provided on the CD, please refer to this report (page 60-67) for further explanations on the buffer program and the modelling process. An example of the output is described below. Each variable is described in Table 1.

This line identifies the variable: in this case, it is trails.

```
      Variable:  A.TRAILS
```

These lines indicate the average values of the variable in the database. If the iterations and grids values are identical, then the Chi square analysis was restricted to only the points within the buffers being analyzed. If they are different, then the Chi square analysis took into account the rest of the values in the ecosection, i.e. outside of the buffers being analyzed.

```
      Average for grids up to end of iterations:
           A.trails
          974.09470
      Average for sites up to end of iterations:
           A.trails
          596.31457
      Average for grids up to end of sample:
           A.trails
          974.09470
      Average for sites up to end of sample:
           A.trails
          596.31457
```

This line identifies if the number of site points is smaller than the number of grid points.

```
      Is A.trails(site) < A.trails(grids) - using sample: YES
```

This line provides the number of grid points and site points within the buffer being analyzed.

```
      grids and sites <   2000
      grids:            1829
      sites:            1131

* indicates that expected value is low
D.F.  = 1
```

These lines indicate the relative number of grid points and site points in each buffer and compute the likelihood that these numbers occur by chance.

```
      Buffer  200 (o-e):  262.72 |   222 grids |   400 sites |  chi^2=  572.25
```

```
Buffer  400 (o-e):   37.56 |   198 grids |   160 sites |  chi^2=   12.92
Buffer  600 (o-e):  -20.45 |   177 grids |    89 sites |  chi^2=    4.23
Buffer  800 (o-e):  -44.31 |   180 grids |    67 sites |  chi^2=   19.56
Buffer 1000 (o-e):  -15.85 |   155 grids |    80 sites |  chi^2=    2.86
Buffer 1200 (o-e):   28.93 |   178 grids |   139 sites |  chi^2=    8.42
Buffer 1400 (o-e):   -4.69 |   179 grids |   106 sites |  chi^2=    0.22
Buffer 1600 (o-e):  -60.78 |   184 grids |    53 sites |  chi^2=   36.10
Buffer 1800 (o-e):  -92.02 |   186 grids |    23 sites |  chi^2=   81.95
Buffer 2000 (o-e):  -91.12 |   170 grids |    14 sites |  chi^2=   87.08
```

A critical value of 2.71 with 2 degrees of freedom was used to determine the appropriate buffer in the following statement:

```
There are significantly more site points than grid points within  400 meters of
A.trails

Buff %  400 (o-e):  300.28 |  23.0%grids |  49.5%sites |  chi^2=  450.68
```

The histograms represent the relative number of grid points (top histogram) and sites (bottom histogram) within each buffer. The Y axis is the distance from the variable, the X axis is the relative number of grid or site points.

```
A.TRAILS Histograms !

     GRID

  200| ************
  400| **********
  600| *********
  800| *********
 1000| ********
 1200| *********
 1400| *********
 1600| **********
 1800| **********
 2000| *********

     SITE

  200| ***********************************
  400| **************
  600| *******
  800| *****
 1000| *******
 1200| ************
 1400| *********
 1600| ****
 1800| **
 2000| *
```

The histograms for trails show that it is a variable very strongly associated with archaeology sites. The grid points show an even distribution across each buffer category (a pattern normal for linear features across a landscape) (Bonner, et al. 2001). In contrast, the site points show that a large portion of the sites are occurring within the first 200 or 400 m close to trails. A Chi-square value of 572.25 is very significant; although the buffer program indicates that a pattern exists that is significant up to 400 m. At 600 m, the observed-expected (written as (o-e) in the printout) becomes negative, so the pattern indicates that the correlation is a negative one.

Division into ecosections

A recommendation was made in the Year Two report that the study area be divided into ecosections to model for each regions separately (Eldridge, et al. 2002). This seemed appropriate to address some of the landscape differences in this large region. For example, the two models that were the focus of this year's terrain modelling, the Muskwa Plateau and the Clear Hills, are very different topographically. The Clear Hills "is a smooth rolling upland that gradually rises in elevation towards the north and east. Numerous wetlands occur throughout" and the Muskwa Plateau is a "dissected upland area that rises above the Fort Nelson Lowland to the east" and is strongly influenced climactically and topographically by the northern Rocky Mountains to the west (Ministry of Sustainable Resource Management 2003). The Year Two Report discusses some of the problems with the broad generalisations required to make a single model for the entire area. Although a greater time commitment is required for the creation of a series of ecosections-based models, this time increased the predictability of each model substantially. It also allowed a much more 'regional' approach, one that relied on local topography, ethnography, and site location patterning.

A separate model was created for each ecosection. Table 6 has the results of the Year Two model in the left-hand column and the Year Three model in the right-hand column. The results in each column are the output of the model program written by Millennia Research. One addition to the output is that the two models created after the introduction of terrain variables have a line for general moderate to high, combining the percentages for moderate, moderate-high, and high. This printout allows for model evaluation. The performance of the models in Table 6 are summarized in four columns: one for sites, one for grid, one for survey and one for Kvamme's Gain statistic. Kvamme's Gain is a simple statistical tool that evaluates a model's performance. It is calculated with the formula (Brandt, et al. 1992):

$$\text{Kvamme's Gain} = 1 - \left(\frac{\%\ \text{Area}}{\%\ \text{Sites}}\right)$$

The values for sites, grid, and survey are given as a percentage. The total number of points involved is given as 'Sample n=.' The Kvamme's gain for L (Low) should be a negative number and the larger the negative, the better the model's performance at identifying low potential areas. For example, the Clear Hills model has a Kvamme's gain of –6.16 for low, which means that few sites and a large amount of area is captured as low. This is reasonable considering the region's large tracts of inundated black spruce muskeg. A near-perfect model would have a Kvamme's Gain score of 1 for the H (High) category. This would indicate that the % area would be very small, and the % of sites would be high. Positive scores will always be a decimal.

Table 6. Modelling by Ecosection, Year Two and Year Three.

Year Two Results	sites	grid	surv	Kv Gain	Year Three Results	sites	grid	surv	Kv Gain
Clear Hills:									
expect = L:	27.2	48.4	38.6	-0.78	expect = L:	9.5	68.1	40.1	-6.16
expect = M:	27.2	27.9	29.3	-0.02	expect = M:	19.7	15.5	19.2	0.21
expect =MH:	24.5	16.0	17.8	0.35	expect =MH:	36.7	13.2	23.2	0.64
expect = H:	21.1	7.7	14.3	0.63	expect = H:	34.1	3.2	17.5	0.91
Sample n=	147	2787	1123		*expect M-H:*	*90.5*	*31.9*	*59.9*	*0.65*
					Sample n=	431	2905	2220	
Etsho Plateau:*									

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv Gain
expect = L:	30.9	69.7	64.1	-1.26	expect = L:	19.2	65.1	9.0	-2.39
expect = M:	14.5	14.7	14.1	-0.01	expect = M:	30.8	25.6	55.0	0.17
expect =MH:	3.6	11.1	14.1	-2.06	expect =MH:	32.7	8.8	26.6	0.73
expect = H:	50.9	4.5	7.8	0.91	expect = H:	17.3	0.5	9.4	0.97
Sample n=	55	3263	462		Sample n=	52	3295	777□	

Fort Nelson Lowlands:**

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv Gain
expect = L:	14.6	52.7	21.6	-2.61	expect = L:	5.2	44.1	13.3	-7.54
expect = M:	20.8	22.7	29.8	-0.09	expect = M:	37.4	42.6	28.5	-0.14
expect =MH:	32.3	16.2	28.6	0.50	expect =MH:	22.6	8.0	23.6	0.64
expect = H:	32.3	8.4	19.9	0.74	expect = H:	34.8	5.3	34.6	0.85
Sample n=	96	6039	1534		Sample n=	155	6108	2380□	

Halfway Plateau:

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv Gain
expect = L:	20.7	27.0	24.1	-0.30	expect = L:	18.1	45.2	46.1	-1.50
expect = M:	34.8	37.9	43.5	-0.09	expect = M:	42.8	39.5	42.5	0.08
expect =MH:	27.4	25.0	22.0	0.09	expect =MH:	31.8	11.6	8.1	0.63
expect = H:	17.0	10.1	10.4	0.41	expect = H:	7.3	3.7	3.3	0.49
Sample n=	135	1129	3176		Sample n=	409	1211	4430	

Muskwa Foothills:

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv Gain
expect = L:	0.0	17.6	25.0	********	expect = L:	0.0	20.1	23.7	********
expect = M:	10.0	45.1	0.0	-3.51	expect = M:	10.5	49.9	39.0	-3.74
expect =MH:	85.0	26.1	75.0	0.69	expect =MH:	68.4	26.6	22.0	0.61
expect = H:	5.0	11.1	0.0	-1.22	expect = H:	21.1	3.4	15.3	0.84
Sample n=	20	153	4		Sample n=	19	796	59	

Muskwa Plateau:

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv Gain
expect = L:	7.4	24.6	19.9	-2.34	expect = L:	12.9	54.7	12.8	-3.24
expect = M:	23.0	38.9	46.6	-0.69	expect = M:	37.3	39.4	38.1	-0.06
expect =MH:	22.9	26.0	24.9	-0.13	expect =MH:	20.5	4.4	34.5	0.79
expect = H:	46.7	10.5	8.6	0.78	expect = H:	29.2	1.5	14.5	0.95
Sample n=	773	3931	2192		*expect M-H:*	*87.1*	*45.3*	*87.2*	*0.48*
					Sample n=	876	4088	4899□	

Peace Lowlands:

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv Gain
expect = L:	50.0	47.8	******	0.04	expect = L:	13.2	39.3	******	-1.97
expect = M:	25.0	17.4	******	0.30	expect = M:	32.1	35.0	******	-0.09
expect =MH:	25.0	21.7	******	0.13	expect =MH:	22.6	21.4	******	0.05
expect = H:	0.0	13.0	**************		expect = H:	32.1	4.3	******	0.87
Sample n=	4	23	0		Sample n=	53	140	0□	

Petitot Plain:%

	sites	grid	surv	Kv Gain		sites	grid	surv	Kv
expect = L:	100.0	77.9	70.7	0.22	expect = L:	14.3	77.7	60.5	4.44
expect = M:	0.0	9.6	13.4	********	expect = M:	0.0	10.0	19.7	********
expect =MH:	0.0	7.1	13.4	********	expect =MH:	28.6	6.9	17.8	0.76
expect = H:	0.0	5.3	2.4	********	expect = H:	57.1	5.3	1.9	0.91
Sample n=	1	1560	82		Sample n=	7	1657	157	

* Etsho Plateau is one area where many sites seem to be occurring in lakes and swamps. Sites that were impossible to relocate using orthophotos and TRIM were excluded from this model.
** The Fort Nelson Lowlands model changed the least as the original model performed quite well on it.
# The Clear Hills model was extrapolated to this small ecosection. Site HdRe-011 was excluded from this model as it was a very large proportion of the site points.
% The low number of sites in this region should be addressed with field survey.

Each model is an improvement over the ecosection-specific performance of the general study area-wide model created last year (with the results reported by ecosection). In some cases the improvements are manifested in the removal of sites from occurring in low potential zones.

In some cases the improvements are most noticeable in the small amount of area and still high number of archaeological sites captured in high potential areas. The numbers in Table 6 are promising statistically, however they also represent a theoretical improvement for the entire region: using separate models for ecologically similar areas improves the ability of a potential model to be representative of local conditions. Every model is a simplified version of a complex system. Therefore, the higher the variability within the system, the less effective the model will be. By developing models that are ecosection specific, there is a significant reduction in the amount of variability that must be accounted for in the model. Hopefully, the result is a model that can more effectively reflect the reality of its system and more accurately indicate potential. This is based on the assumption that the ecosystems occupied by hunter-gatherers were strongly influencing their decisions to inhabit or use any location; and that taphonomic factors affecting site preservation are also related to ecosystem-specific or environmental variables.

Two models included the new terrain variables previously described: the Clear Hills and the Muskwa Plateau. The Clear Hills ecosection was selected for its rolling and incised landscape and large tracts of farmland. The Muskwa Plateau was selected upon recommendation from the Oil and Gas Commission. What follows is an examination of these two areas in depth (see also the AIS methodology and topographic modelling sections above) and a review of the other six ecosections, which will have DEMs built for them and terrain variables included in the next year.

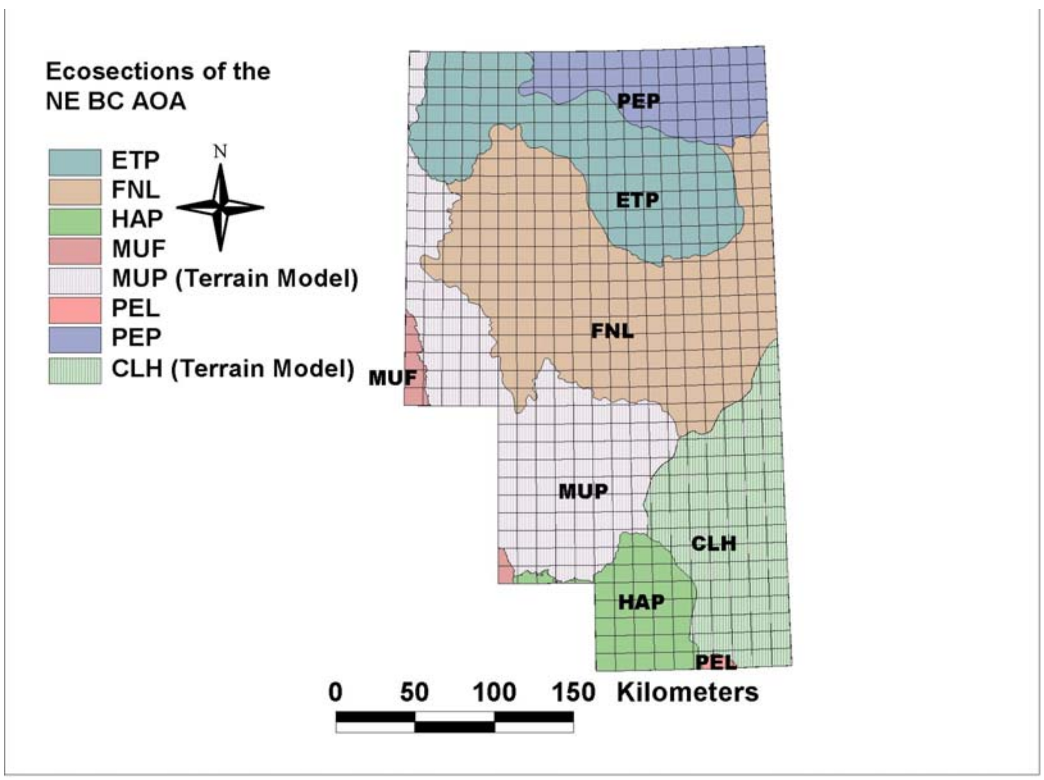


Figure 28. Ecosections of the NE BC AOA.

The Clear Hills Ecosection

The Clear Hills ecosection is in the southeast of the study area, and is characterised by rolling hills, hummocks, wetlands, and incised river valleys. Much of the productive farmland in the study area is contained within this ecosection, making forest cover less useful as a proxy for terrain and drainage. The use of terrain variables in this region vastly improved the performance of the model. In the northern portion of the Clear Hills, the rolling farmland becomes increasingly inundated and characterized by black spruce muskeg. In these regions in particular, terrain features are important, as non-raised areas are generally wet, low in desired resources, and uninviting (see Figure 31 and Figure 32).

Although moose is the most common large ungulate now, prehistorically bison, moose, caribou, and deer were probably important. Bison may have been the most important large game (Fladmark 1996). The boreal forest also supports many edible fish and bird species that could have been accessed for food resources. In this gradually rising upland, the climate "is typically continental since most of the moist Pacific air has dried crossing successive ranges of mountains before it reaches the area. In warmer months rain is largely due to surface heating, which leads to convective showers. Winters are cold because there are no barriers to irruptions of Arctic air" (Ministry of Sustainable Resource Management 2003).

Figure 29. Incised Blueberry River valley in the southern Clear Hills ecosection.

Figure 30. Rolling farmland in the southern Clear Hills.

	
Figure 31. Small topographic high in northern portion of Clear Hills.	**Figure 32. Small creek terrace in northern Clear Hills.**

At this point, about 180 previously recorded sites are located within the Clear Hills ecosection. The majority of these sites (167) are lithic scatters. Other site types include cultural depressions, burials, historic structures, trails, and a tipi frame. As with much northern archaeology, the acidic podzolic soils preclude the preservation of most bones, elsewhere a major component of many archaeological sites. An understanding of human use of the area in the past from animal bone remains or floral remains therefore relies heavily on several sites that have unique taphonomic conditions and ethnographic documents. One such site is Charlie Lake Cave. Faunal remains at this site span Palaeo-Indian to recent times (Fladmark 1996).

Modelling for the Clear Hills ecosection was conducted first to identify where sites were occurring using the buffer program; and second to select variables that were reasonable considering the local topography, culture history, and glacial history. The buffer program was run on all new and changed variables and the updated information was used to recreate the point allocation in the model database. When this information was provided to Timberline, they converted all polygonal coverages to grids and used the GRID extension to Arc/INFO to overlay all the grids and produce a model. Each 20 m cell was awarded points based on the specific parameters for each variable used in the models. The points in the model ranged from around –2 to 11. The Kvamme's Gain statistic for this spread went from very low (as low as –25) up to a perfect 1 for the highest point category, where several sites, but no random grid points, occur.

The Clear Hills model used forest cover (adding points for aspen, aspen combined with pine; lowering points for black spruce or no aspen/pine) although not as extensively as the Muskwa Plateau model. This was in part due to the amount of farmland in the area. Some water variables have been removed as such from the Clear Hills model, and have been replaced with terrain variables. However, very small lakes remain in the model as they were found to be extremely predictive; this addition of points acts in conjunction with the terrain model to ensure that areas around very small lakes are designated as having increased potential. Other water variables remaining in the model are single line rivers, small wetlands, and tracts of land between a small and large swamps. We feared that the terrain model was missing these 'fingers' of land between swamps due to relatively wide-spread spot elevations in the DEM. Ground-truthing the terrain model indicated that potential increases in these regions, and next year a focus of the GIS component of the modelling might be to identify these fingers digitally in a more rigorous manner. For actual model parameters see Table 7.

Selected terrain cells from the moving window technique were a major new component of the Clear Hills model. For developing the model, actual values (positives and negatives) were provided by Timberline for each point in the model database. This allowed rapid experimentation to arrive at precise combinations that indicate potential. The Buffer program, updated to include analysis of combinations of two variables, was used extensively in this process (described below). Terrain variables increased the effectiveness of the Clear Hills model substantially. The selected cells that were ground-truthed this year in the field were also useful. When an analysis was conducted using the selected cells and slope, large flat lands away from river valleys could be filtered out. Few sites occur in these regions.

Another new component was aspen stand size (described below). While ground-truthing the terrain model, Millennia staff noted that aspen stands were significant in indicating potential only under very particular circumstances. That is, if the stand were small and surrounded by Black Spruce Muskeg or swamp, then the aspen stand had more potential for sites than a large, undifferentiated aspen stand close to lodgepole pine. If a large aspen stand was surrounded by swamp, it seemed more likely that sites would occur close to the borders of the stand. To test this hypothesis, aspen stand polygons were created by Timberline, and the stand size and proximity to a border was calculated for each point in the model database. The polygons were based on forest cover data, where polygons containing 50% or more of aspen were dissolved into a single polygon. Using the buffer program, Millennia determined that the aspen stands were indeed indicative of potential, especially those under 50 ha. An interesting note is that sites do not occur in the first 50 m of a large stand. Possibly, this is due to the swampy nature of the periphery of some aspen stands. If aspen stands were larger than 100 ha, then the centre portion of them was also very low potential. In general when sites were found in large aspen stands, they were in the area between 50 and 300 m from the border of the stand polygon.

Future directions for the Clear Hills include an adjacency analysis of aspen and possibly other forest cover polygons and an attempt to integrate more trails and other Traditional Use or Traditional Ecological Knowledge into the model. The small region of the Peace Lowlands within the study area was included in the Clear Hills model, as it was often only a fringe on the bottom of CLH mapsheets.

The Muskwa Plateau Ecosection

The Muskwa Plateau ecosection is in the far west of the study area. It is a rolling wet upland, rising above the lowlands to the east. Many rivers and streams dissect the region and provide habitat for the numerous moose. Archaeologically the region is represented by 298 sites, 261 of which are lithic scatters (site information from HRIA database). Seventeen sites recorded in the HRIA database are culturally modified tree sites. Historic sites account for 34 sites in this region, and include aboriginal and European remains such as trappers cabins and a military structure dating to the construction of the Alaska Highway. Thirteen burials and one cemetery have been recorded in the region.

The climate of the Muskwa Plateau is continental. "Cold, dense Arctic air is unimpeded from the north and may easily blanket the area in winter and spring. The long sub-Arctic winters are generally dark with little heating by solar radiation. In summer, its location between the Arctic and Pacific air masses give it long periods of cloud cover and unstable weather. In years of cold temperatures, or of more moisture, some soils may remain frozen" (Ministry of Sustainable Resource Management 2003).

The Year Two model performed relatively poorly in this ecosection, which is indicative of the difficulty modelling for upland boreal forest environments. Terrain variables created and used in this Muskwa Plateau model were not quite as effective as the Clear Hills example. Slope, while not useful separately in the Clear Hills, was a useful variable in the Muskwa Plateau. Sites tend to occur on moderate slopes or flatter regions. Steep areas, while not a large portion of the landscape, contained an inordinately low proportion of the archaeological sites.

Forest cover was quite effective, as were the water variables that remained a part of the model. Water variables that were included in the MUP include very small lakes as they are extremely predictive (up to 600 m away!). Small rivers and small wetlands are also predictive in the MUP ecosection. A concern was that topographic changes around these features may be less distinct, so including a buffer around them was prudent. Fingers of land between large and small swamps was indicative of potential. Further analysis will attempt to extract the regions between closely space swamps of any size.

Aspen stand size was also used in the Muskwa Plateau (polygons were dissolved based on any aspen present, this may be a weakness that can be improved next year). Future versions of the model will probably incorporate dissolved pine stands, as pine is very predictive in this ecosections. Several combinations of variables were found to be useful in this ecosection. For example, a statistically very significant combination was areas close to (within 100 m) selected terrain cells and having a moderate (35 to 70%) amount of pine. More site points than random grid points occurred!

An important variable for the Muskwa Plateau is trails. Trails are very predictive of site locations. Some work on creating a model to find trails instead of focussing on 'sites' was conducted this year (we reasoned that we could probably predict natural trail locations quite well with out terrain modelling and, if so, then this could be a proxy for site location). Better trails data is needed for this research to continue, since there were too few 'near trail' random grid points to be a representative sample of typical trail locations. A focus for the Year 4 model will be a better trails database in this ecosection as they are more predictive in the Muskwa Plateau than in any other ecosection in the region. This might be an 'artifact' due to biases in previous survey, but it might also be due to the terrain. These points will be addressed next year.

Ecosections without Terrain Variables

Terrain variables were only calculated for the Muskwa Plateau and the Clear Hills (with a small portion of the Peace Lowlands included in Clear Hills). The other ecosection models were improved using the same variables as the Year Two model (Eldridge, et al. 2002). Updated variables will be incorporated in these models next year; new variables such as aspen stand size can also be created and used, if they are relevant. Several problems were identified while modelling for these individual ecosections:

- In the Etsho Plateau ecosection many sites are mapped as occurring in lakes and swamps. For this reason, sites that were impossible to relocate using orthophotos and TRIM were excluded from this model. A portion of the fieldwork conducted next year should be specifically to relocate and correctly map these sites.

- The Peace Lowlands model performs only marginally due to a small sample size. A single site, HdRe-011, was so large that it dominated the sample. In order to create a model that didn't rely too heavily on this single site's location, it was excluded from this model. Since the area was so small and seemed little different from the remainder of the mapsheets shared with Clear Hills, the Clear Hills model was applied the Peace Lowlands parts of shared mapsheets.
- The Petitot Plain is a large area with only 7 site points. These come from three sites, all lithic scatters. The low number of sites in this region should be addressed with field survey, as this region is a substantial portion of the study area and creating a model for it using only three sites is statistically inappropriate.

Variable analysis

Variable analysis was conducted on new and changed variables. The new variable data was used to create the Clear Hills (CLH) and Muskwa Plateau (MUP) models, and will be used to update the other models in the next phase of this project.

Forest Cover: New Forest Cover and Stand Size

It was noticed that a large number of sites (5%) were occurring in areas delineated as swamp in the forest inventory. This was negatively affecting the Kvamme's Gain statistic, which measures the effectiveness of the model, as these sites were being assigned a score of zero (automatically assigned as low potential) (Brandt, et al. 1992, Hobbs 2001). While doing orthocorrections of the sites that were mapped in swamps, it became apparent that there were problems with the forest cover data we were using, which appeared to be shifted 200 m to the east. This shift is not a NAD problem, and was not a projection problem, as we had originally anticipated. It appears that certain inaccuracies existed in the forest cover data for sections of our study area. These inaccuracies were on the order of 200 m, and this is a very substantial difference considering the reliance on forest cover. Figure 33 displays the problem we encountered. The tan polygons are the old forest cover pine polygons. While viewing these polygons over the orthophoto, it became apparent that they were not in the correct spot. Pine polygons of the correct shape existed on the orthophotos; they were just in different locations. To see this, a purple line representing the pine polygon was shifted to be on the actual pine stand visible in the orthophoto. When moved 200 m to the west, this purple line follows the actual pine stand quite well. Therefore, the problem was not that the data was old (for example, if stands had changed in size or shape over the years), they were just inaccurate.

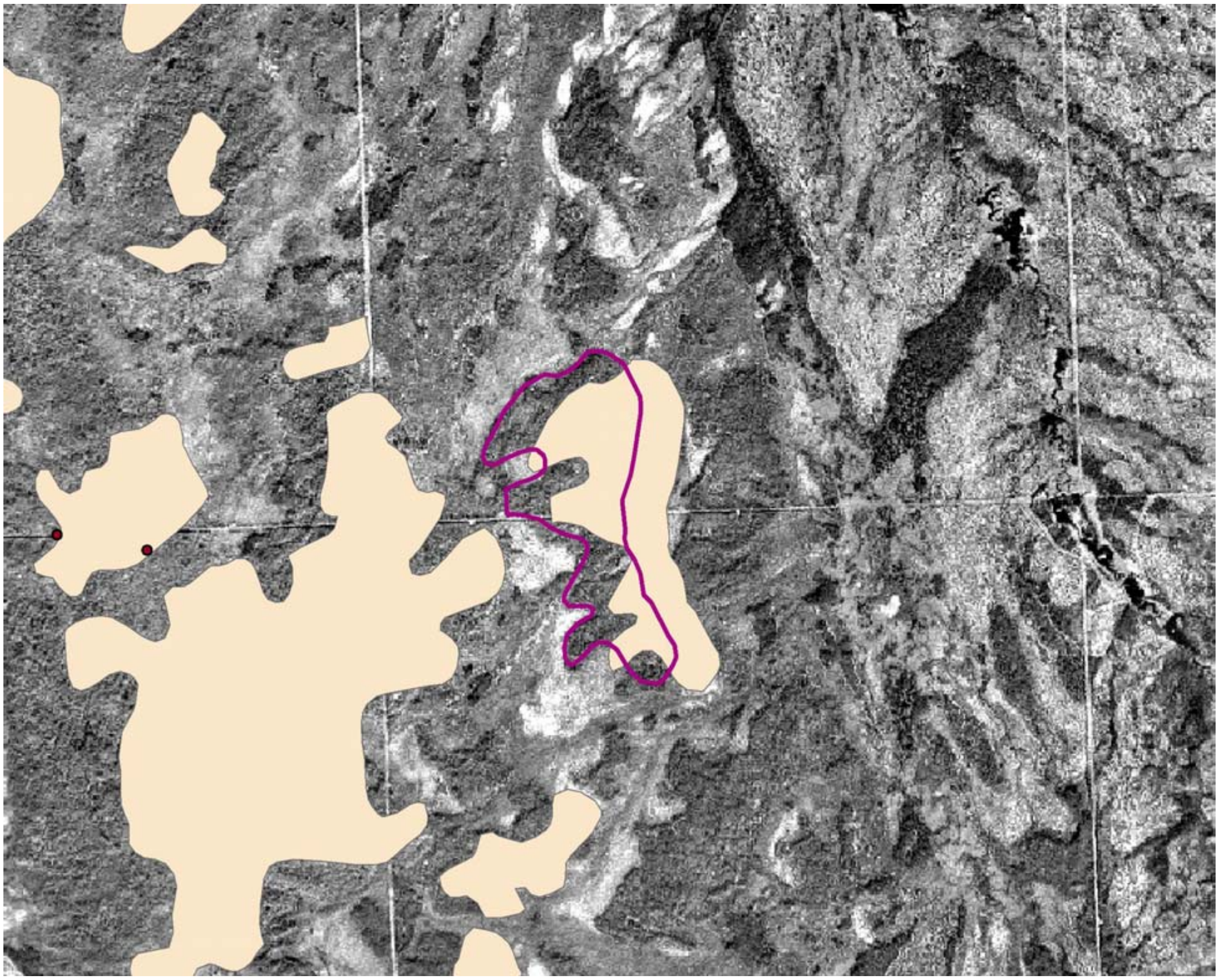


Figure 33. Forest Cover Inaccuracies.
Tan polygons represent forest cover data. Purple line represents one polygon shifted to the west showing that the shape is accurate but the position is not.

To attempt to deal with this issue, Timberline contacted MoF and obtained a new TRIM-based forest cover (current as of 1999), and compared it to the TRIM data, and the old forest cover (current as of 1994). After overlaying the three sets of data, it appeared that the TRIM data and the 1999 forest cover data matched up more precisely. Figure 34 displays the differences between the old and new data.

This revised forest cover was used in the creation of the Clear Hills and Muskwa Plateau model. The buffering analysis was re-done over this new data and integrated into these models. Analysis of site patterning using the old (1994) forest cover data must now be considered less useful (although updated forest cover is used to build the model, the variables were analyzed using the old forest cover data except for CLH and MUP). A reanalysis of forest cover will begin early in Year 4.

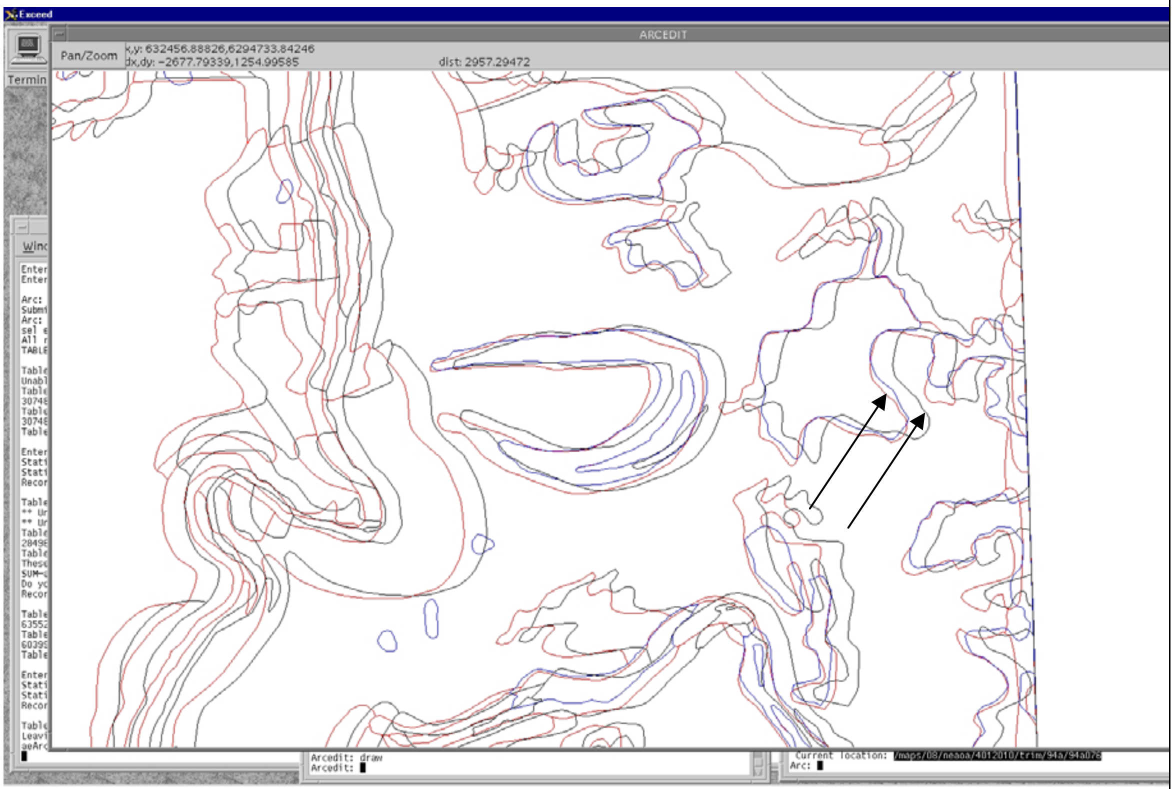


Figure 34. Comparing old and new forest cover data.
The three datasets:
BLACK - old forest cover (1994)
RED - new forest cover (1999)
BLUE - TRIM swamps
Note that the new forest cover matches the TRIM data much more precisely than the old data (see arrows), in many places it cannot be distinguished from TRIM.

As forest cover data is important as both a variable and a proxy indicator of terrain, Millennia decided to query whether certain types and sizes of stands were correlating with known archaeological site locations. Extensive fieldwork over several decades had determined that both aspen and pine stands were archaeologically significant (Keary Walde, pers. comm., 2003). We hypothesised that although pine was almost always associated with increased potential, aspen would have potential only when it was a smaller stand, and/or surrounded by swamp and black spruce. This supposition was determined from field observations, as we were noticing a correlation between aspen stands and site locations. However, we recognized that there might be a stronger correlation with more complex factors: a smaller stand size might be more attractive; if the stand size is large, the sites might cluster near the edges; aspen would be more likely used if surrounded by swamp.

Timberline extracted forest stands containing aspen from the forest inventory data using the species composition percentage attribute. These extracted stands were then dissolved on the basis of their species composition percentages (see Figure 35 and Figure 36). Polygons with no aspen or with lower than the required amount of aspen were disregarded. Millennia subsequently buffered these aspen stands using their modelling software to determine appropriate thresholds for the percentage of aspen contained within a stand – relative to the location of known sites. For the CLH ecosection it was found that a stand that contained 50 % or more aspen had archaeological significance, while in the MUP ecosection, any amount of aspen was found to be significant. Stands with no aspen or with percentages of aspen below the required level were disregarded.

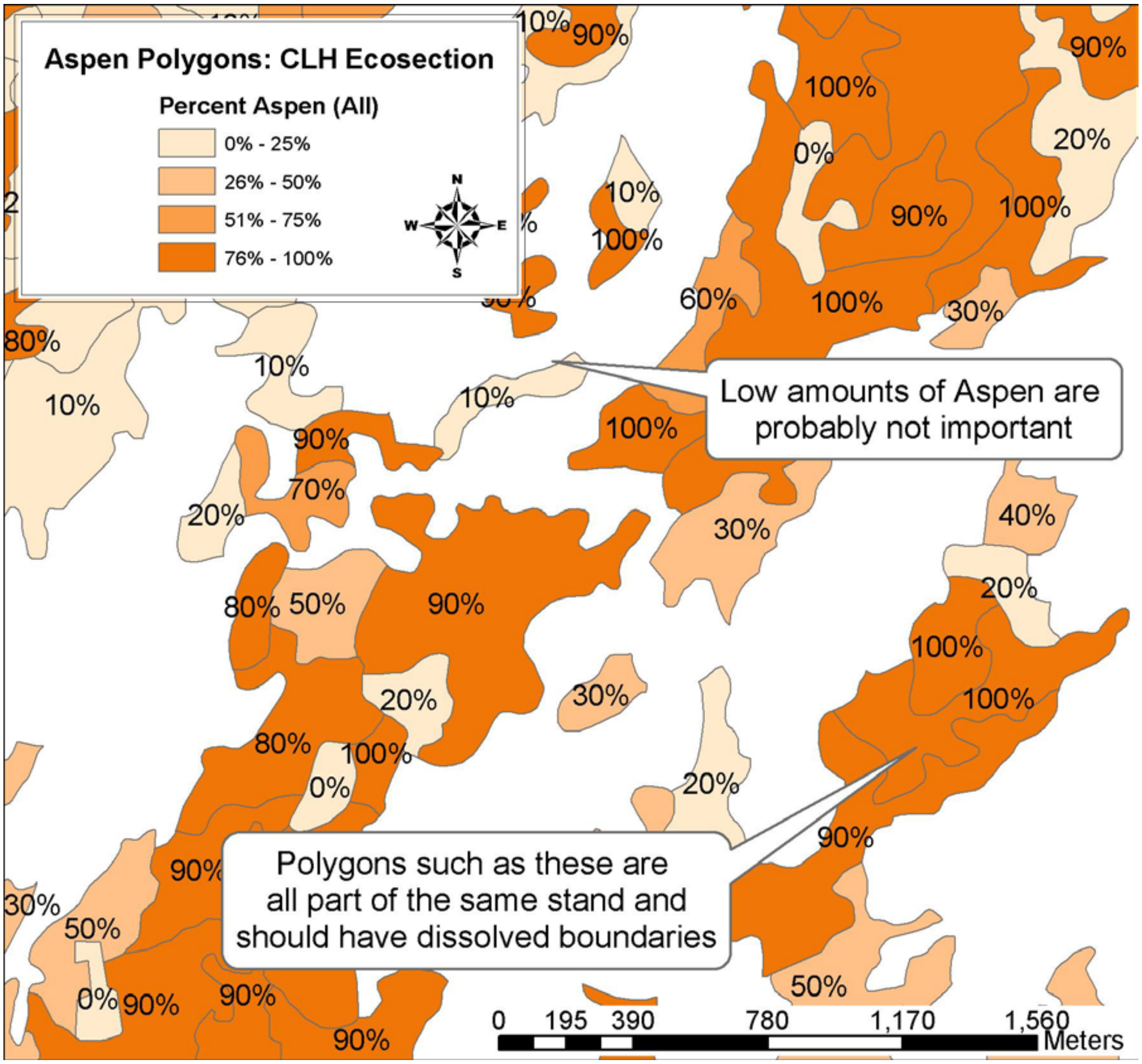


Figure 35. Aspen Polygons displayed based on percent aspen.

Using the dissolved and archaeologically significant aspen stands, two new variables were introduced to the model database: aspen stand size and distance to aspen stand border. These new variables were applied to sites falling within aspen stands. Using Millennia's Buffer Program, we determined that there was indeed a positive correlation between smaller polygons (<100 ha) and archaeological sites. The near-to analysis was also queried using the Buffer Program. This indicated that there is a significant pattern of sites being located from 50 to 225 m from the edge of a polygon. Although some sites do occur in the 50 m closest to an aspen polygon, the high number of grid points (random background) caused a negative correlation – the low number of sites was statistically significant.

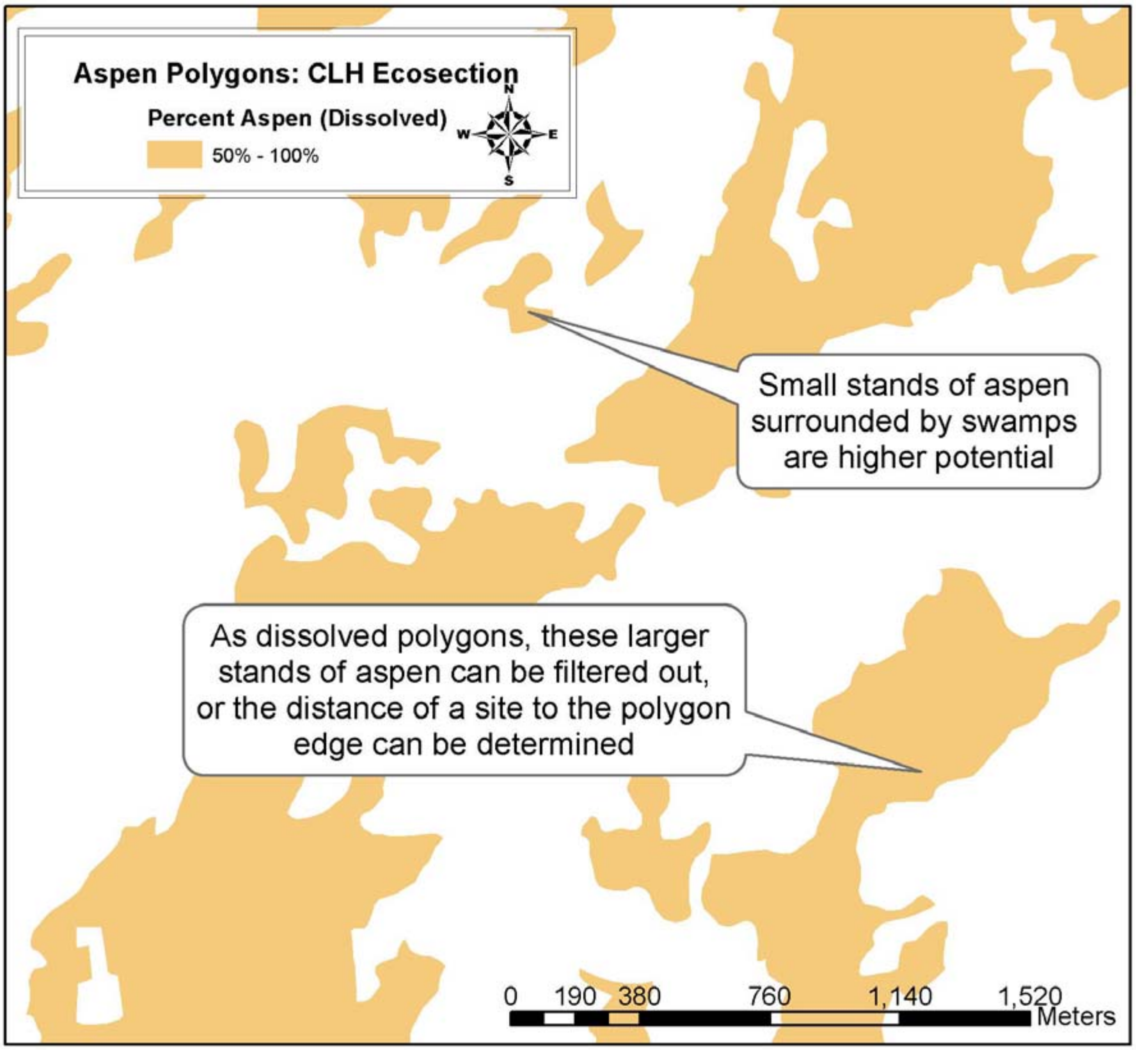


Figure 36. Aspen polygons dissolved on 50% or greater percent aspen, lower percentages deleted.

Terrain model variables: selected cells and moving window results

As indicated in the section discussing the identification of topographic features, terrain model variables were very important in the creation of the Clear Hills and Muskwa Plateau models. The Selected Cells, as ground-truthed, were used in both models. The Buffer program was run on positive, negative, and count variables to determine if any range of values indicated potential. Additionally, a multi-dimensional analysis of positive and negative values for both the 20 m and 50 m grids was used to fine-tune the terrain model (see next section). This resulted in the addition of 18 statement in the Clear Hills model that each reflect a small 'suite' of appropriate parameters to capture terrain. Appendix 4 contains the model program text.

Modelling Using Two Variables

Identifying patterns that relate to multiple variables is a strength of logistic regression software. To try to access the patterns that relate to several variables, the Buffer program was modified to allow for multiple filters. Initially this change was for cell value modelling, to determine where the cut-off should be for positive and negative values. The program was modified by adding a DO WHILE loop, which incrementally changed a filter on one cell variable and did the normal buffering on the other variable within this filter. After the appropriate cell values were identified, it occurred to us to use this program to determine if other variables (like terrain variables and forest cover, for example) co-vary.

This modified buffer program outputs a series of chi-square statistics and histograms to represent site/grid relationship within the intersection of the filter and of each buffer level, as specified by the user. Essentially, it outputs the optimal buffer multidimensionally. Quick runs on the positive and negative 7x7 cell values helped to refine the parameters used to create the selected cells. Both the original terrain model "selected" cells (which were essentially selected intuitively, while examining the results visually on the computer screen) and specific statements from the two-variable buffering were used in the models.

In addition to the selected cells, several other variables were 'crossed.' Successful runs included aspen stands and terrain variables and pine stands and terrain variables. We anticipate that crossing variables will play an important role in the modelling of other ecosections in Year 4.

Model evaluation

The model printouts for the Clear Hills and Muskwa Plateau follow (Year Two report has a guide to interpreting this output (Eldridge, et al. 2002)and is included on the CD attached to each report):

```
Preliminary model draft 10 - North East
For the Ecosection Clear Hills Central Alberta Uplands

                sites  grid  surv   Kv Gain
expect  -5:      0.0   0.1   0.0********
expect  -4:      0.5   5.0   0.7   -9.68
expect  -3:      0.2   5.9   1.0  -24.52
expect  -2:      1.2   7.8   3.2   -5.71
expect  -1:      2.3   8.7   9.1   -2.74
expect   0:      5.3  40.6  26.1   -6.61
expect   1:     10.0   8.0   9.4    0.20
expect   2:      9.7   7.5   9.9    0.23
expect   3:     10.7   6.2   8.1    0.42
expect   4:     12.3   3.9   8.5    0.68
expect   5:     13.7   3.1   6.6    0.78
expect   6:     13.7   1.6   7.0    0.88
expect   7:      9.5   1.0   4.9    0.90
expect   8:      8.4   0.3   2.7    0.96
expect   9:      1.4   0.2   1.9    0.83
expect  10:      0.7   0.0   0.9    1.00
expect  11:      0.5   0.0   0.1    1.00
```

```
OVERALL CLH

                  sites  grid  surv   Kv Gain
expect = L:         9.5  68.1  40.1   -6.16
expect = M:        19.7  15.5  19.2    0.21
expect =MH:        36.7  13.2  23.2    0.64
expect = H:        34.1   3.2  17.5    0.91
expect M-H:        90.5  31.9  59.9    0.65
Sample n=           431  2905  2220
```

The Clear Hills model performs very well, with a progression of a very low Kvamme's Gain to value of 1, the highest possible (when sites are captured but no land) (Brandt, et al. 1992). The variable parameters used to build this model are interpreted in Table 7 in non-technical language. **Bold** text indicates a positive correlation, or an addition of 1 to the potential value (called 'expect'). *Italic* text indicates a strong negative correlation with potential, or the subtraction of the potential value of the region.

Table 7 Clear Hills Model Variable Parameters

Variable Parameters	Interpretation
expect + 1 for aspen_p > 50	Aspen stands more than 50% aspen
expect - 1 for bspr_p != 0	Any black spruce indicates low potential
expect + 1 for (lpine_p < 45 and aspen_p!=0)	Stands with a moderate amount of lodgepole pine and any amount of aspen
expect - 1 for (Lpine_p != 0 or Aspen_p !=0)	Sites tend not to occur in areas with no aspen and no lodgepole pine
expect + 1 for aspen_p = 100	Stands of pure aspen
expect - 1 for bspr_p > 80	Stands of mainly black spruce tend not to have archaeological sites
expect + 1 for lakevs <= 600	The regions within 600 m around very small lakes are very predictive in this ecosection. Although landforms around these lakes will be captured with terrain variables, there also appears to be an association with the actual body of water.
expect + 1 for rv_sgl <= 200	This variable (single-line rivers, or small rivers) is extremely predictive within 200 m. Topographic changes around these features may be less distinct, so including a buffer around them was prudent.
expect + 1 for (wetsm <=100 or (wetsm<=300 and wetlg<=300))	The region within 100 m around small

	wetlands or between large and small wetlands (i.e. if the wetlands are less than 600 m apart) is considered predictive. Next year, GIS will be used to find the 'fingers' of land between swamps.
expect + 1 for trails <= 400 **expect + 2 for trails <= 100**	Trails are predictive of site location. Any human habitation site needs access to it through the landscape. A peoples understanding and use of their territory is constructed through trails networks (see for example Goodchild (2002))
Moving window grid cell parameters not included here due to length and complexity – see appendix with model code	Selected cells and moving window results are numerical. Essentially, if a cell is elevated relative to neighbours, it will be selected.
expect + 1 for aspensize < 50	Small aspen stands (less than 50 ha) are more likely to have sites.
expect – 1 for aspennear > 300	In large aspen stands, central areas are unattractive.

The Muskwa Plateau model output follows:

```
Preliminary model draft 10 - North East
For the Ecosection Muskwa Plateau, Muskwa Plateau

                sites  grid  surv   Kv Gain

expect  -5:      0.0   0.0   0.0********
expect  -4:      0.0   0.2   0.0********
expect  -3:      0.0   1.0   0.0********
expect  -2:      0.3   3.9   0.2  -10.36
expect  -1:      0.2   5.4   0.9  -22.46
expect   0:      4.5  19.2   5.6   -3.31
expect   1:      7.9  25.0   6.2   -2.18
expect   2:     16.1  23.8   8.8   -0.48
expect   3:     10.5  10.3  10.3    0.02
expect   4:     10.7   5.3  18.9    0.51
expect   5:      9.1   2.7  23.7    0.70
expect   6:     11.4   1.6  10.8    0.86
expect   7:      8.0   0.9   6.9    0.89
expect   8:      4.7   0.5   3.4    0.90
expect   9:      5.5   0.1   2.0    0.98
expect  10:      4.9   0.1   1.4    0.99
expect  11:      4.3   0.0   0.5    1.00
```

```
MUP

                sites  grid  surv   Kv Gain
expect = L:     12.9   54.7  12.8   -3.24
expect = M:     37.3   39.4  38.1   -0.06
expect =MH:     20.5    4.4  34.5    0.79
expect = H:     29.2    1.5  14.5    0.95
expect M-H:     87.1   45.3  87.2    0.48
Sample n=        876   4088  4899
```

The Muskwa Plateau model performs well with a progression of a very low Kvamme's Gain to value of 1, the highest (when sites are captured but no land). As with the Clear Hills, the variable parameters used to build this model are interpreted in Table 7.

Table 8 Muskwa Plateau Model Variable Parameters

Variable Parameters	Interpretation
expect + 2 for (lpine_p+bspr_p)>90 and lpine_p>40 and lpine_p<90	Complex forest cover polygons can indicate potential. In this case, a polygon that is made up of pine and black spruce, with a moderate to large pine component, indicates increased potential.
expect + 2 for (cotton_p > 30 and s_p != 0) or cotton_p = 100	Several polygons are entirely cottonwood in this ecosection, and they have increased potential. Also, potential increases if a stand is at least a moderate amount of cottonwood and is not mixed with spruce (which apparently lowers the suitability of the stand).
expect + 2 for bgc_zone = 'SWB' and agecls > 5	Spruce Willow Birch (SWB) is a biogeoclimatic zone designation that covers only 1.1% of the entire study area. This parameter was initially included for CMTs.
expect + 1 for (agecls > 6 and hghtcls < 4 and (lpine_p != 0 or aspen_p != 0) and bspr_p < 51)	Old, low tree stands with some aspen or pine, with less than half of the stand black spruce, have potential. Further research in such areas could identify if this pattern indicates resource use of a specific type.
expect + 1 for lakevs <= 200	Areas within 200 m of very small lakes have increased potential.
expect + 1 for lakesm <= 200	Areas within 200 m of small lakes have increased potential.
expect + 1 for lakemd <= 600	Areas within 600 m of medium-sized lakes have increased potential.
expect + 1 for wetsm <= 200	Areas within 200 m of small wetlands have

	increased potential.
expect + 1 for trails <= 300 **expect + 2 for trails <= 100**	Trails are the most predictive variable in this ecosection.
expect - 1 for slope > 12 *expect - 1 for slope > 16* **expect + 1 for slope < 5**	Extreme slopes represent a very small proportion of the land but have no or very few archaeological sites. Moderate to flat areas are more likely to have sites.
expect + 1 for aspensize < 100	Areas within aspen stands smaller than 100 ha are more likely to have sites.
expect - 1 for aspensize > 200	On the other hand, aspen polygons greater than 200 ha are less likely than random to have sites. Stands 100 to 200 ha have a close to random probability of having sites.
expect + 1 for (aspennear > 75 and aspennear < 225)	Within medium aspen polygons, sites cluster away from the edges (at least 75 m away from stand edge) but not in the middle either, rather in a doughnut shape just in from the edges.
expect - 1 for aspennear < 50	There is a negative correlation (i.e. sites occur much less than random) within the first 50 m inside a medium to large aspen polygon.
expect + 2 for (lpine_p > 35 and lpine_p < 70 and sel2 < 101) *expect - 1 for (lpine_p > 35 and lpine_p < 70 and sel2 > 200)* **expect + 1 for (aspen_p != 0 and aspen_p < 35 and sel2 < 101)**	Areas close to terrace edges or other terrain features (as captured by the selected cells) with a moderate (not high or low) amount of pine or a low amount of aspen seem to be very attractive for human activity. On the other hand, pine polygons (with a moderate amount of pine) further than 200 m from a terrain feature are less likely than random to have sites.
Moving window grid cell results not included here - see appendix with full model code.	Selected cells and moving window results are numerical. Essentially, if a cell is elevated relative to neighbours, it will be selected.

The complexity of the models is increasingly attempting to model for the complexity of human behaviour. Different ecosections provide different environments and therefore different choices and patterns. The models seem to be capturing many sites and allowing much of the landscape to be removed from moderate and high potential ratings. Further research and survey will allow refinements to the models.

Modelling for Palaeo-Indian Sites in the Clear Hills

Producing a model that could identify and protect Palaeo-Indian sites was a concern identified by the Steering Committee early in the NE BC AOA. Palaeo-Indian sites date to the late Pleistocene and early Holocene (pre-8000 BP) and are found in this region (Fladmark 1996). Often, they are only represented archaeologically by a single projectile point base. However, Palaeo-Indian sites represent significant evidence of ancient occupations in the northeast and throughout the province of British Columbia. They also present a unique challenge to modellers as their patterning is generally not associated with modern landforms and drainage.

Palaeo-Indian sites tend to be associated with the retreat of the major glaciers of the last glaciation. During the retreat of the Wisconsin Laurentide and Cordilleran ice, large lakes covered much of the landscape. Even into the early Holocene, these lakes formed a dominant feature of the landscape (Fladmark, et al. 1988). Much of the southern study area was covered by Glacial Lake Peace, which in its later stages drained through the Peace River valley and was dammed by the retreating Laurentide ice to the east. The most recent stage of Glacial Lake Peace is the Clayhurst Phase, when the lake was at 660 to 690 m ASL (Mathews 1978). Clayhurst is the one assumed to correlate with human occupation in the area. The shore of this lake and the post-glacial landscapes of the northeast supported human groups who were (re)populating this region from the south.

After the recession of the glaciers, the landscape looked very different than it does today. A succession of herbs, grasses, and mosses to a deciduous forest preceded the establishment of coniferous forests in the southern portion of the region. The open grassland probably supported a comparatively large number of human occupants; big game hunting with stemmed projectile points was an important economic activity that is recognizable thousands of years later. As these sites have a particular significance due to their age and distinctiveness, the most recent model Millennia has created attempts to model for them specifically by emphasising terrain over water courses.

An important characteristic of modelling for Paleo-Indian sites is that modern hydrography probably doesn't indicate potential. Changing hydrographic conditions in the last 10, 000 years have caused rivers and other bodies of water (especially muskeg swamps in the last 6000 years) to appear and disappear. Instead, Millennia has used the actual terrain to isolate regions where potential exists to find sites dating to Palaeo-Indian times (see previous section on terrain identification). As peri- and post-glacial levels of glacial lakes are known in this region, it is also possible to identify terrain that might be associated with glacial lake strandlines.

In an attempt to determine whether or not our model was capturing palaeo-sites, a visual inspection of the GIS model and the site locations was carried out on screen using GIS. Five palaeo sites (we have included some lanceolate points that may date to the early archaic, or just after the true palaeo time period) are within the Clear Hills ecosection, two of which are captured in high (HeRc-007 and HdRe-014), two in moderate (HhRb-002 and HkRe-001, which was functionally in a high cell), and one which has an uncertain location but is likely to have been captured in high (HiRi-001).

HeRc-007 and HdRe-014 are both in reasonable proximity to Glacial Lake Peace Clayhurst Phase levels. To determine if these sites are possibly associated with this lake, the known elevation (660-690 masl) of the Clayhurst Phase was pulled from the spot elevations provided in TRIM (Mathews 1978). This area flanks the modern pathway of the Peace River and its larger tributaries. Neither site is conclusively associated with the lake or peri-glaciolacustrine deposits; however, HdRe-014 is on a terrace directly above the lowest (latest) level of Glacial Lake Peace Clayhurst Phase. If this site was occupied in very early post-glacial times, it would have been on the shoreline of this lake. However, Palaeo-Indian sites as we defined them date to as late as 7,000 to 8000 years BP, while the most recent glaciation ended (in this area) well before 10, 000 BP (Catto, et al. 1996).

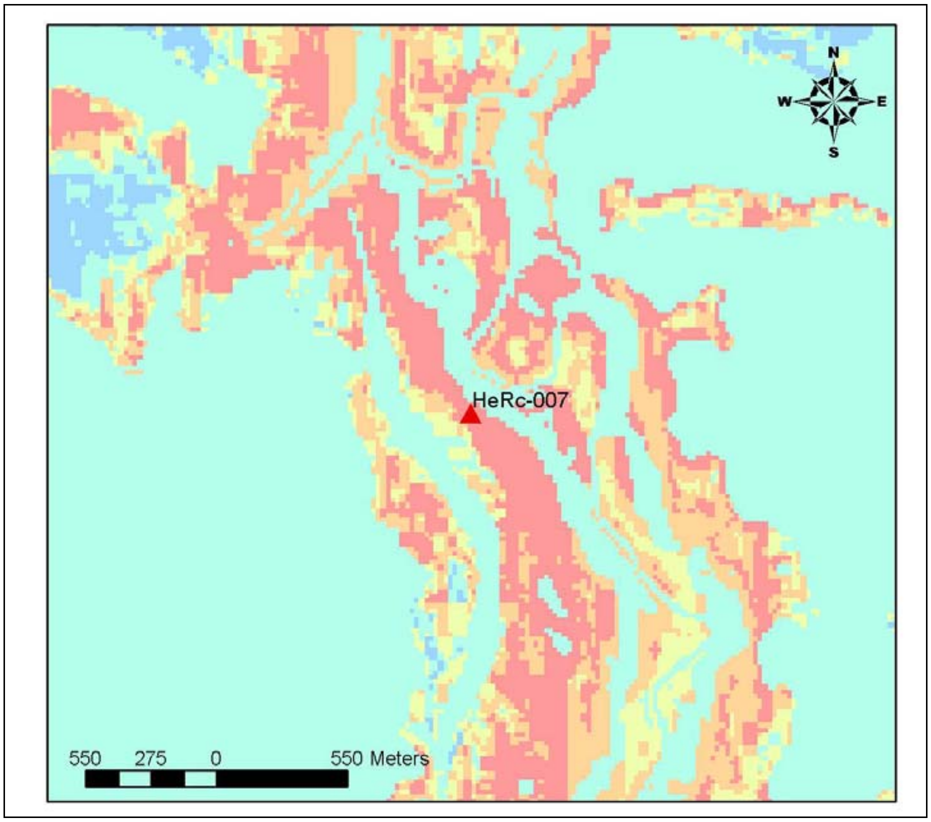


Figure 37. Palaeo-Indian site HeRc-007.

In Figure 37, Palaeo-Indian site HeRc-007 is displayed with the Clear Hills model beneath it. The site is clearly captured in red (high). The site form indicates that the site is on a knoll with a break-in-slope. Its association as 'Palaeo-Indian' is based on the single lithic artifact recovered, a lanceolate point. This site flanks the modern Doig River valley running north-south. Figure 38 displays the location of site HdRe-014, recorded as an 850 sq m site on a small topographical rise above nearby black spruce muskeg. This site contained a burinated lanceolate point as well as lithic debitage and tools. The small rise that the site was on is all captured as high, but muskeg to the south and larger muskegs to the east and west were categorized as low.

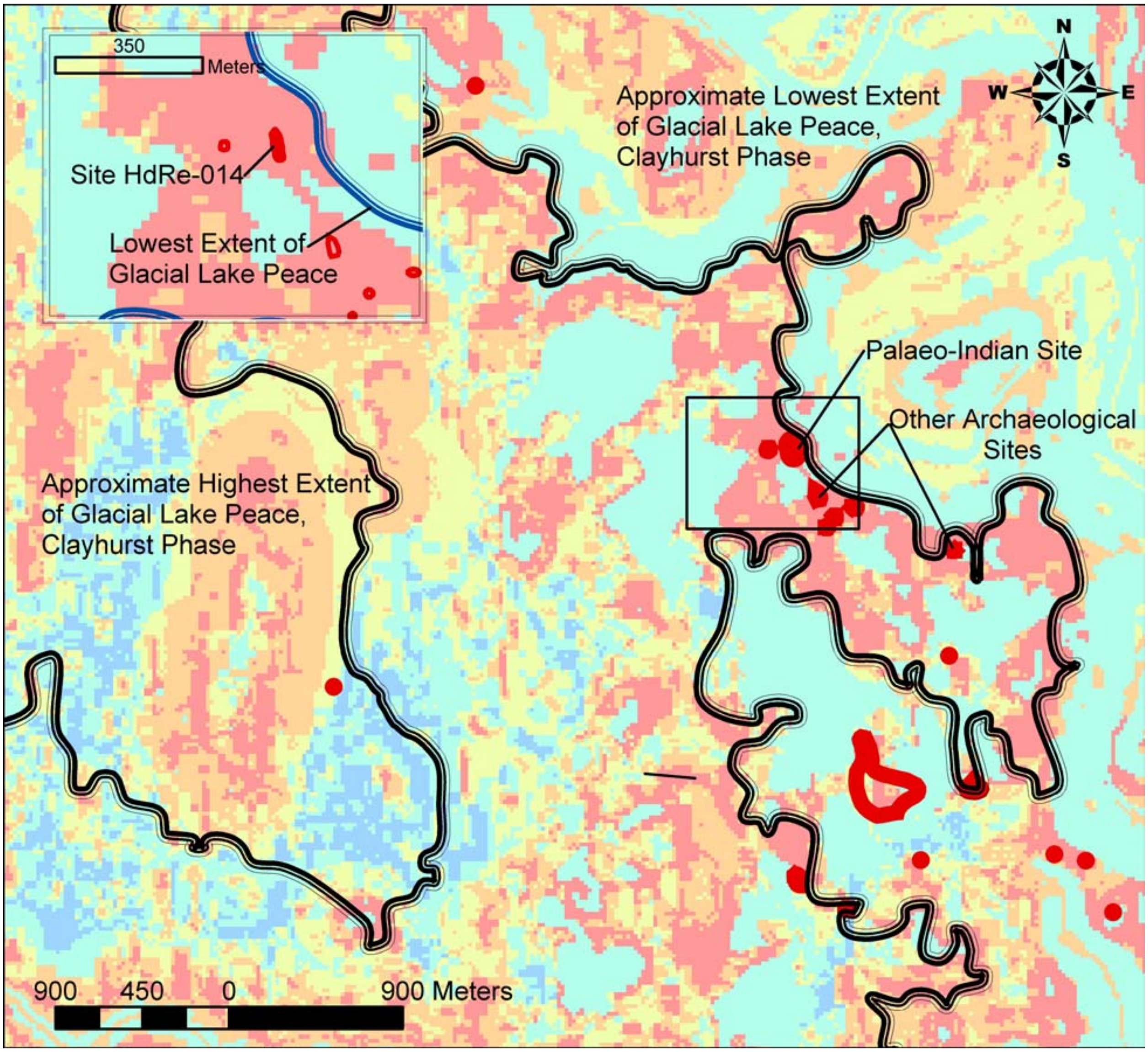


Figure 38. Palaeo-Indian site HdRe-014 with CLH model.

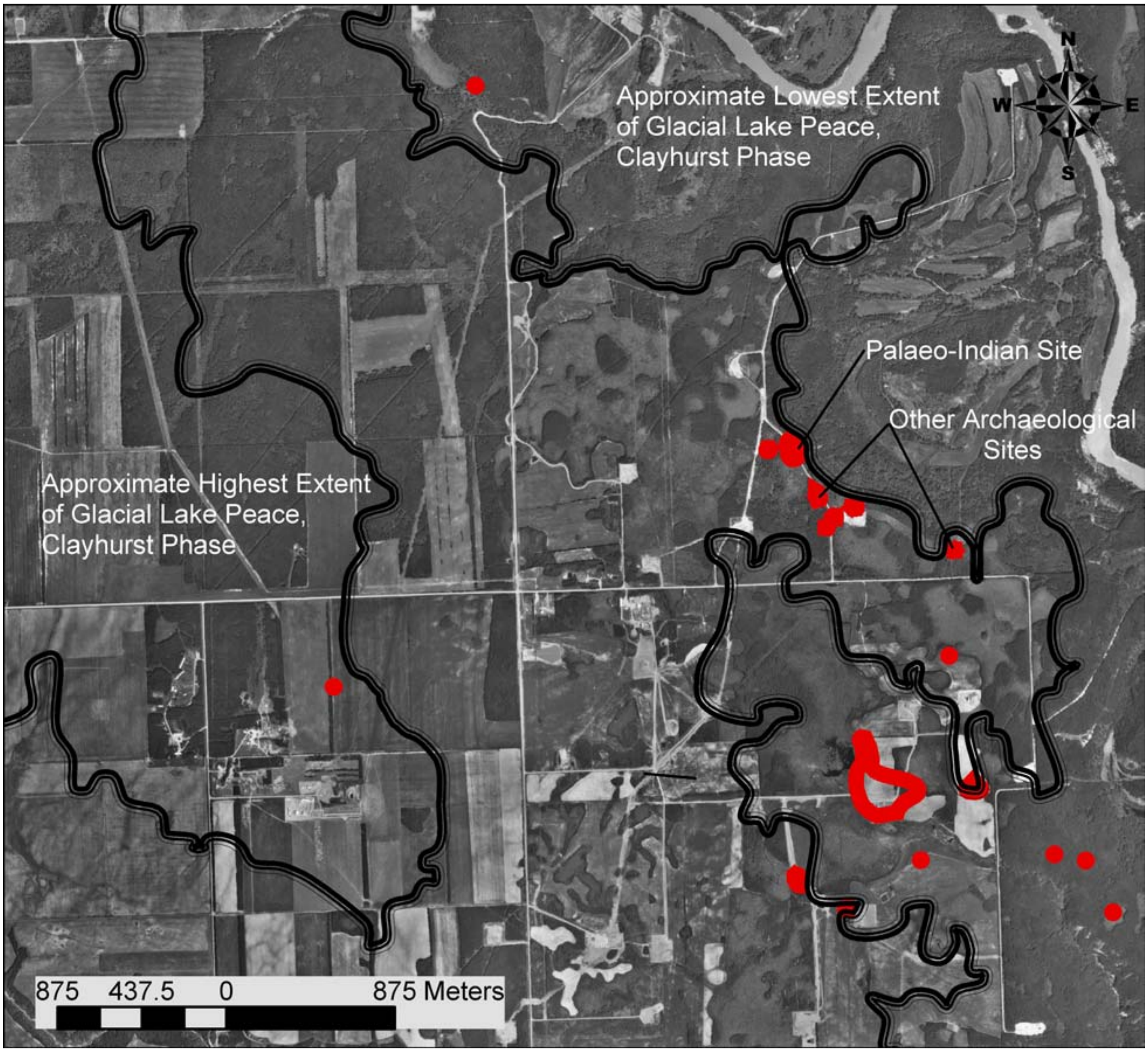


Figure 39. Palaeo-Indian site HdRe-014 with Orthophoto.

HhRb-002 is a Palaeo-Indian site along a pine ridge. The site is comprised of a single isolated find, a Scottsbluff point (see Figure 40 and Figure 41).

Figure 40. HhRb-002 Scottsbluff Point 7000-9000 BP.
Courtesy of Heritage North Consulting Ltd

Figure 41. HhRb-002 Location.
Courtesy of Heritage North Consulting Ltd

Site HkRe-001 is actually probably an Archaic site rather than a Palaeo-Indian site. It is located on a small ridge overlooking a swampy lake (see Figure 42). This east-west running ridge feature is associated with other ridge features in the area, including several that are running north-south.

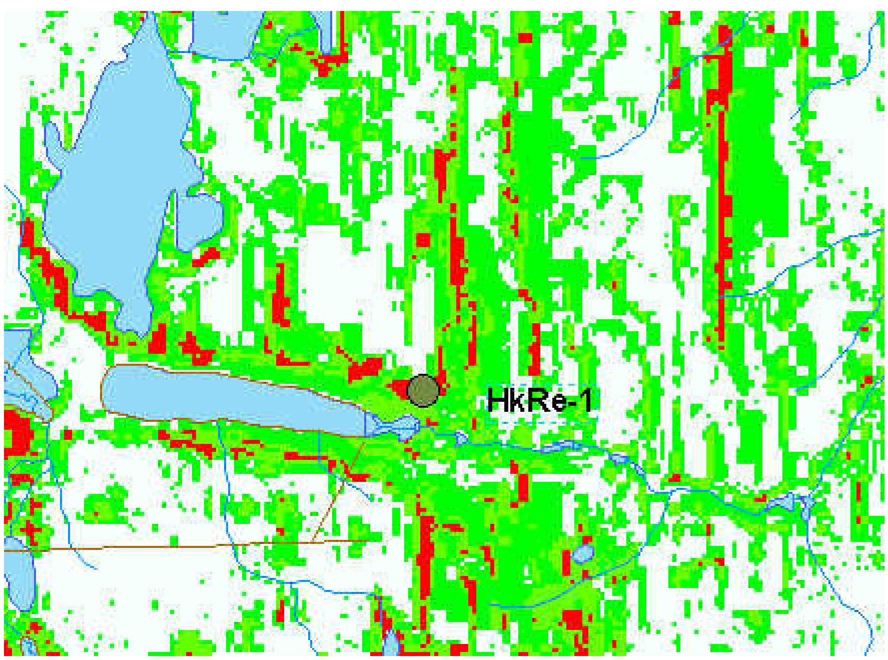


Figure 42. HkRe-001 Palaeo Site.

The east-west turning to north-south ridge where the site is located is captured in high. This site was recorded as ‘palaeo’ on the presence of an expanding-stem point (see Figure 43).

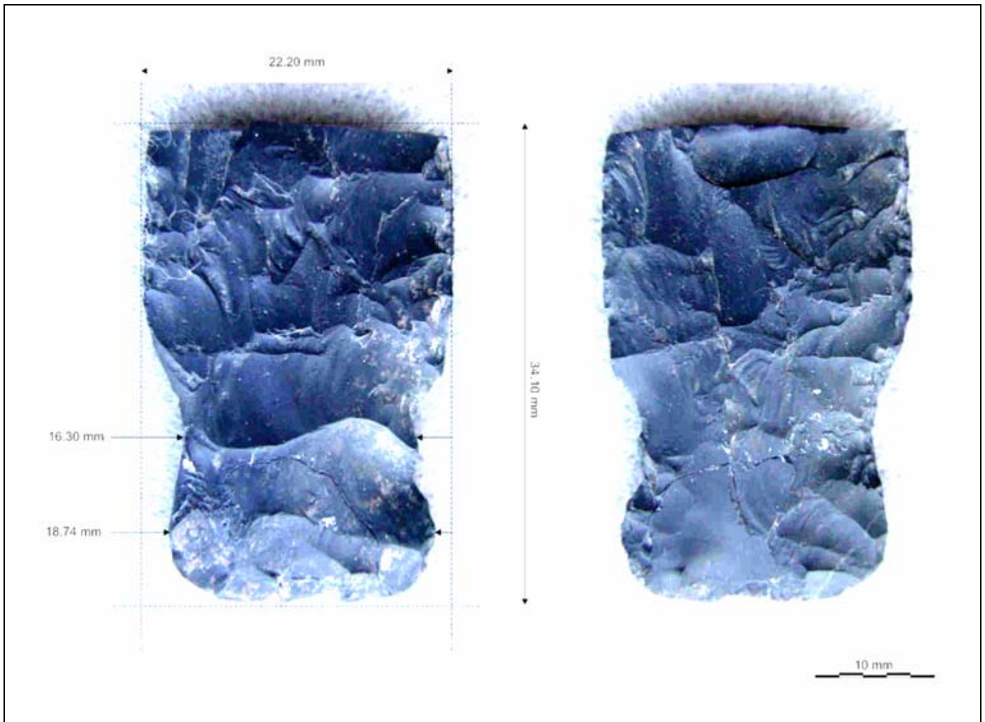


Figure 43. HkRe-001 Projectile Point Base.
Courtesy of Heritage North Consulting Ltd.

Figure 44 is a profile of the relief of the Beatton River Valley (with exaggerated relief), showing the elevation of the highest and lowest level of Glacial Lake Peace Clayhurst Phase. Note the terrain within the glacial lake basin is much more subdued than that outside. On the east side, if the glacial topography was similar to modern landscapes, the cliff would have bound the glacial lake. On the west side, the glacial lake would have flooded over the incised gully and spilled out along the shelf of land. The lip of land that contains the extent of the lake on the west might be due to the glacial lake itself or may be an artifact of other deposition/erosional factors. The lip to the west is captured by the Millennia moving window terrain identification technique (see Figure 45).

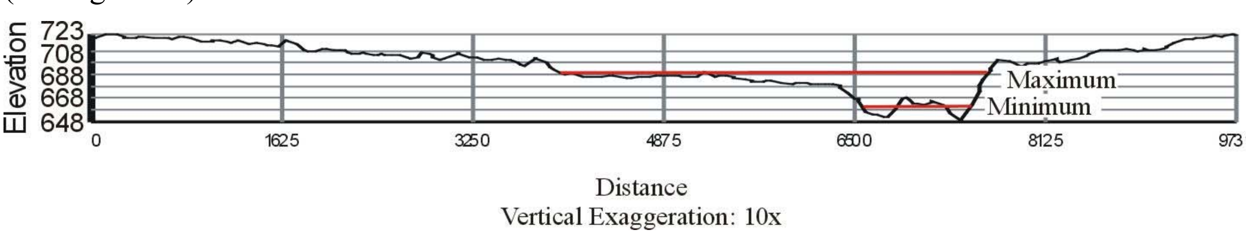


Figure 44. Profile of Tributary of Peace River.

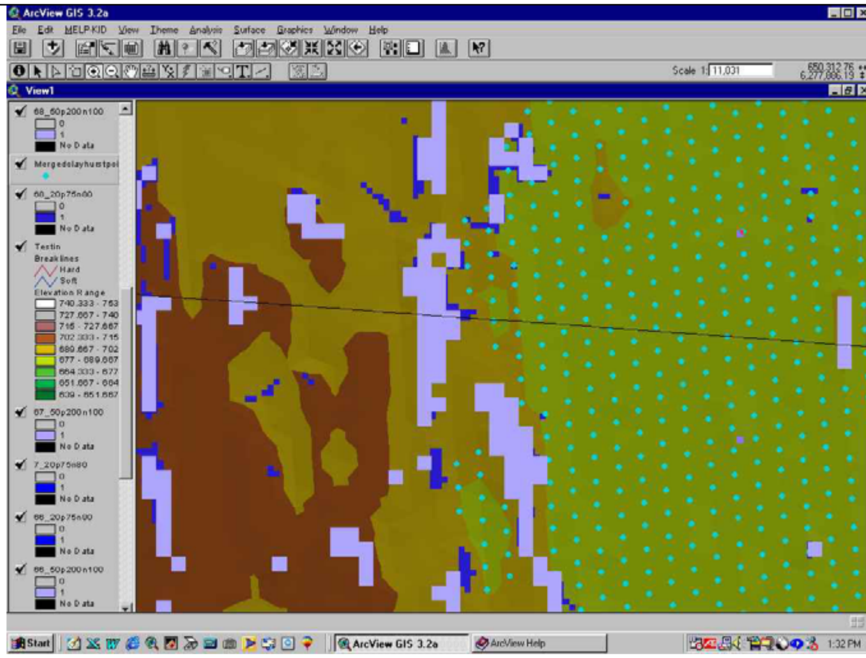


Figure 45. Close-up of glacial lake shore.
Blue dots represent extent of Glacial Lake Peace, purple squares are Millennia's terrain model. The black line shows the profile location of the previous figure.

One more archaeological site was identified in our database as being Palaeo-Indian (HiRi-001). Only a single lithic artifact, a lanceolate point base, represents the site. The exact location of this site is unknown due to inconsistencies of the site map and area maps provided with the site form. However, the site form indicates that the site is situation at the southeast facing edge of a prominent southwest-northeast trending ridge. This ridge is most likely captured as 'high potential' from the terrain model variables.

Palaeo-Indian research is considered a priority for Millennia Research as these sites were potentially missed by earlier models and represent a significant archaeological resource.

A look at the utility of ecosystem data in archaeological site prediction

Introduction

In March 2003, Millennia Research hired Joanna Burgar and Magnus Bein to determine if ecosystem maps are useful in predictive modelling for archaeological sites. Millennia Research was interested in improving the quality of the model by incorporating more ecosystem variables.

The BC government has instituted a standard ecosystem classification to map the province for a range of values. Terrestrial Ecosystem Mapping (TEM) and Predictive Ecosystem Mapping (PEM) are the products of this classification system and they characterize areas of the province at various scales.

Ecosystem mapping is the stratification of a landscape into area-based units, according to a combination of ecological features, primarily climate, physiography, surficial material, bedrock geology, soil, and vegetation (Resources Inventory Committee 1998, Resources Inventory Committee 1999, Resources Inventory Committee 2000a, Resources Inventory Committee 2000b). TEM inventories are conducted by the private sector and provincial government with the government providing quality assurance and data custodian roles. TEMs are produced at scales of 1:5,000 to 1:50,000. At the first stage of ecosystem mapping, ecosystem units are delineated on aerial photographs following a bioterrain approach. To draw and label polygons, the mapper considers vegetation, topographic, and terrain (surficial geology) features. Site, vegetation and terrain attributes are recorded in a polygon database, and final map completed. The polygons are digitized and compiled in a geographic information system, and stored in a provincial database.

PEM is a new and evolving program designed to use available spatial data and knowledge of ecological-landscape relationships to automate the computer generation of ecosystem maps (Resources Inventory Committee 1999 & 2000b). The PEM standard refers to the creation of 1:20,000 PEM maps designed to emulate 1:20,000 TEM maps. The mapping entities for PEM are: Ecosection, Biogeoclimatic unit (zone, subzone and/or variant), Site unit (site series or approximate equivalent), and Slope and aspect modifiers.

Methods

The TEM information was downloaded from the government website. Three areas were downloaded that were within the Millennia Research study site of Northeast BC: Sandy Creek, La Biche, and Dunedin. The BC government also has PEM data for Muskwa, an area within the study area (see reference section). The Muskwa data was not included in this report because there were no overlaps with the PEM data and the archaeology sites and the PEM data was in a different format than the TEM (PEM Data warehouse 2003, TEM Data warehouse 2003). Figure 46 displays the distribution of these areas.

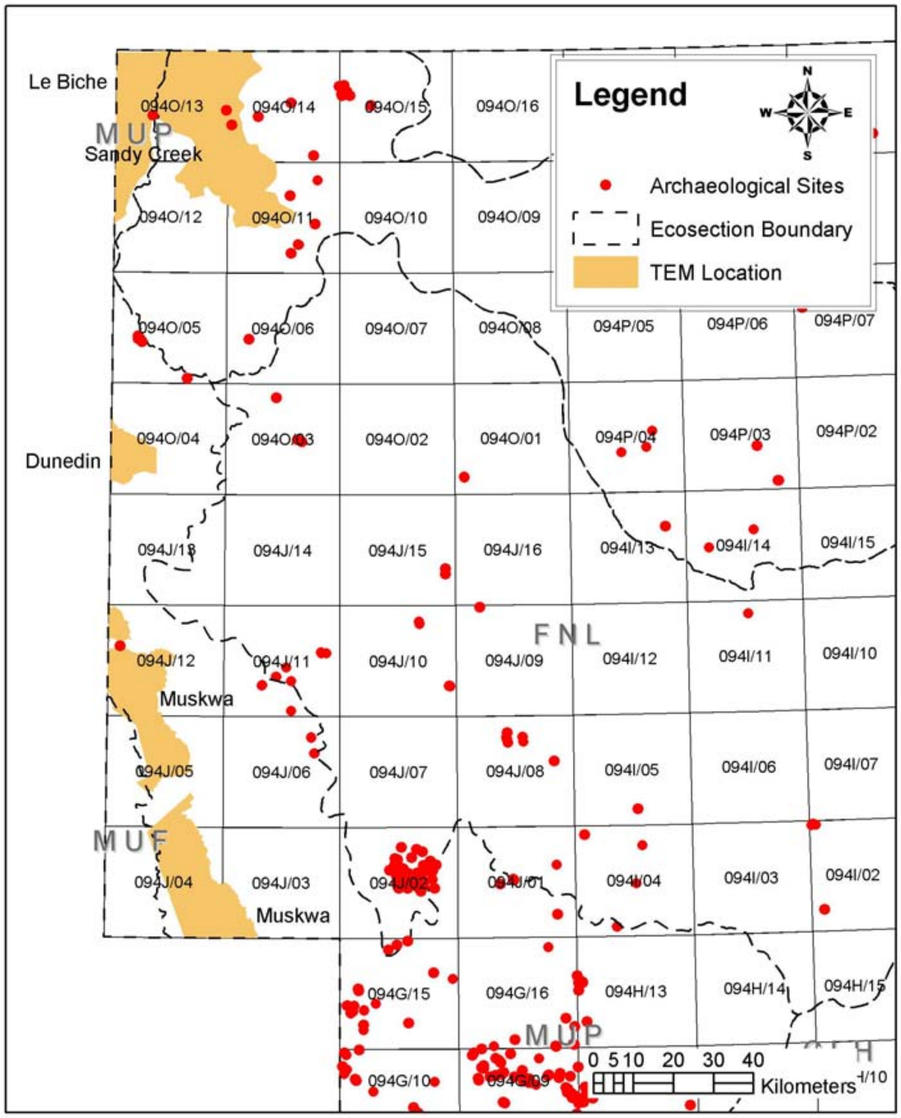


Figure 46. Distribution of ecosystem maps and archaeological sites within Northeast BC as shown with National Topographic Service map sheet numbers and ecosection boundaries.

All the shapefiles were confirmed and/or corrected for projection as well as ecological data. BC provincial government staff were contacted as the need arose to assist with the access, identification of data sources, and clarify file structures and relationships. The ecosystem and archaeological map layers were visually examined for overlap, and the archaeological site location points were found to overlap with Sandy Creek only.

With the proper preparation of the files for the archaeological sites, Sandy Creek, Dunedin, and La Biche complete, they were then queried for various values and attributes. Table 9 describes which attributes were analyzed. The recorded query results were finally interpreted and reported.

Table 9: TEM attributes with a description that were used in this analysis (Resources Inventory Committee 2000a).

TEM attribute	Description
Ecosection	Broad ecological region based on physiography.
Biogeoclimatic Zone	Broad ecological region based on climate, geography, and climate. Each biogeoclimatic zone has its own set of site series.
Site Series or Plant Community	The plant community occurring at the mapped unit with a certain structure and stage (see structural stage below). A plant community is the variety of plants growing on the site. The names of these series refers to the plants (usually trees and a common understory plant) that differentiate the community from other series. If a site series is named with a tree species and it is at a herb or shrub stage this is because the site series refers to the mature community that the site will tend to grow given time.
Structural Stage	The state of growth of the plant community at the time of mapping. It is based on the form of mature vegetation such as herbs, shrubs, or trees. The stage is the "ecological age" of the vegetation community (site series), usually since the last disturbance. The structural stage of a plant community changes over time, ideally progressing from a pioneer stage to a climax stage.
Decile	Is the occurrence of multiple sites series (plant ecosystems) occurring in the same mapped area. Each map unit can have up to three component site series. The extent of each component is based on percent multiples of ten. It is a measure of ecological complexity. Each decile will have a site series and structural stage.
Terrain Decile	The occurrence of multiple types of terrain in the same map unit. It is a measure of the variety of terrain in the area.
Drainage	The drainage type for the soil on site. Drainage refers to the rate and extent of water removal from the soil over the year. Multiple Terrain Deciles will each have their own drainage values.

Please note, in this section of the report, "site" refers to a mapped ecological unit and is often qualified with another term. "Archaeological site" in particular refers to archaeological sites that coincide with a mapped ecological area.

Results and Discussion

The ecosystem maps provided a total of 1,288 polygons or map unit areas. The areas covered by the polygons are in the Boreal White and Black Spruce Moist Warm Variant (BWBSmw) biogeoclimatic zone as well as the Maxhamish Uplands (MAU) and Muskwa Plateau (MUP) ecosections (DeLong 1991). The biogeoclimatic zone is assumed as occurring in Fort Nelson portion (BWBSmw2) due to the areas northerly situation (DeLong 1990). Table 10 presents the number of map units occurring in each of the ecological maps used in the analysis of data.

Table 10: Number of ecological map units within each map area.

Archaeological sites	Sandy Creek	Dunedin	La Biche
3	754	182	352

The resulting archaeological sites overlapped with the available ecosystem maps. The sites are all historic native burials.

Certain vegetation communities yielded some possibly significant results. The site series Sweet gale-three-leaved Solomon's seal fen and White spruce - Currant – Horsetail is a rare occurrence (Appendix 2 gives a description of this plant community) and two burial sites are associated. The Sweet gale-three-leaved Solomon's seal fen plant community is a classification unique to only Sandy Creek and La Biche areas. Appendix 2 provides a description of this plant community. Table 11 highlights the occurrence of the two plant communities in map areas as percent of the number of occurrences rather than physical area covered.

Table 11: Occurrences of Sweet gale-three-leaved Solomon's seal fen and White spruce - Currant – Horsetail ecological community types (decile 1) in map units.

Plant Community	Archaeological sites	Sandy Creek	Dunedin	La Biche
Sweet gale-three-leaved Solomon's seal fen	67%	25%	0%	0%
White spruce - Currant – Horsetail	33%	>1%	>1%	30%

Structural Stage of the plant community pertains to structure and age. Table 12 summarizes the occurrence and distribution of these values in the analyzed maps. The archaeological sites possessed values of 3 (67%) and 6 (33%). No adequate results were obtained from Sandy Creek in this analysis. 40% of polygons in Dunedin had a structural stage of 3 and 1% had a value of 6. In La Biche 81% of the map units had a value of 4 or 5.

Table 12: Occurrence of structural stages in decile 1.

Value	Archaeological sites	Sandy Creek	Dunedin	La Biche
3	67%	n.d.	40%	n.d.
4 to 5	0%	n.d.	n.d.	81%
6	33%	n.d.	1%	n.d.

A value less than 3, which would include a structure ranging from sparse vegetation to abundant low lying, non-woody plants (herbs), can be a characteristic of wetlands. A structural stage of "3" refers to a shrub/herb stage: the plant community is characterized by woody plants ranging from 2 to 10 m in height. The site at stage 3 may be maintained by environmental conditions or disturbance (e.g. snow fields, avalanche tracks, wetlands, flooding, intense grazing, intense fire damage). The age of the shrub structure is usually 20 to 40 years after the last major disturbance, unless the site controlled by an environmental conditions or disclimax. In such a case the environmental stage could be older and considered a non-forest ecosystem like a wetland or grassland. Structural stage of "6" means the site is a mature forest, from 80 to 140 years old.

Table 13 shows that the map units are complex, because they contain more than one kind of plant community. The table presents the kinds of plant communities that resulted from the archaeological sites and how much they occurred in the mapped areas. The archaeological sites had two have values: White Spruce – Trembling Aspen - Step moss and Black Spruce - Lingonberry - Knight's plume (refer to Appendix 2). In Sandy Creek there was a 15% occurrence of White Spruce – Trembling Aspen - Step moss and 3% for Black Spruce - Lingonberry - Knight's plume. In Dunedin, 14% of the polygons had White Spruce – Trembling

Aspen - Step moss and 16% had Black Spruce - Lingonberry - Knight's plume. 12% of polygons in La Biche have values of White Spruce – Trembling Aspen - Step moss; none had Black Spruce - Lingonberry - Knight's plume values.

Table 13: Occurrences of White Spruce – Trembling Aspen - Step moss and Black Spruce - Lingonberry - Knight's plume ecological community types (decile 2) in map units.

Plant Community	Archaeological sites	Sandy Creek	Dunedin	La Biche
White Spruce – Trembling Aspen - Step moss	67%	15%	14%	12%
Black Spruce - Lingonberry - Knight's plume	33%	3%	16%	0%

Some of the structural stages of the additional plant communities are presented in Table 14. The archaeological sites had values 3, 4 or 5, and 6. 52% of additional plant communities in Sandy Creek were at 4 or 5. In Dunedin it was 59%. La Biche had 32% of additional plant communities at structural stage of 4 or 5.

Table 14: Occurrence of structural stages in decile 2.

Attribute	Archaeological sites	Sandy Creek	Dunedin	La Biche
3	33%	n.d.	n.d.	n.d.
4 to 5	33%	52%	59%	32%
6	33%	n.d.	n.d.	n.d.

A structural stage of "3" refers to a shrub/herb stage, as described in the paragraph presenting the results of Structural Stage 1. The structural stage of "4" is a forest at a sapling stage, woody species are greater than 10 m high and usually dense, and may vary widely in age since last disturbance, less than 40 years or upwards of 100 years. The structural stage of "5" is a young forest which is less dense than the sapling structural stage (4) and ranges in age from 30 to 80 years since the last major disturbance. Structural stage of "6" means the site is a mature forest, from 80 to 140 years old.

Table 15 shows that the map units in all map areas are quite complex and contain up to three different plant communities in each map area unit or polygon.

Table 15: Occurrence of a third decile in any map unit.

Archaeological sites	Sandy Creek	Dunedin	La Biche
Yes	Yes	Yes	Yes

The map area units in the maps have a further aspect of complexity. Table 16 indicates that all the maps have up to two different occurrences of terrain descriptions. These do not necessarily coincide with the occurrence of various ecological communities.

Table 16: Occurrence of terrain deciles in any mapped units.

Attribute	Archaeological sites	Sandy Creek	Dunedin	La Biche
Terrain Decile 1	Yes	Yes	Yes	Yes
Terrain Decile 2	Yes	Yes	Yes	Yes
Terrain Decile 3	No	No	No	No

Table 17 shows some of the specific values of terrain that the map units show. 67% of the archaeological sites have organic soils and medium textured soils; 33% occur on a warm aspect. In Sandy Creek 47% of the units have organic or peaty soils, 2% are on a warm aspect and 9% have medium textured soils. 16% of polygons in Dunedin are peaty and medium textured and 35% occur on a warm aspect. 19% polygons of La Biche have values of either p or w. Peaty/organic soils means up to a depth 60 cm of the soil is classified as organic. The warm aspect means the map unit faces southerly or westerly direction on slopes with 25-100% grade.

Table 17: Occurrence of peaty soil, a warm aspect, and medium textured soils in the map areas.

Attribute	Archaeological sites	Sandy Creek	Dunedin	La Biche
Organic soils	67%	47%	16%	10%
Warm aspect	33%	2%	35%	9%
Medium textured soils	67%	9%	16%	0%

Interpretation and Recommendations

There are interesting ecological associations that may prove to relate to archaeological sites given additional study including ground truthing and fieldwork. There were only three archaeology sites that overlapped with the ecological map units, much too small a sample for general analysis. A better analysis (in lieu of a larger archaeological sample) would be to compare the TEM with the potential model ratings, which were not available at the time of TEM assessment. The three sites were all burials, and are probably not typical of locations for lithic scatter sites (the most common archaeological site), but burial sites are highly sensitive, and any correlation with useful mapped data would be helpful. The associations yielded important values for plant community type (site series), present character of ecosystem (structural stage), and terrain attributes (soil texture, slope, aspect, *etc.*). Detailed analysis of ecological data, addition of other ecosystem maps, and different approaches will yield more information and help find definite ecological indicators of archaeological sites.

All three of the archaeological sites that overlapped with the TEM polygons were historical burial sites. They had a gentle slope to level ground. Two of the sites were considered organic wetland with a Sweet gale-three-leaved Solomon's seal fen; a unique ecosystem only mapped in the Sandy Creek and La Biche areas at the shrub structural stage. White Spruce – Trembling Aspen - Step moss community also occurred in these polygons. The other site was classified as a moist, receiving site, with coarse textured soil and the dominate vegetation was White spruce - Currant - Horsetail at a mature forest stage. Black Spruce - Lingonberry - Knight's plume community also occurred in this polygon.

The occurrence of these plant communities, especially in combination, appears to be related and may be an important indicator related to archaeological sites. Sweet gale-three-leaved Solomon's seal fen and Black Spruce - Lingonberry - Knight's plume occur infrequently in the map areas. White spruce - Currant – Horsetail communities is considered common only by rivers, and was infrequent in the analyzed maps. These plant communities, especially in combination with other site series of complex polygons, may indicate increased archaeological potential.

The structural stages of these polygons also may provide a clue to potential archaeological sites. Old structural stages (6 and above) and relatively young stages (1-3), may further specific significant polygons. This may be true for younger stages that are that way due to environmental controls, like shallow soils or flooding, and non-forest ecology, such as meadows, wetlands, and berry thickets, that have persisted for longer than 40 years. The structural stages confirm the age of the polygons since last major disturbance and the nature of the site from normal climax forest conditions. The history of disturbances may be a major factor in site prediction because traditional resource use often prefers younger seral stages. Ecological units with greater natural disturbance ratings may have a higher archaeological potential.

Further analysis could prove useful in finding strong relationships between ecological data and archaeological sites. Available maps and tables that were not accessed as well as future ecosystem maps are recommended for study including:

- point samples use to generate polygon classifications – these contain detailed site descriptions that include a soil pit description, micro-topography, and other observations of note;
- PEMs, like Muskwa, that provide a further base to find unique patterns and combinations;
- Habitat rating maps for existing and future areas; and,
- Future ecological maps, like Snake/Sahtenah.

The data could be analyzed according to known links to archaeological values. For example, analysis of ecosystem maps could be based on traditional First Nation's uses and values in relation to animal habitat, plants, ecosystems, and topographic situation as signified by site series, structural stage, terrain, and other relevant attributes.

These databases could also be searched for attribute values that are already known to be indicative of archaeological sites such as hummocky surface topography. This kind of information is documented in the TEM databases and are likely useful for finding habitation, resource use, and burial sites.

Field work within a sample of TEM polygons will reveal the relative importance of the attributes in determining archaeological potential. The current overlap is too small to draw statistically significant conclusions. With more ground-truthed ecological and archaeological overlaps, important relationships should be apparent. Fieldwork in existing sites to characterize and ground truth ecological values could evaluate the usefulness of TEM.

TEM polygon size and accuracy relates to the scale at which they were created. For example, the Sandy Creek TEM was created at a 1:50,000 scale, with a nominal accuracy of 50 m (Resources Inventory Committee 1998, Resources Inventory Committee 1999, Resources Inventory Committee 2000a, Resources Inventory Committee 2000b). The average size of the polygons in this TEM was 116 ha, with a standard deviation of 161 ha. The large standard deviation indicates that the distribution was not normal. Polygon size ranged quite drastically from only one hectare to hundreds. All currently available TEMs in the study area are at a 1:50,000 scale, although TEM standards accept scales from 1:5000 (with a 5 m accuracy) to 1:50,000 (with a 50 m accuracy).

Potential Map Interpretation

The maps show archaeological potential according the model score for each 20 m cell. These potential ratings are essentially archaeological density or probability values. Archaeological sites will be in the highest density in the Very High potential zone, which has the largest number of sites in the smallest area of all the classes. The Low potential zone has the fewest sites in the largest area (and we believe many of these sites are actually mis-mapped).

An impression of the general potential of the area can also often be obtained by viewing a small-scale map such as an entire 1:50,000 sheet. The headwaters of several drainages in the Milligan Hills is represented in 94H/07 (Figure 47).

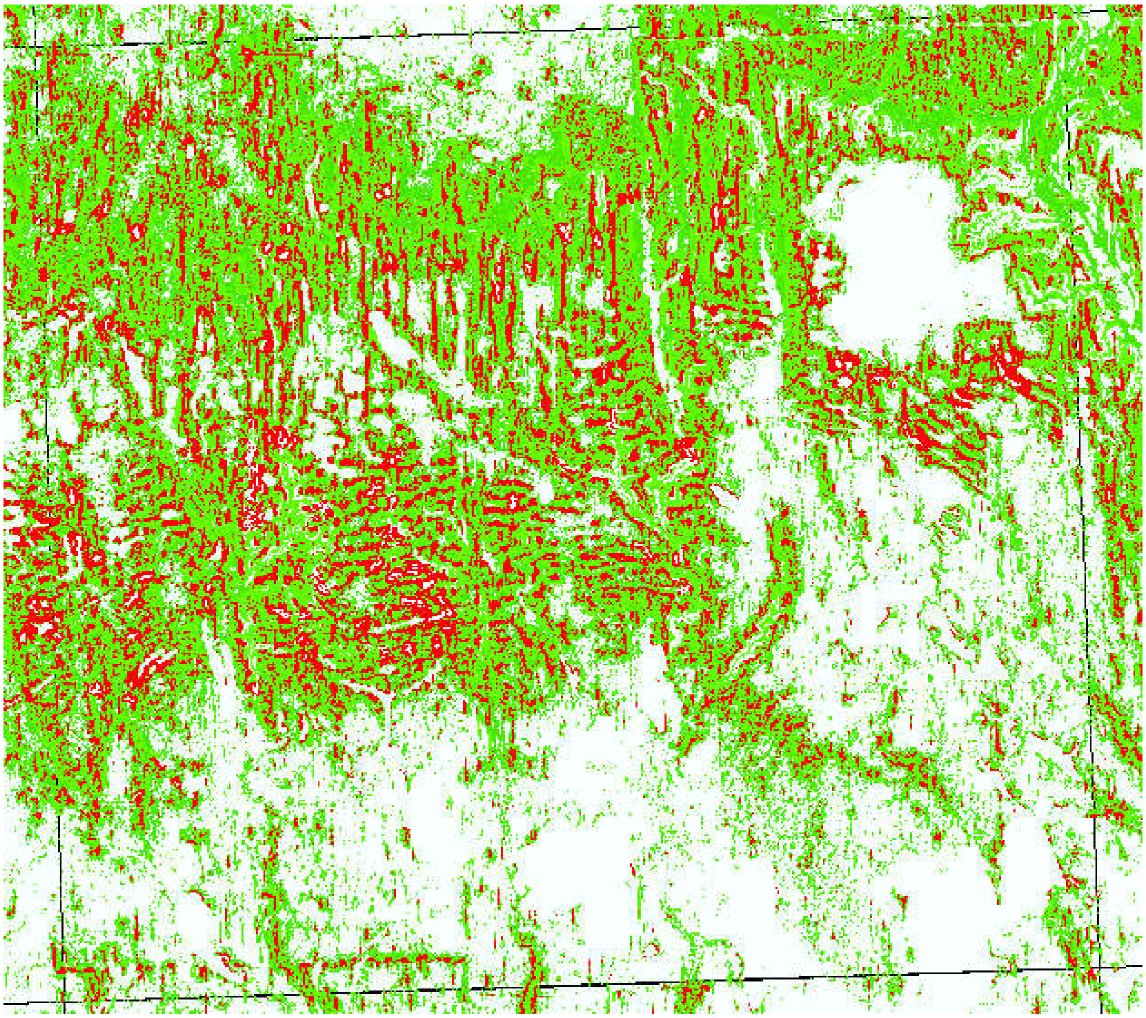


Figure 47. Entire 1:50,000 mapsheet 94H/07 archaeological potential map.

Green areas moderate and red high potential. Shown about 1:250,000 scale. This is a complex area of east-west hummocks (centre) and north-south pine ridges (north) at the headwaters of several drainages.

This area has numerous glacial features resulting in a large proportion of moderate and high potential. By contrast, 94H/10 (Figure 48), the map just to the north of 94H/07, has extensive low potential that reflects large wetland and muskeg areas.

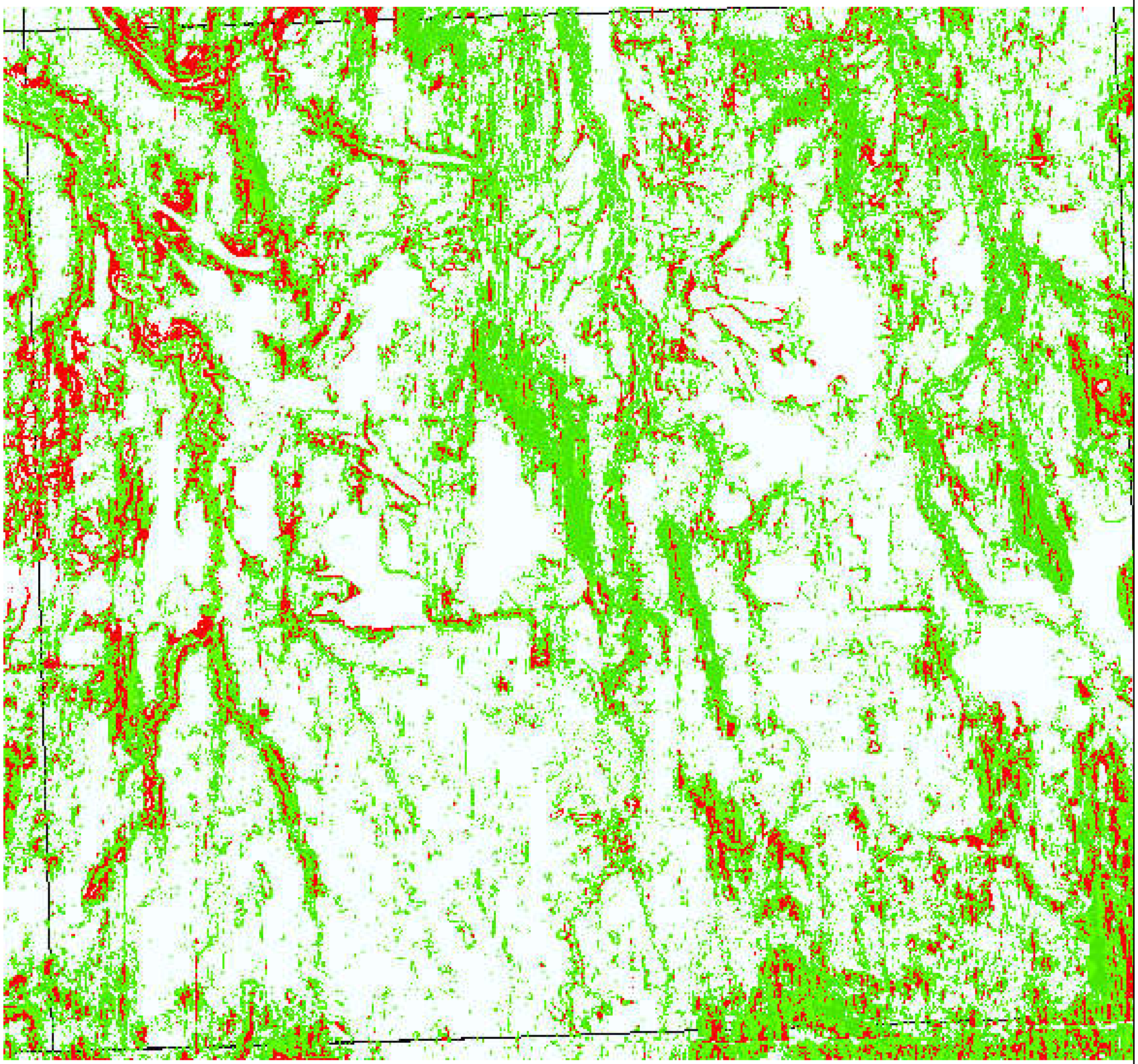


Figure 48. Entire 1:50,000 mapsheet 94H/10 archaeological potential map.

Shown about 1:250,000 scale. This area has far less archaeological potential relative to the preceding figure, which adjoins to the south.

We believe the maps need to be interpreted relatively. That is, in an area of extensive high potential, many moderate potential areas that border high potential may actually have lower potential. Conversely, some moderate potential areas may actually rate high if they are the only higher potential areas in a large area of low potential. Keary Walde often states (personal communication, 2003) of such moderate potential areas "they may be not very nice places, but everything else around them is worse so they are the best option for a camp". This assumption regarding relative potential needs to be tested in the field further, but initial ground truthing suggests this is accurate (Figure 49, Figure 50).

Map user that need to interpret the map should look for patterns of higher potential that suggest a complex terrain feature or a natural trail corridor may be present.

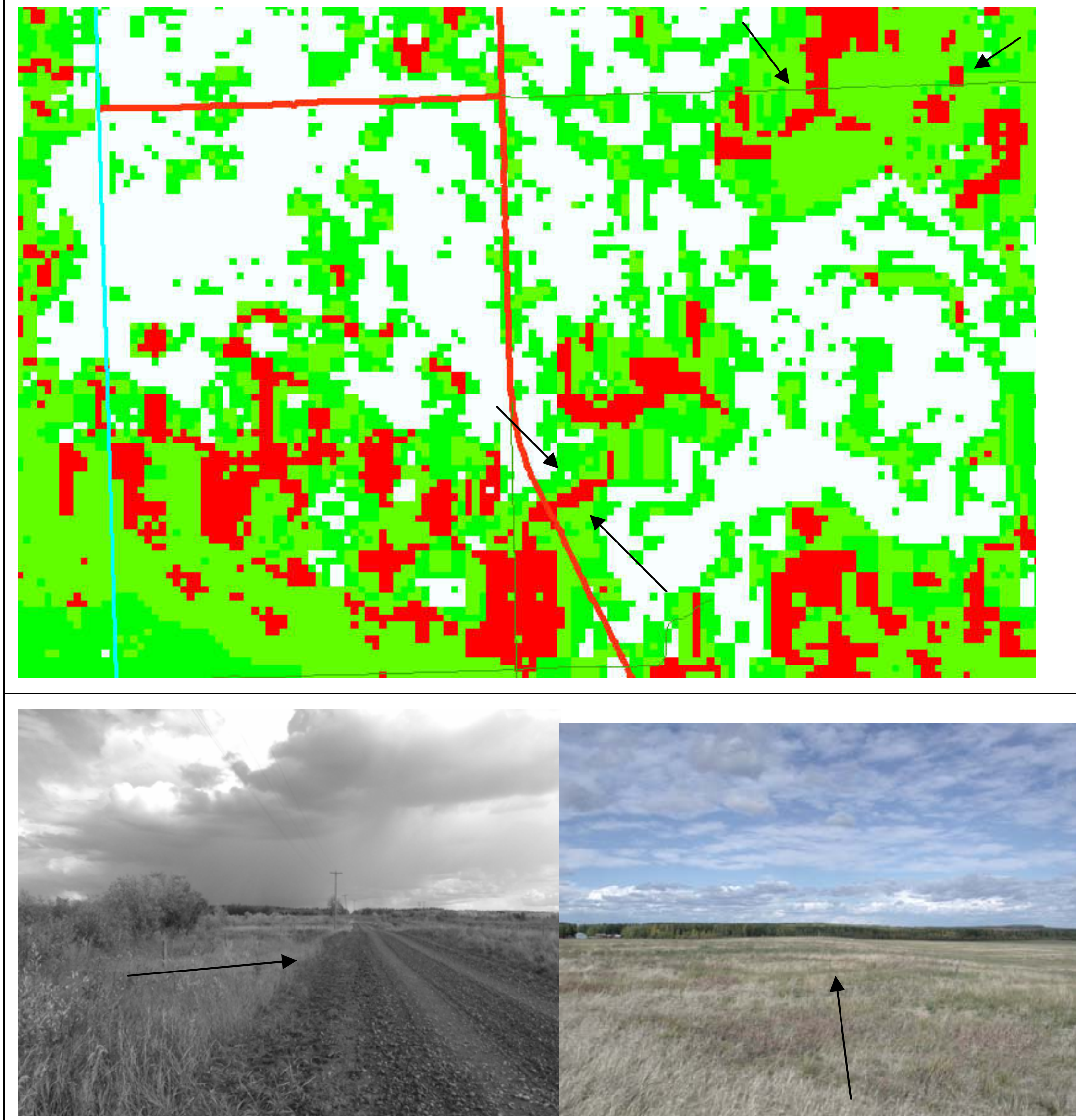


Figure 49. Microtopographic features identified in field and on map.
Photo at left shows road passing over ephemeral ridge with archaeological potential. This portion of ridge was identified by original topographic model. Current model (top map) shows red high potential, upper leftmost arrow. Photo at right shows ephemeral ridge with potential, much of it not identified in original topographic model. Current model improvements shows this feature as red line between paired arrows in the lower-central portion of the map above. In these areas, green moderate potential flanking red is over-rated, and should be considered low potential. Area indicated by upper right arrow was also identified as having potential in a field survey. *K.Walde, Heritage North photos.*

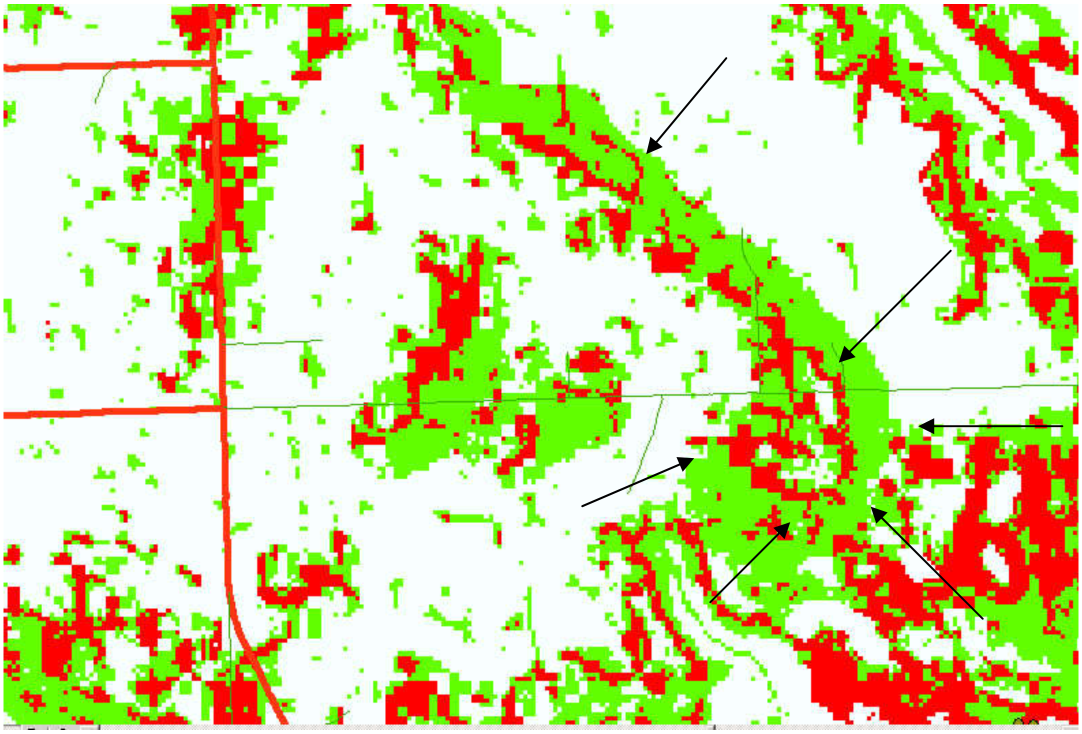


Figure 50. Topographic feature identified in field and on map.

Map shows long, hooked feature between arrows. This corresponds with marked slope break in photo The origin of this feature is unknown, but it may be a glacial outwash channel or a glacial lake scarp. Red high potential follows top of slope break. Green moderate potential flanking red is over-rated, and should be considered low potential. *K.Walde, Heritage North photo.*

Figure 50 shows a hook-shaped feature in a large area of plains. The origin of this feature is uncertain (it is at the correct elevation to be a shoreline of Glacial Lake Peace, Clayhurst Phase), but the archaeological potential of the feature is clear, and a site was found here when testing the terrain model. Figure 51 shows an area of 1:50,000 map 94H/2. A linear area of north-south ridge is evident through the centre of the map creating a natural corridor connecting Big Arrow Creek to Milligan Creek. This appears to be a low ridge through an extensive area of muskeg swamp and would be a natural place to expect many archaeological sites even though much of the area is moderate potential rather than high.

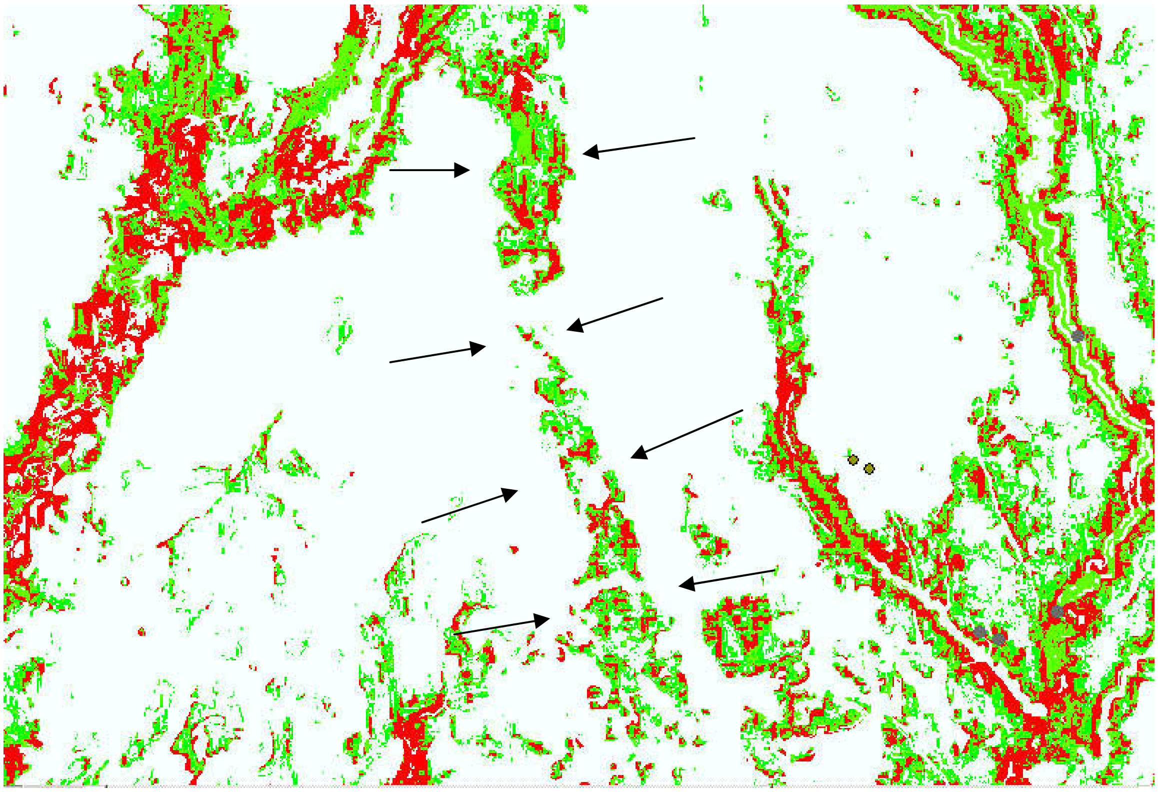


Figure 51. Map interpretation – possible trail corridor and potential upgrading.

Map shows 12 km long, low ridge at height of land connecting drainage systems to the north and south. As a natural trail corridor, virtually all this area should be considered high potential, possibly even low potential lands interpolated between higher potential along the route.

Areas of the map where there are many small high potential patches likely represent hummocky or ridged areas with high potential. Often (at least in the Clear Hills), these are oriented north and south.

In rare cases the model generates high levels of potential when the potential is actually Low. Many of these can be recognized during map interpretation. Breaklines around lake or swamp features can have inaccurate (for our purposes) elevations in TRIM. If neighbouring spot elevations are accurate (when they should be very similar), then the model will recognise this as a hillock or terrace edge which isn't actually there. (TRIM elevation accuracy is supposed to be within 5 m of absolute elevation, so many of these differences are technically not "errors" or "inaccurate", but we rely on finer **relative** elevation differences for our modelling). In some cases these are obvious from a single line of pixels with higher potential (Figure 52).

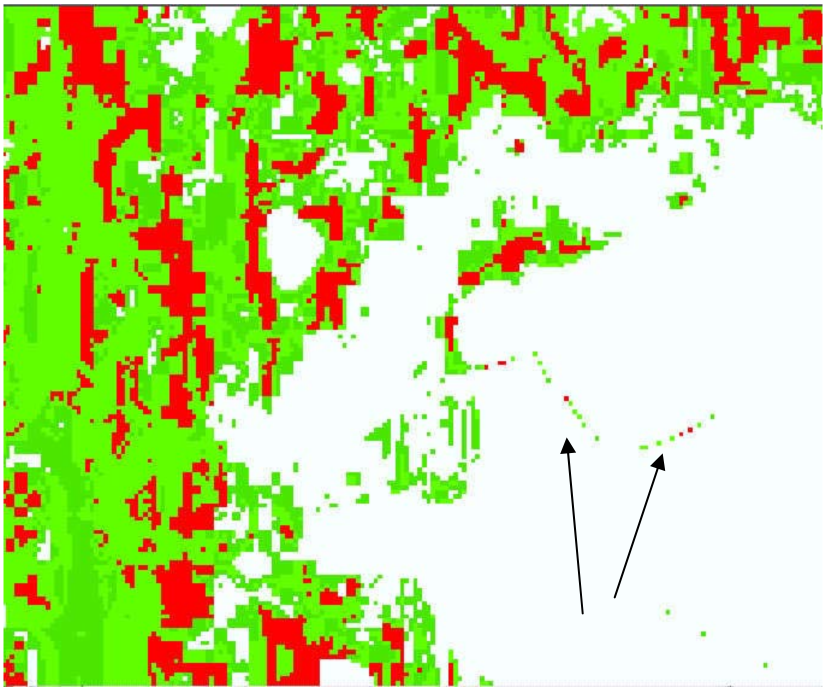


Figure 52. Lines of high potential pixels from TRIM breakline elevation error.

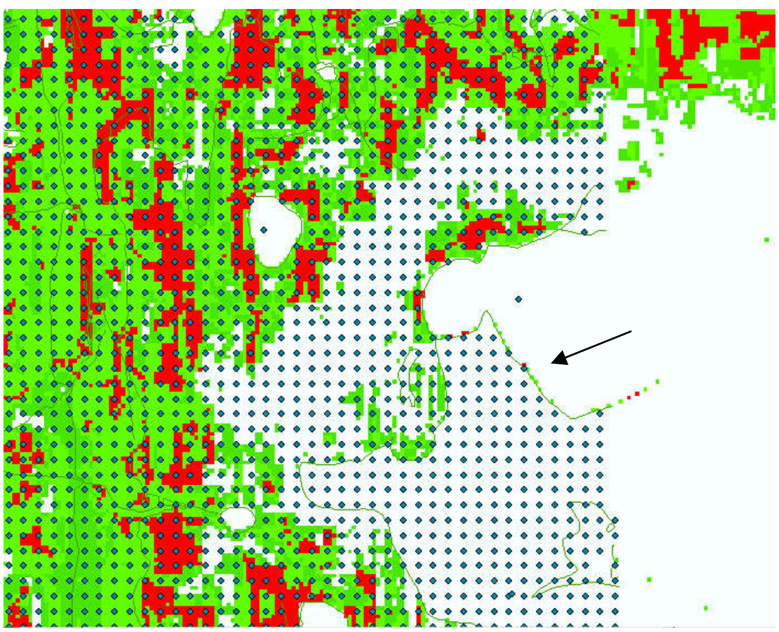


Figure 53. Same map showing lake to swamp breakline with matrix of elevation points that led to incorrect high potential pixels.
This error is simple to identify because it occurs along the dividing line between lake and swamp. The lake is the blank area in which the arrow is placed: the swamp is the white area to the left overlapped by the matrix of elevation points (green dots).

When the same error occurs along swamp edges, oxbow lakes, river banks, etc, it can be more difficult to spot the inaccuracy. A tentative observation is that suspect slope breaks seem to show as high potential directly on the boundary of a swamp or lake or on a river sandbar, whereas real breaks have high potential separated from the feature by 20 or more metres (one or more cells) (Figure 54). This needs to be confirmed during ground truth survey. In such cases, if the higher potential is suspect due to its appearance on orthophotos, etc, and if TRIM data is accessible, the breaklines and spot elevations (the “l_ha arc” and “l_ha point” layers) can be added and labelled to see if breaklines are responsible. In Figure 54 such an area has been displayed, and the relatively high elevation in the centre of the top part (955-956 m) compared to the surrounding area (many below 950m) suggests a low rise is, indeed, present and the user can have reasonable confidence in the model. The area of higher potential to the left of the lake, however, is less likely to be associated with a landform feature, since the elevation is only 1 to 3 m above the lake. The upland elevations behind this high potential indicate very flat terrain and this lakeshore feature should be considered low potential unless additional data sources suggest otherwise. The TRIM II map coverages are supposed to have updated, much more accurate, breakline data, and using the new data (in Year 4) may remove most of these inconsistencies.

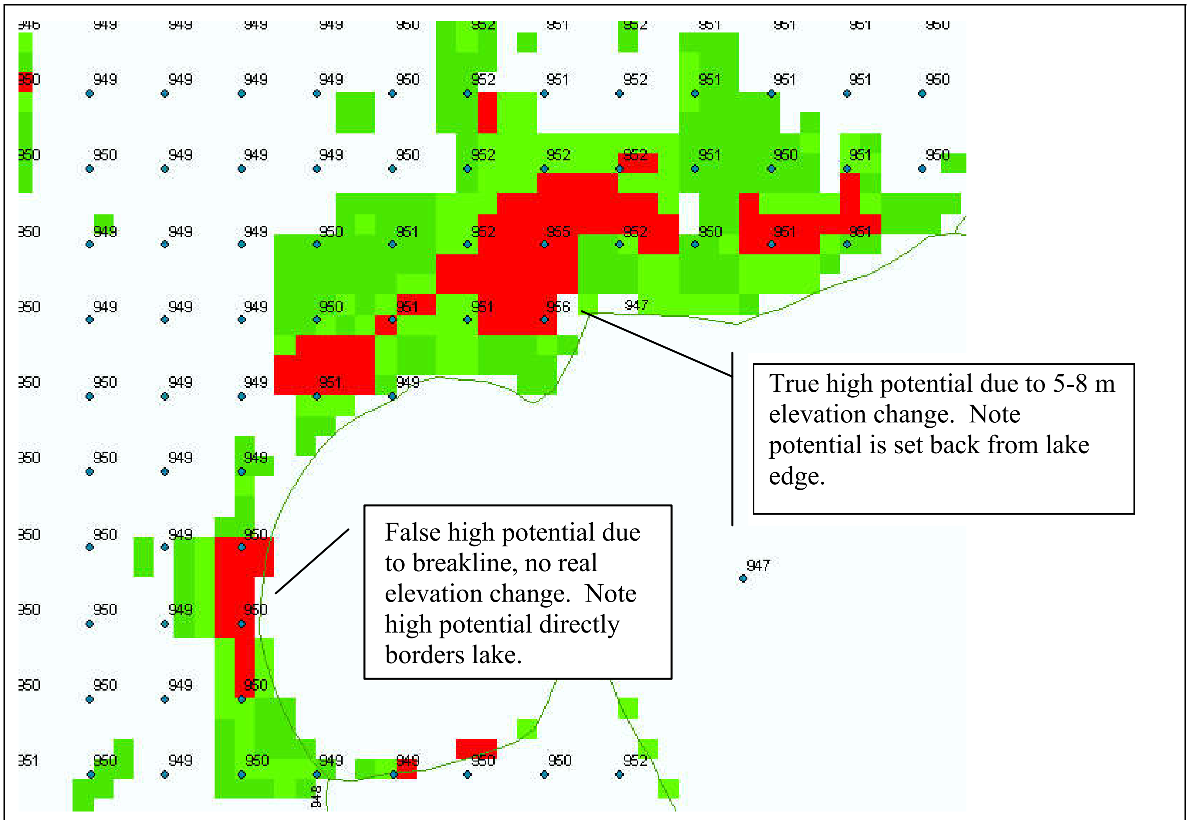


Figure 54. Enlargement of lake margin within previous figures.
Spot elevations and breaklines (shoreline and lake elevation 947) confirm that at least some of this potential area is substantially higher than surrounding terrain, and higher potential appears justified.

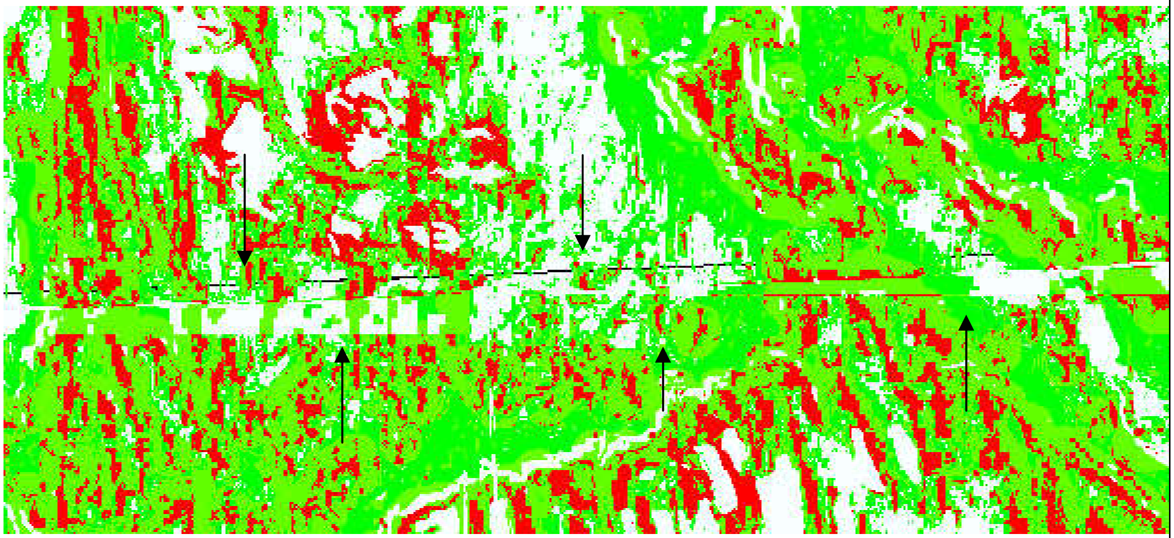


Figure 55. East-west linear features of both higher and lower potential due to TRIM mapsheet join errors.
Inconsistencies between elevations in the Digital Elevation Model for overlapping adjoining mapsheets produce white (low potential) and red (high potential) errors. Nearby landscape features remain accurate.

In other cases errors arise due to mapsheet joins (Figure 55, Figure 56). Mainly, features following (or up to 200 m away and parallel to) map joins should be considered suspect. These areas are easy to find and interpret. Other long east-west alignments may have nothing to do with mapsheet joins, but increased potential is dubious if they end at map sheet boundaries (Figure 57). Such features may be have been introduced during the TRIM mapmaking process, perhaps where the spot elevations calibrate to another known elevation in order to remain within the 5 m true elevation accuracy requirements of TRIM. A sudden 4 or 5 m aligned shift will cause our model to interpret this as a slope break, despite the absolute elevations remaining within acceptable accuracy limits.

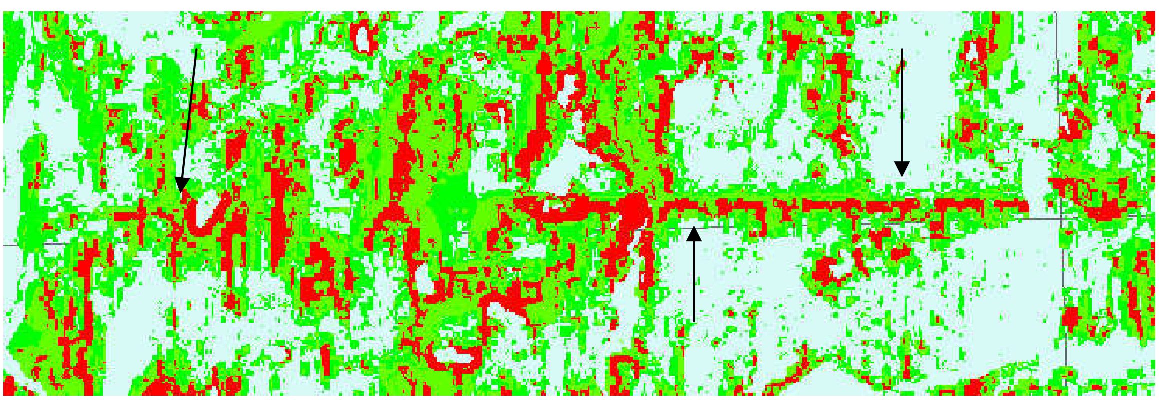


Figure 56. East-west linear features of higher potential due to TRIM mapsheet join errors.
Inconsistencies between elevations in the Digital Elevation Model for overlapping adjoining mapsheets produce all green and red (high potential) errors. Mapsheet boundaries appear as black lines.

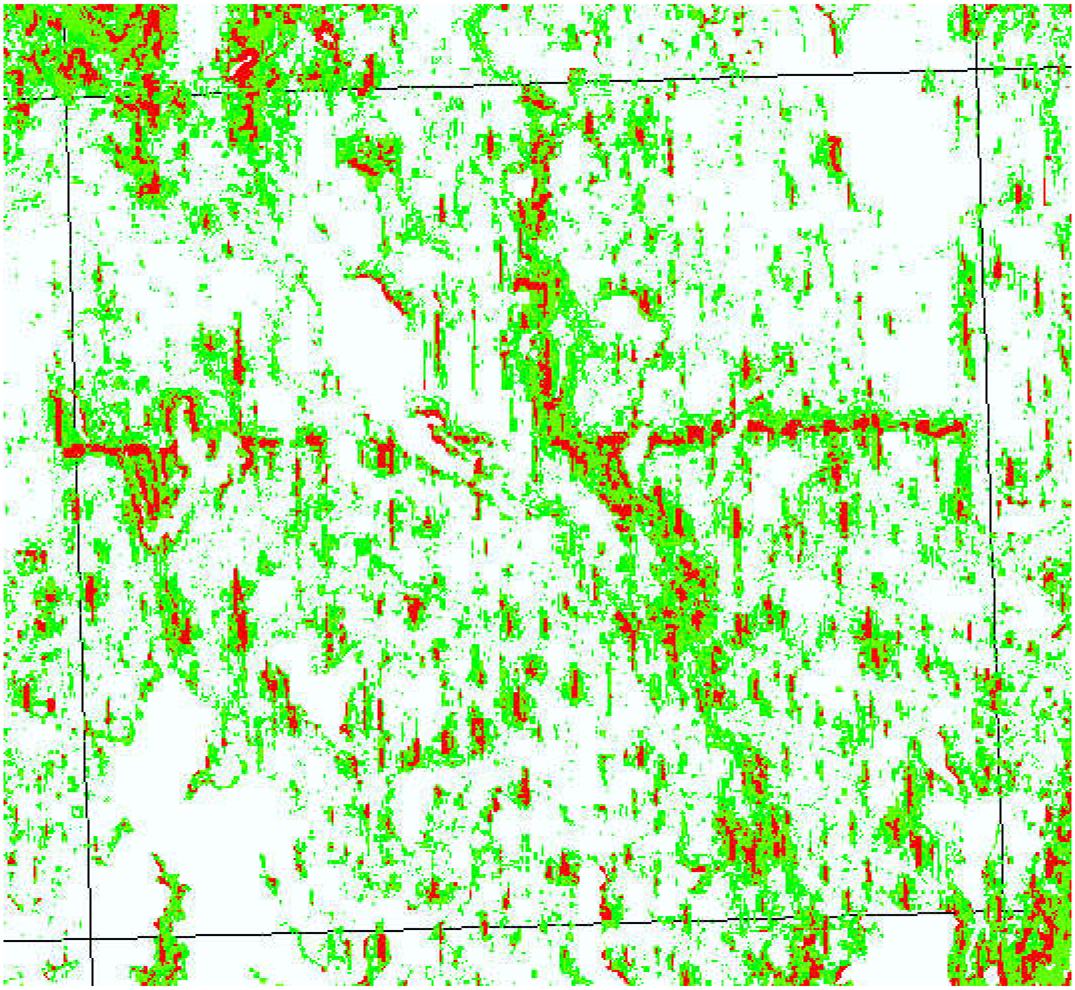


Figure 57. East-west linear feature of doubtful higher potential attributed to a mapping problem (not a mapsheet join error).
This linear feature is independent of the TRIM boundaries, which appear as black lines.

Model errors where actual high potential is shown as low potential are more difficult to identify and compensate for during map interpretation. Some hummocks and microtopographic rises and ridges are too small to be captured with the current DEM.

Sometimes landforms too small to be identified by the model parameters can be interpolated between points that the model does capture. Thus, an apparent landform such as a ridge or terrace edge may appear intermittent on the map, but if not destroyed by erosion or other forces, it may still be present on the ground and interpolated from map reading (Figure 51).

Above all, the map should be taken as a guide. Additional information such as large-scale development plans with detailed tree cover data and fine resolution topographic mapping may contain information that will override the potential map.

Future Directions

Several important directions were identified during the course of fieldwork, modelling, and reporting for the northeast AOA, for Year 4. These are organized into data, field, and modelling categories:

Data

1. A renewed effort to identify and map trails could include adding trails data from the Prophet River Band, who have tentatively agreed to copy their trails maps for the model (pers. comm. Dave Caldwell to Morley Eldridge 02/2003). This could also include Surveyor General's maps and maps in Leonard (1995), who possibly uses maps from Surveyor General's (pp. 83 including map on pp. 38 and 230, "Native Trails [to Dunvegan] from the Geological Survey of 1891"). Other bands will be approached as well.

2. Pertaining to point 1), we should attempt to model for trails using terrain and/or other variables. This is particularly important in areas where trails are very strongly associated with potential, for example the Muskwa Plateau. This might help us identify where trails are likely to have existed in the past. This year's database was unable to analyse trail location due to the lack of near-to and identity data for a large enough sample of trail points. This data could easily be obtained from a series of evenly spaced interval points along known trails. As well a new TYPE may be required in the modelling database, for example "TRAL."

Field

3. As reported by Bein (in this report), Terrain Ecosystem Mapping (TEM) may be useful and additional TEMs are being carried out within our study area. In particular, the Snake-Sahtenah TEM, which hasn't yet been released, is directly within the study area and will be cross-referenced with known archaeological site information in the near future.

4. Some field work should be directed at working with elders, including revisiting known archaeological sites and identifying trends in traditional landscape use and ecological knowledge. This information can add human variables to the model, and ensure that local knowledge of use and reuse of the landscape is integrated and valued. By focussing on trends and broad categories of understanding instead of location-specific information, traditional use and ecological knowledge can be integrated into a potential model.

5. The terrain model identified hilltops of varying relative height, but none were statistically associated with sites in the model database, so hilltops were not used in the model. Shovel testing a sample of these features could determine if they are, in fact, high potential and are underrepresented. Many of the Clear Hills model-identified larger hilltops were, in fact, eroded terrace or ridge remnants, rather than hilltops in the normal sense. Hilltops in other ecosections may be more likely to be associated with sites.

6. Large tracts of land, especially in the northern portion of the study area, are only represented by burials in the database of known archaeological sites. Obviously, other types of sites exist in these regions. As burials are a very special and ceremonial site type, habitation and hunting sites are unlikely to pattern in the same way. Some survey should be directed at

these regions and sites need to be recorded to alleviate this bias. This is particularly important in the Petitot Plain, which has only three sites.

7. In the Muskwa Plateau ecosection, a very interesting pattern of site locations was discovered. In the model database, more site points than (the much more numerous overall) random grid points occurred in regions within 100 m of terrain features (such as terrace edges and ridges) and having a moderate (35 to 70%) amount of pine. Currently, reasons for this are unknown. However, the statistical significance of this pattern is very robust, and ground-truthing this variable and attempting to understand it could be a focus of the field work in the Muskwa Plateau next year.

Modelling

8. The model database will be reworked to remove sample points from polygonal site boundaries. Problems were noted with using the boundary to obtain model database points. Instead, the 'grid' coverage for sites will be used to identify data points. Very small sites which have one cell will supply one sample point for the database, while polygonal sites will contribute as many points as cells as they contain. Very large sites may be sampled to ensure that a single site doesn't dominate the model database and skew the parameters chosen for each variable.

9. Some time in both office and field will be allocated to site location correcting in the Etsho Plateau ecosection. Sites appear to be located in lakes and swamps in high numbers in this region. A sample of sites should be ground-truthed (relocated and mapped) and all should be orthocorrected.

10. TRIM II data is now available virtually all of the study area. TRIM II DEM breaklines are apparently much improved. TRIM II will be used to build topographic models for all areas without a model. The data will be investigated to determine whether or not it sufficiently improves the quality of the terrain mapping to make worthwhile re-running the terrain models for Clear Hills and Muskwa Plateau.

11. Adjacency analysis for relevant forest cover polygons should be tested in select ecosections to determine if this is archaeologically relevant. For example, aspen stands in the Clear Hills might have increased potential if they are surrounded by spruce, but not if surrounded by pine. These patterns might be accessible digitally if an adjacency analysis is carried out.

Standards for Site Inventory Forms and AIA/PFR reporting

12. Site Inventory Forms should require as a standard a mid-range scale map, such as 1:5000 to 1:10,000, be included to allow for accurate site location checking. Large-scale site maps combined with a 1:50,000 inset often do not provide sufficient information.

13. A very useful check of the model performance could be obtained from comparing field assessments to the mapped model. The OGC could consider making this a requirement and tracking the results to assist with model updating and map interpretation.

References:

Bonner, F., M. Eldridge and P. Dady

2001 *Final Report for the Archaeological Overview and Inventory of a Portion of Ditidaht First Nation Traditional Territory*. Report on file at the Heritage Resource Centre of the Ministry of Community, Aboriginal, and Women's Services.

Brandt, R., B. J. Groenewoudt and K. L. Kvamme

1992 An Experiment in Archaeological Site Location: Modelling in the Netherlands Using GIS Techniques. *World Archaeology* 24(2):268-282.

Catto, N., D. G. E. Liverman, P. Bobrowski and N. Rutter

1996 Laurentide, Cordilleran, and Montane Glaciation in the Western Peace River - Grand Prarie Region, Alberta and British Columbia. *Quaternary International* 32:21-23.

DeLong, C., A. MacKinnon, and L. Jang

1990 *A Field Guide for Identification and Interpretation of Ecosystems of the Northeast Portion of the Prince George Forest Region*. Land Management Handbook Number 22. Research Branch, Ministry of Forests, Victoria, BC.

DeLong, C., R.M. Annas, and A.C. Stewart

1991 Chapter 16: Boreal White and Black Spruce Zone. In *Ecosystems of British Columbia*, edited by D. Meidinger and J. Pojar. Ministry of Forests, Victoria, BC.

Eldridge, M., D. A. Owens, R. Vincent, L. Seip, P. Dady and K. Benson

2002 *Archaeological Overview of Northeastern British Columbia: Year Two Report*. Prepared for the BC Ministry of Energy and Mines by Millennia Research. Submitted to the Oil and Gas Commission, Ministry of Forests, Ministry of Sustainable Resource Management, D. Quentin Mackie (UVic), the Prophet River Band, the Fort Nelson First Nation, the Halfway River First Nation, the Dene Tha', the Blueberry River First Nations, the West Moberly First Nations, the Doig River First Nation, the Acho Dene Koe, the Saulteau First Nation, and the Treaty Eight Tribal Association. Archaeology Branch permit 2001-270.

Fladmark, K.

1996 The Prehistory of Chalie Lake Cave. In *Early Human Occupation in British Columbia*, edited by R. L. Carlson and L. Dalla Bona, pp. 11-20. University of British Columbia Press, Vancouver, B.C.

Fladmark, K., J. C. Driver and D. Alexander

1988 The Paleoindian Component at Charlie Lake Cave (HbRf 39), British Columbia. *American Antiquity* 53(2):371-384.

Goodchild, M. P.

2002 *First Nations and Traditional Use Trails: Toward Collaborative Cultural Landscape Management.* Undergraduate, Northwest Community College.

Hobbs, E.

2001 MN/Model GIS Standards and Proceedures. In *A Predictive Model of Precontact Archaeological Site Location for The State of Minnesota. Final Report.*, edited by G. J. Hudak, E. Hobbs, A. Brooks, C. A. Sersland and C. Phillips, APPENDIX B. Available at http://www.mnmodel.dot.state.mn.us/chapters/TOC.html Mn/DOT Agreement No. 73217 SHPO Reference Number 95-4098.

Leonard, D. W.

1995 *Delayed Frontier: The Peace River Country to 1909*. Detselig Enterprises Ltd, Calgary, AB.

Mathews, W. H.

1978 Surficial Geology, Charlie Lake, Peace River District, British Columbia 1460A. "A" Series Map ed. Geolocal Survey of Canada.

Ministry of Environment Lands and Parks Geographic Data BC

1992 *British Columbia Specifications and Guidelines for Geomatics*. Content Series Volume 3 Digital Baseline Mapping at 1:20 000 Release 2.0.

Ministry of Sustainable Resource Management

2003 An Introduction to the Ecoregions of British Columbia. vol. http://srmwww.gov.bc.ca/rib/wis/eco/bcecode4.html.

PEM Data warehouse

2003 PEM Data warehouse <ftp://ftp.env.gov.bc.ca/dist/wis/pem/warehouse/index/>. vol. 2003.

Resources Inventory Committee

1998 Standard for Terrestrial Ecosystem Mapping in British Columbia <http://srmwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm>. vol. 2003. The Province of British Columbia.

—

1999 Standards for Predictive Ecosystem Mapping Inventory <http://srmwww.gov.bc.ca/risc/pubs/teecolo/pem/index.htm>. vol. 2003.

—

2000a Standard for Terrestrial Ecosystem Mapping (TEM) - Digital Data Capture in British Columbia Ecosystem Technical Standards and Database Manual <http://srmwww.gov.bc.ca/risc/pubs/teecolo/temcapture/index.htm>. vol. 2003. The Province of British Columbia.

—

2000b Standards for Predictive Ecosystem Mapping (PEM) - Digital Data Capture Predictive Ecosystem Technical Standards and Database Manual <http://srmwww.gov.bc.ca/risc/pubs/teecolo/pemcapture/index.htm>. vol. 2003.

TEM Data warehouse

2003 TEM Data Warehouse <http://srmwww.gov.bc.ca/rib/wis/tem/smmap.htm> or <ftp://ftp.env.gov.bc.ca/dist/wis/tem/warehouse/index/>. vol. 2003.

Teversham, J., L. Veach, and D. Becker

1998 *Ecosystem Mapping and Wildlife Interpretations for the La Biche and Sandy Creek Areas of Northeastern British Columbia*. Slocan Forest Products.

Appendix : Variable Analysis Printouts

Appendix 1 is a 950 page document of model program and buffer program outputs. Due to this large size, it is included on the CD attached to this report. In this format, it is searchable using the 'Find' command.

Appendix 2: TEM Data

Appendix 2

BWBSmw2/05

Sw - CURRANT- HORSETAIL

VEGETATION

Rosa acicularis

Cornus canadensis

Equisetum pratense

Tree Layer: 45% cover
White spruce, paper birch

Shrub Layer: 35% cover

Rosa acicularis	(prickly rose)
Viburnum edule	(highbush-cranberry)
Alnus incana ssp. tenuifolia	(mountain alder)
Ribes oxycanthoides	(northern gooseberry)
Cornus sericea	(red-osier dogwood)
Ribes triste	(red swamp currant)
white spruce	

Herb Layer: 70% cover

Cornus canadensis	(bunchberry)
Mitella nuda	(common mitrewort)
Goodyera repens	(dwarf rattlesnake orchid)
Equisetum pratense	(meadow horsetail)
Equisetum scirpoides	(dwarf scouring-rush)
Rubus pubescens	(trailing raspberry)
Pyrola asarifolia	(pink wintergreen)
Linnaea borealis	(twinflower)
Mertensia paniculata	(tall bluebells)
Viola renifolia	(kidney-leaved violet)
Galium triflorum	(sweet-scented bedstraw)
Calamagrostis canadensis	(bluejoint)

Moss Layer: 3-75% cover (depending on time since last flood)

Hylocomium splendens	(step moss)
Ptilium crista-castrensis	(knight's plume)

SOIL AND SITE

Moisture Regime:	subhygric
Nutrient Regime:	medium - rich
* Slope Gradient (%):	1-2
* Slope Position:	upper terrace (level)
* Parent Material:	fluvial
* Soil Texture:	moderately fine to moderately coarse
Site Index (m @ 100 yr):	Sw 22

DISTRIBUTION: common along major rivers

White Spruce-Current-Horsetail Site Series (DeLong et al. 1990)

Sweet Gale Three-leaved false Solomon's seal fen (Teversham 1998).

General Distribution: These ecosystems occur in extensive patches on level organic plains where typic fibrisols or mesisols have developed. The surface may have 10% standing water.

Typical Situation: Level, organic wetland.

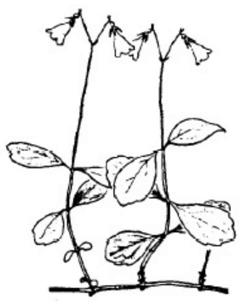
Assumed Modifiers: No site modifiers have been used.

Vegetation Description: This unit is always structural stage 3a. Sweet gale, scrub birch, and leatherleaf form a thick low shrub cover. Labrador tea and willows including Pacific, tealeaved, and Athabasca may occur. The herb layer is dominated by sedges including water sedge and poor sedge. Three-leaved false Solomon's seal and marsh cinquefoil are sparse. There may be a few plants of bog cranberry and cloudberry. Moss cover is lush and is a mixture of glow moss, golden fuzzy fen moss, and sphagnum species. Hummocks of common brown sphagnum become common adjacent to ribbons of treed higher land.

BWBSmw2/01

SwAt - STEP MOSS

Viburnum edule



Linnaea borealis

Hylocomium splendens

VEGETATION

Tree Layer: 70% cover
White spruce, trembling aspen, black spruce

Shrub Layer: 20% cover

Viburnum edule	(highbush-cranberry)
Rosa acicularis	(prickly rose)
white spruce	

Herb Layer: 20% cover

Linnaea borealis	(twinflower)
Cornus canadensis	(bunchberry)
Rubus pubescens	(trailing raspberry)
Orthila secunda	(one-sided wintergreen)
Mertensia paniculata	(tall bluebells)
Mitella nuda	(common mitrewort)
Viola renifolia	(kidney-leaved violet)
Vaccinium vitis-idaea	(lingonberry)

Moss Layer: 60% cover

Hylocomium splendens	(step moss)
Ptilium crista-castrensis	(knight's plume)
Pleurozium schreberi	(red-stemmed feathermoss)

SOIL AND SITE

Moisture Regime:	(submesic) - mesic
Nutrient Regime:	poor - rich
* Slope Gradient (%):	0-22
* Slope Position:	level, upper to mid
Parent Material:	morainal, glaciofluvial, lacustrine
* Soil Texture:	moderately fine
Coarse Fragments:	few
Site Index (m @ 100yrs):	Sw 22 (21-27) Pl 20

DISTRIBUTION: very common

BWBSmw2/03

Sb - LINGONBERRY - KNIGHT'S PLUME

VEGETATION

Tree Layer: 40% cover
Lodgepole pine, trembling aspen, (white spruce)

Ledum groenlandicum

Shrub Layer: 50% cover

Ledum groenlandicum	(Labrador tea)
Viburnum edule	(highbush-cranberry)
Rosa acicularis	(prickly rose)
Salix bebbiana	(Bebb's willow)
Salix scouleriana	(Scouler's willow)
Shepherdia canadensis	(soopolallie)
trembling aspen	
white spruce	
black spruce	

Viburnum edule

Herb Layer: 60% cover

Cornus canadensis	(bunchberry)
Vaccinium vitis-idaea	(lingonberry)
Epilobium angustifolium	(fireweed)
Lycopodium annotinum	(stiff clubmoss)
Elymus innovatus	(fuzzy-spiked wildrye)
Linnaea borealis	(twinflower)
Lathyrus ochroleucus	(creamy peavine)
Orthilia secunda	(one-sided wintergreen)
Maianthemum canadensis	(false lily-of-the-valley)
Equisetum sylvaticum	(wood horsetail)
Equisetum arvense	(common horsetail)
Equisetum pratense	(meadow horsetail)
Viola renifolia	(kidney-leaved violet)
Lycopodium complanatum	(ground cedar)
Pyrola asarifolia	(pink wintergreen)

Moss Layer: 70% cover

Hylocomium splendens	(step moss)
Pleurozium schreberi	(red-stemmed feathermoss)
Peltigera aphthosa	

SOIL AND SITE

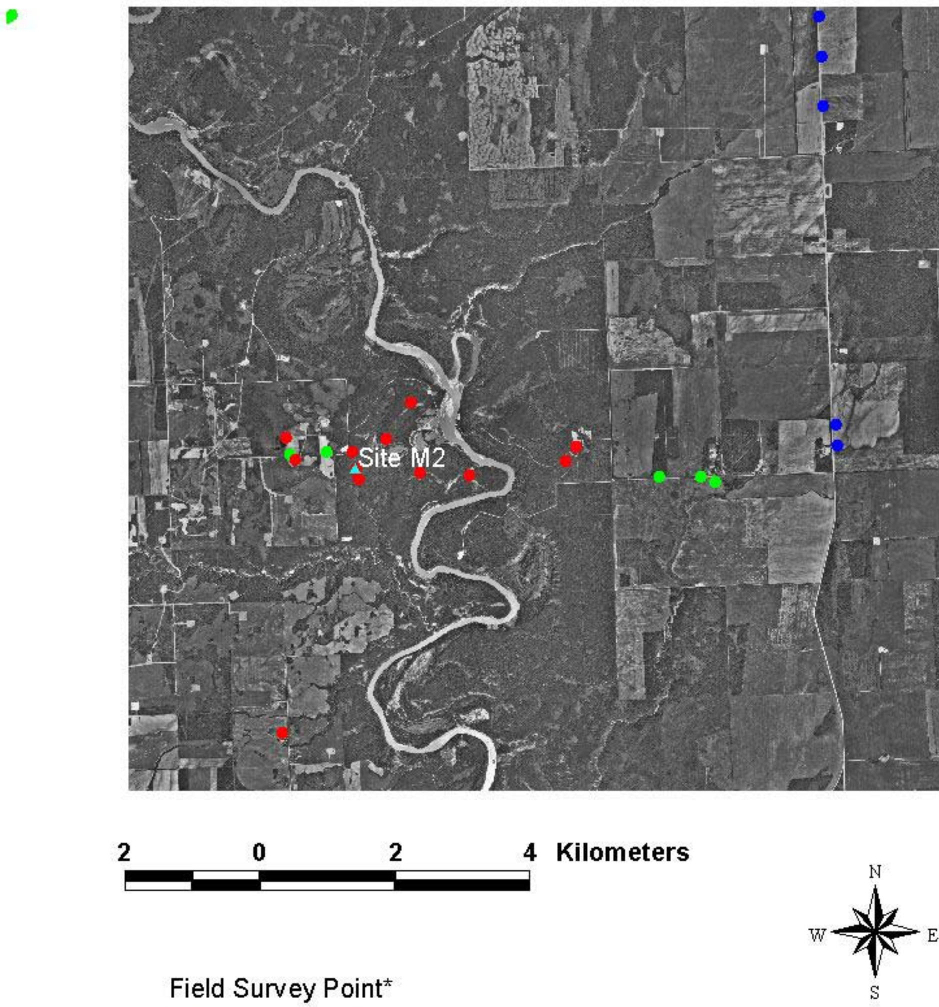
Vaccinium vitis-idaea

Moisture Regime:	submesic
Nutrient Regime:	poor - medium
* Slope Gradient (%):	0-5
* Slope Position:	crest to upper, level
Parent Material:	morainal, (eolian)
* Soil Texture:	fine - moderately fine
Site Index (m @ 100 yr):	Pl 17 (15-22)

DISTRIBUTION: uncommon

Appendix 3: Field Data Maps

94A.067

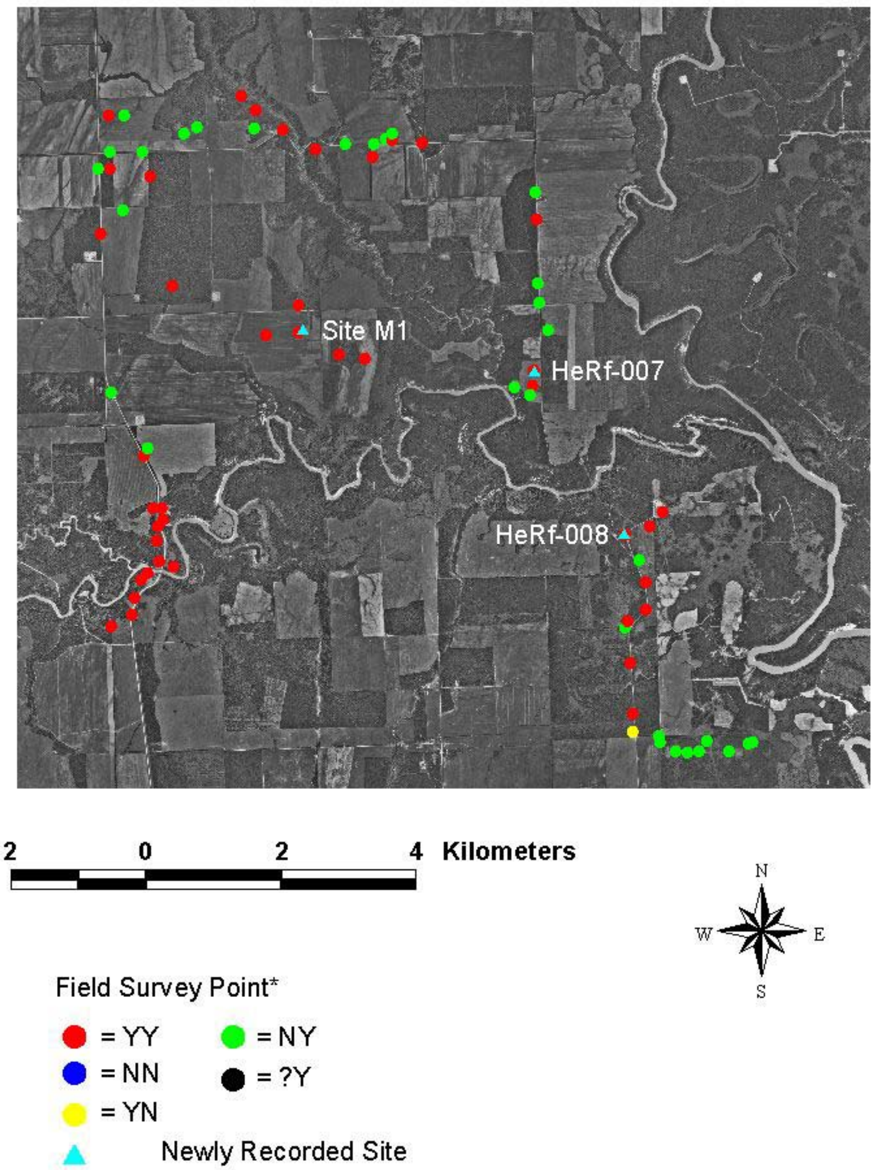


Field Survey Point*

- ● = YY (red)
- ● = NN (blue)
- ● = YN (yellow)
- ● = NY (green)
- ● = ?Y (black)
- ▲ Newly Recorded Site

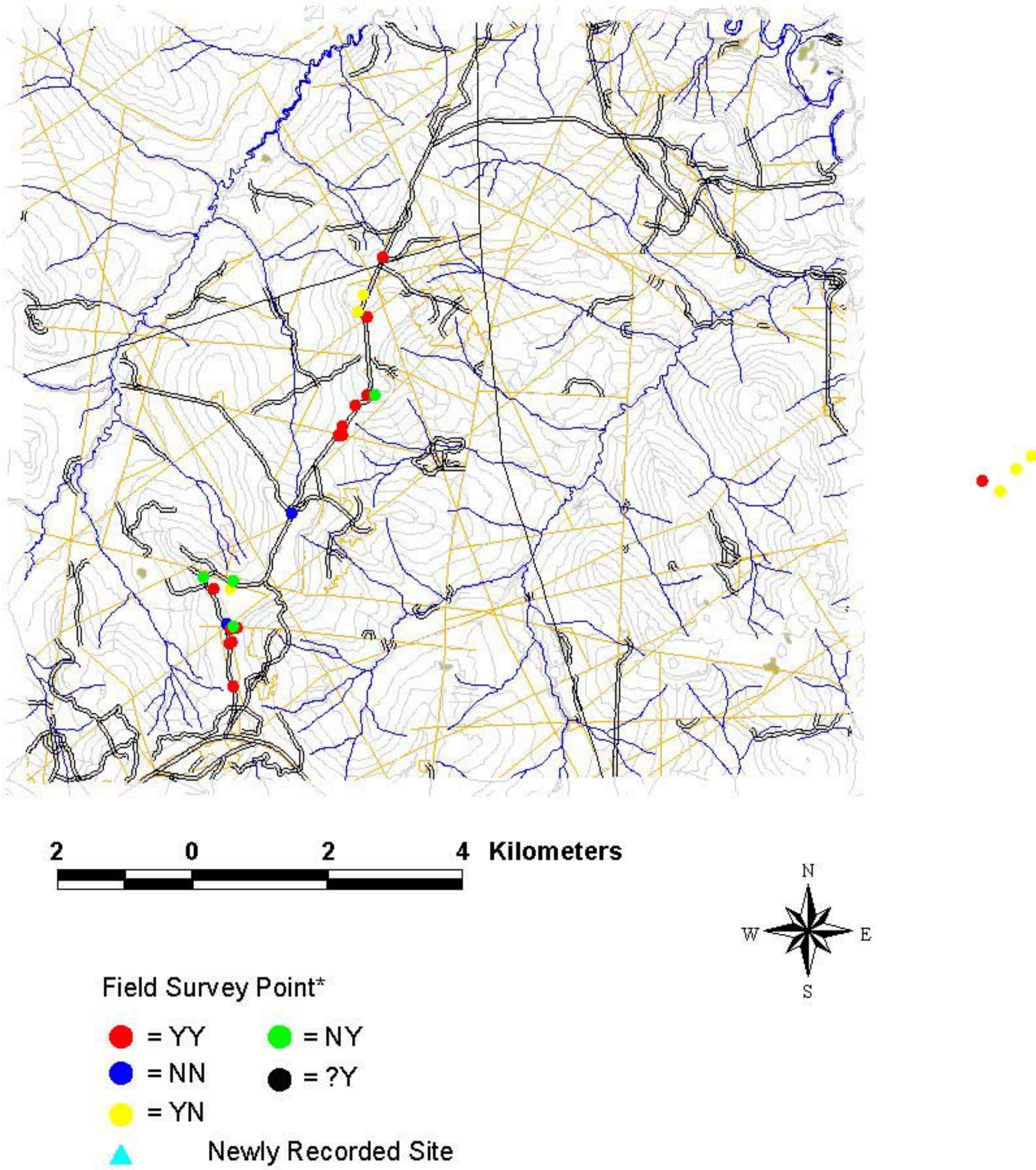
* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94A.076



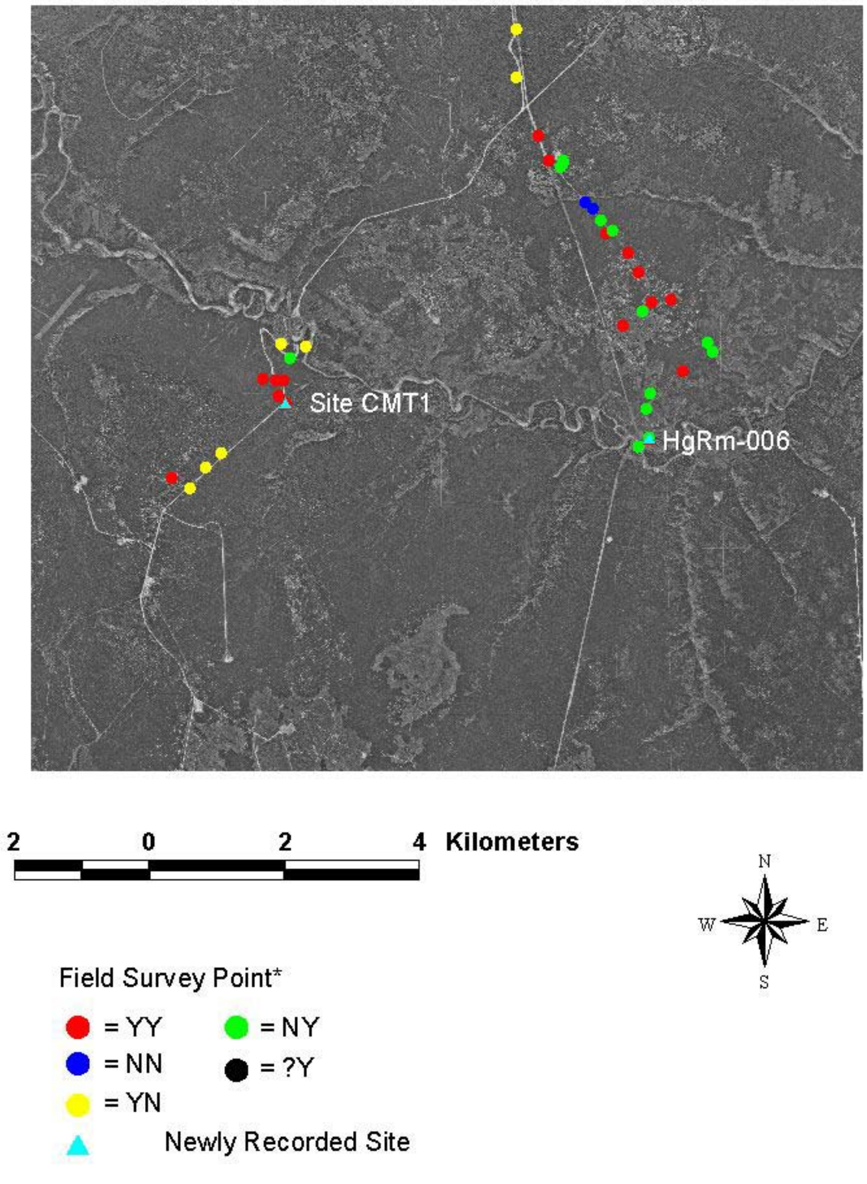
* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94G.009



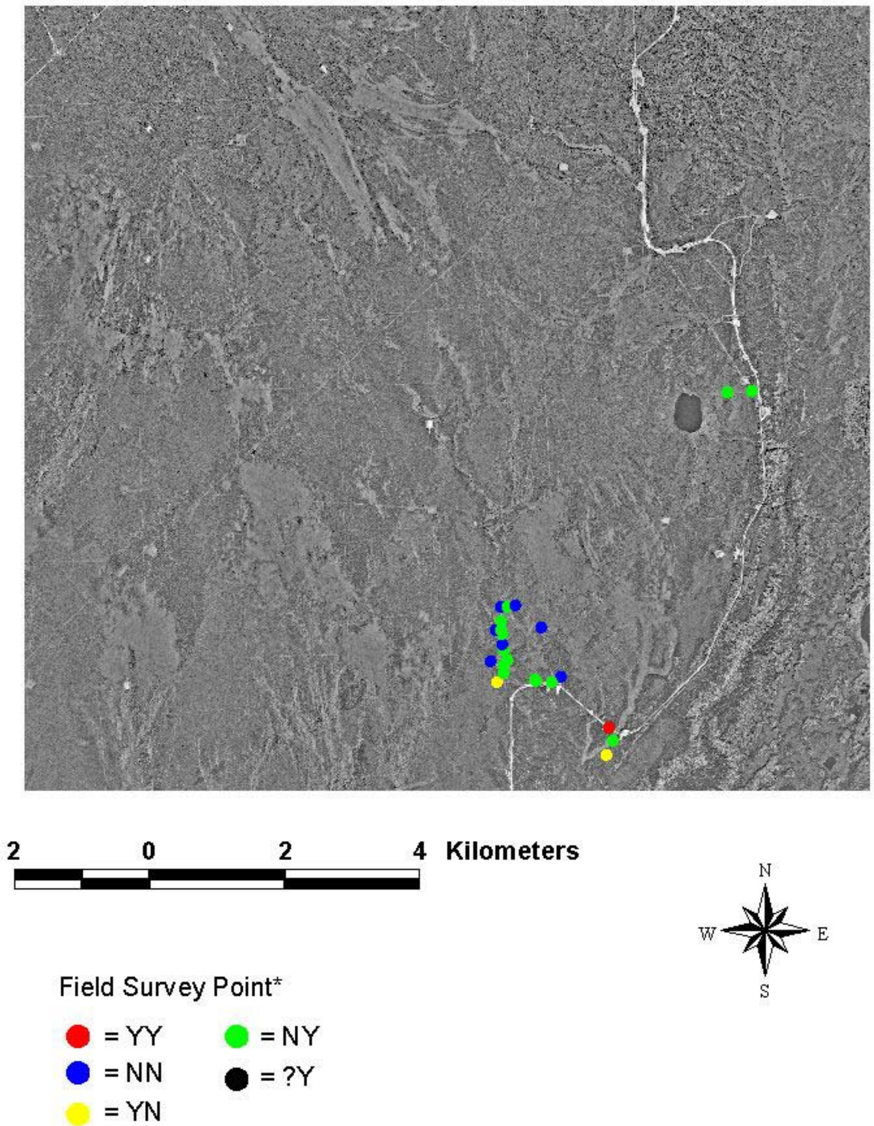
* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94G.010



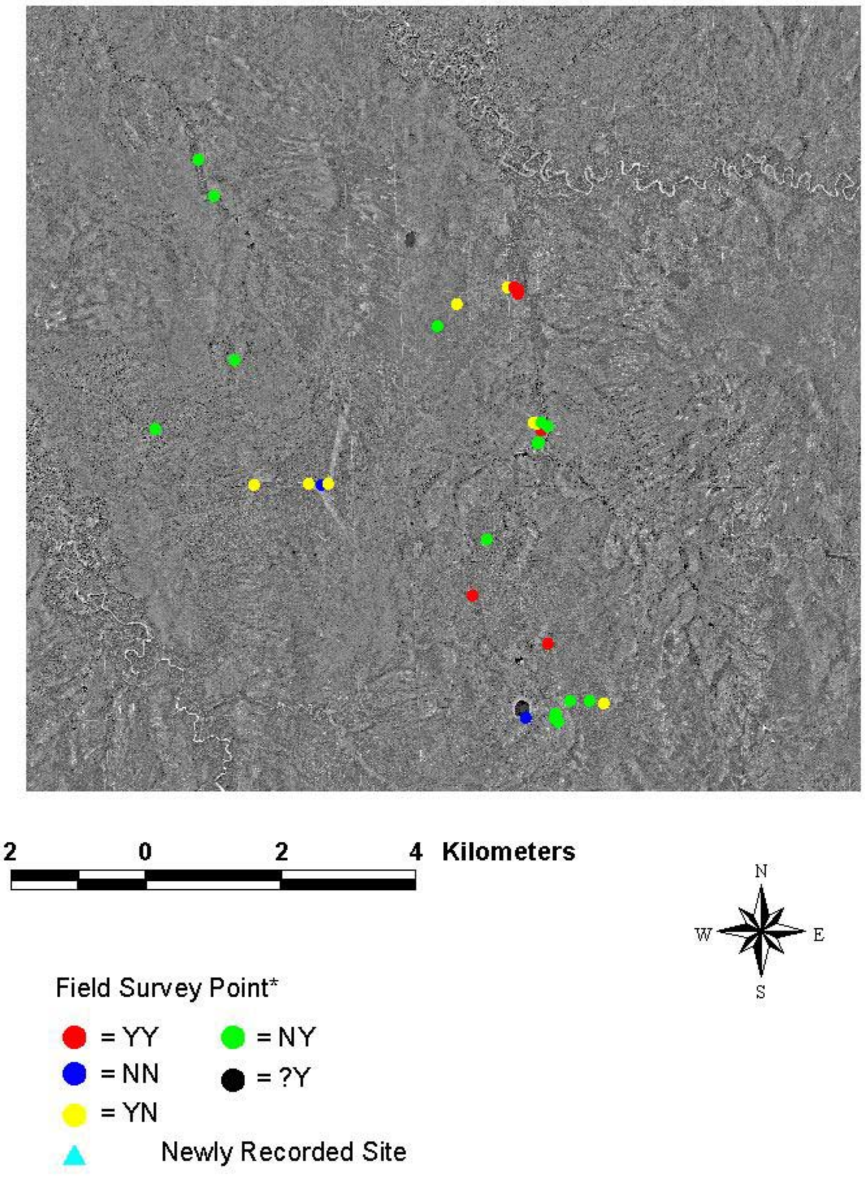
* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94H.028



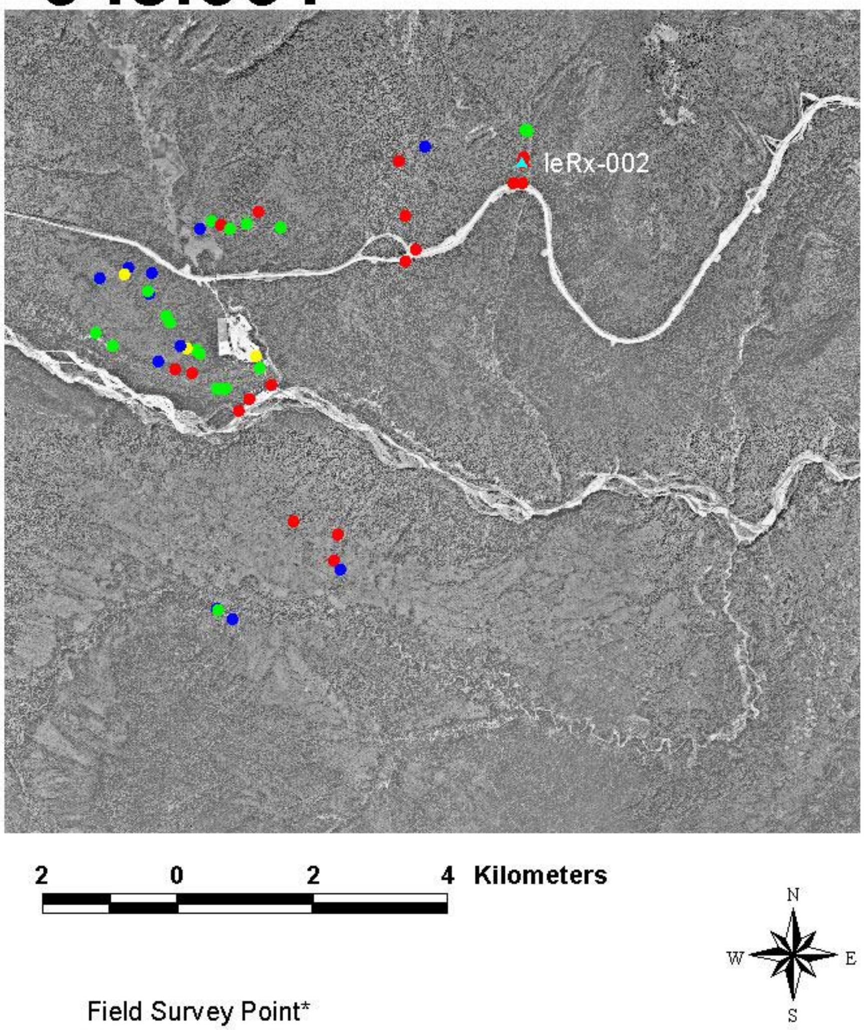
* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94H.078



* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94J.061

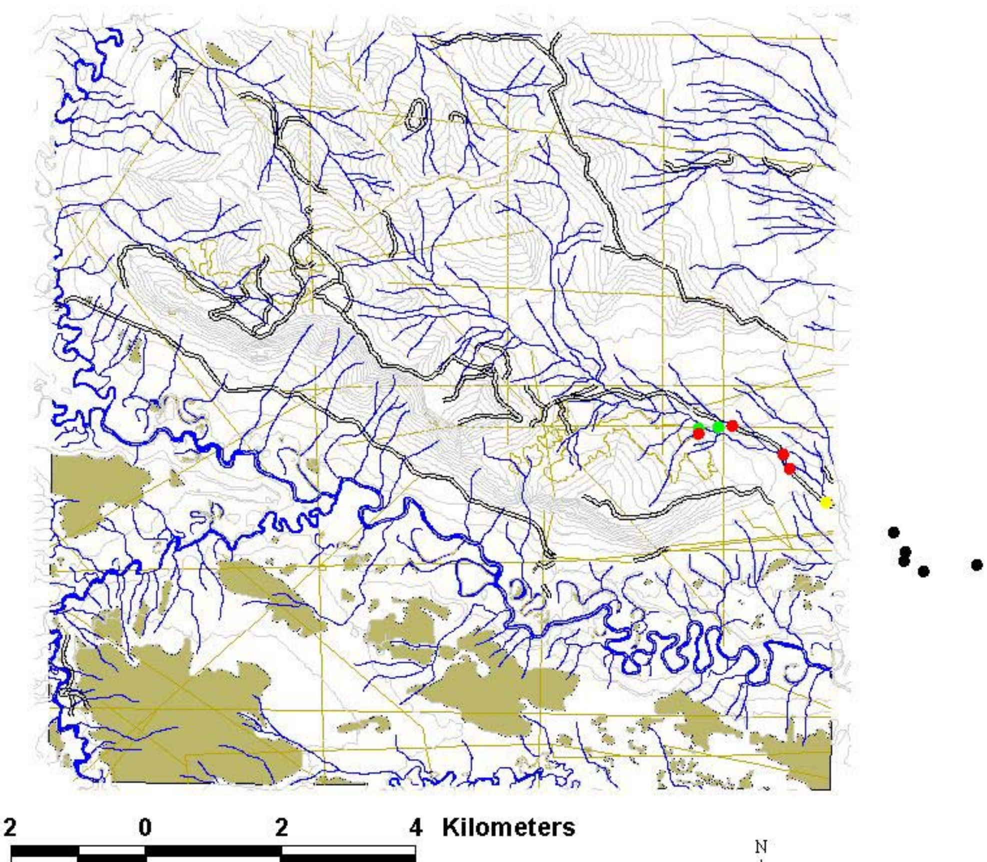


Field Survey Point*

- = YY
- = NY
- = NN
- = ?Y
- = YN
- Newly Recorded Site

* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94J.082

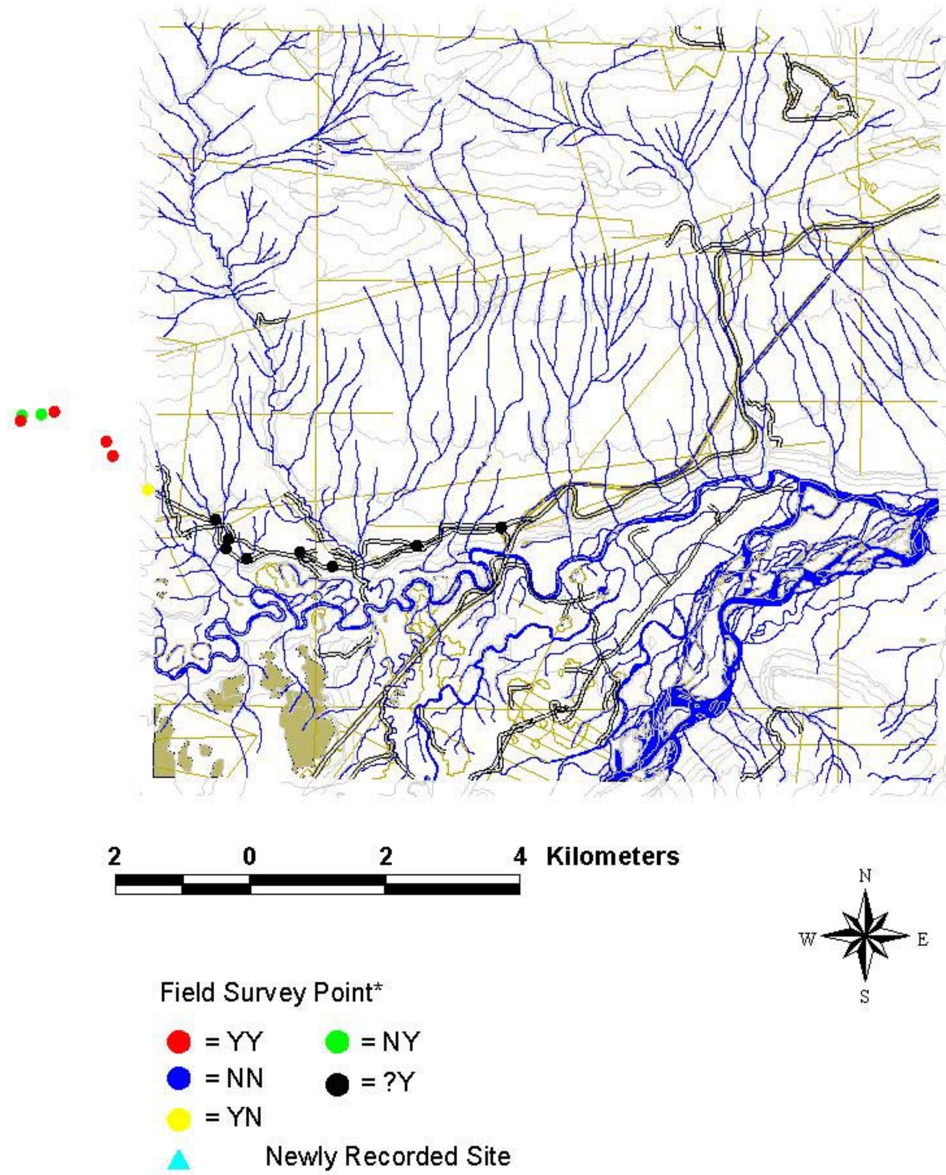


Field Survey Point*

- ● = YY
- ● = NY
- ● = NN
- ● = ?Y
- ● = YN
- ▲ Newly Recorded Site

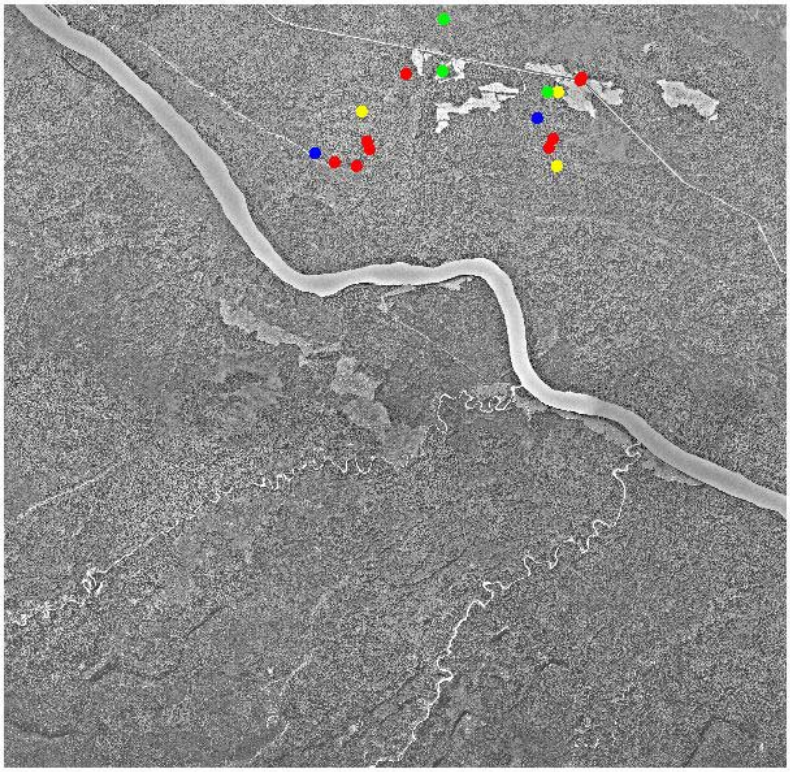
* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94J.083



* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94O.022

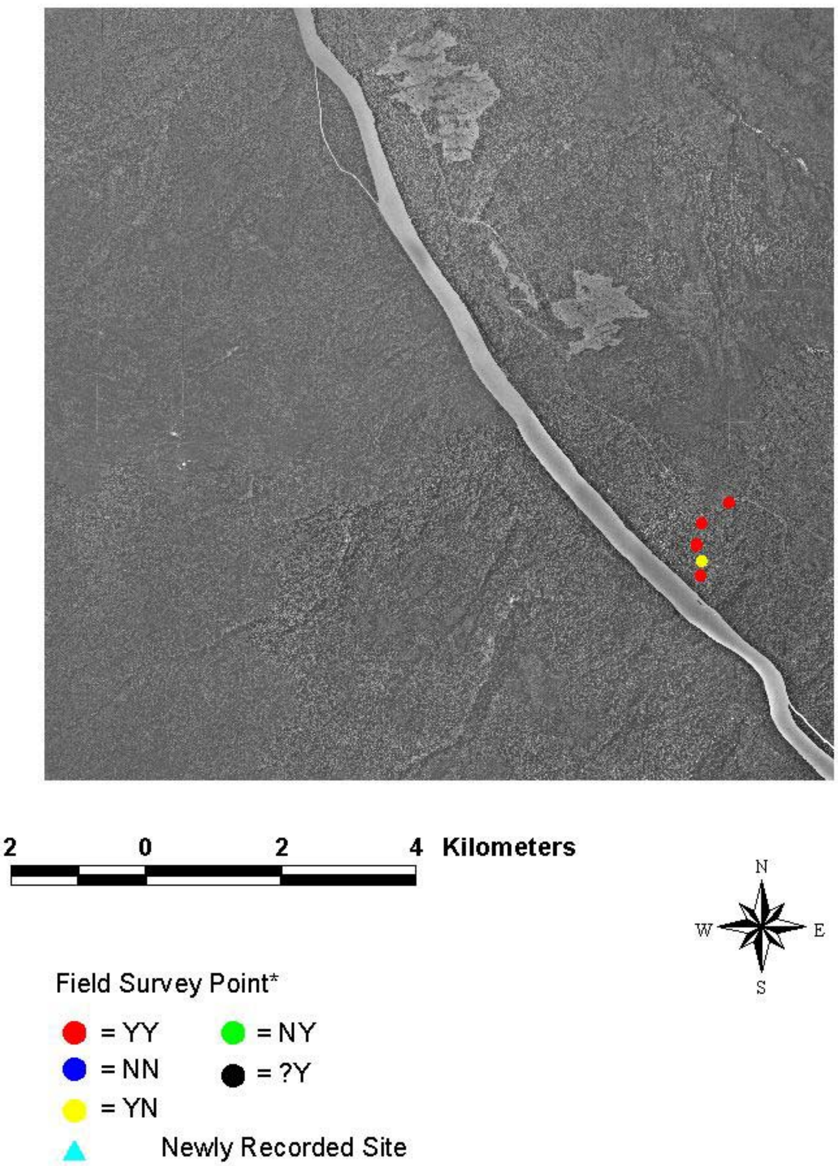


Field Survey Point*

- = YY
- = NY
- = NN
- = ?Y
- = YN
- Newly Recorded Site

* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

94O.031



* The first letter (Y=Yes, N=No, ?=Unknown) represents a map predicted terrain feature. The second letter represents a field observed terrain feature.

Appendix 4: Model Program Code

Muskwa Plateau

```
***     NE model 10 Refined for Muskwa Plateau (MUP) Ecosection

***     July 3 2002 Kristi B
***   January 30 2003 Kristi B for integrating new FC data and moving window
data



set filter to eco_sec='MUP'

***

repl all expect with 1

*** forest cover

set filter to in_wet = ' ' and in_lkrv = ' ' and eco_sec='MUP'
*** this was a two:
repl all expect with expect + 2 for (lpine_p+bspr_p)>90 and lpine_p>40 and
lpine_p<90
*** repl all expect with expect + 1 for (lpine_p > 30 and lpine_p != 100)
*** repl all expect with expect + 1 for (aspen_p != 0 and lpine_p > 50)
*** repl all expect with expect + 1 for bspr_p < 60
*** this was a two:
repl all expect with expect + 2 for (cotton_p > 30 and s_p != 0) or cotton_p
= 100
*** repl all expect with expect - 1 for (cotton_p < 30 and cotton_p !=0)
*** repl all expect with expect - 1 for (birch_p != 0 and birch_p != 100)
*** repl all expect with expect - 1 for fir_p != 0
*** repl all expect with expect - 1 for wspruce_p != 0
*** repl all expect with expect + 1 for (s_p >= 70 and (lpine_p != 0 or
aspen_p != 0))

*** this was a two:
repl all expect with expect + 2 for bgc_zone = 'SWB' and agecls > 5

repl all expect with expect + 1 for (agecls > 6 and hghtcls < 4 and (lpine_p
!= 0 or aspen_p != 0) and bspr_p < 51)

*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'MUP'

repl all expect with expect + 1 for lakevs <= 200
repl all expect with expect + 1 for lakesm <= 200
*** repl all expect with expect + 1 for lakesm <= 600
repl all expect with expect + 1 for lakemd <= 600

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'MUP'

repl all expect with expect + 1 for wetsm <= 200
```

```
*** eco and ethno features

set filter to eco_sec = 'MUP'

repl all expect with expect + 1 for trails <= 300
repl all expect with expect + 2 for trails <= 100
*** maybe even more points here, it is an extremely large corrolation



*** slope

repl all expect with expect - 1 for slope > 12
repl all expect with expect - 1 for slope > 16
repl all expect with expect + 1 for slope < 5

*** moving window results:  7 x 7 window

repl all expect with expect - 1 for negative7 < -300

repl all expect with expect + 1 for (positive7 < 50 and (negative7 < -100 and
negative7 > -225))
repl all expect with expect + 1 for (positive7 < 25 and (negative7 < -75 and
negative7 > -100))
repl all expect with expect - 1 for ((positive7 > 50 and positive7 < 100) and
(negative7 < -75 and negative7 > -100))
repl all expect with expect + 1 for ((positive7 > 50 and positive7 < 100) and
(negative7 > -25))


*** moving window results:  9 x 9 window

repl all expect with expect - 1 for (positive9 < 150 and negative9 > - 125)
repl all expect with expect + 1 for (positive9 > 150 and (negative9 > -75 and
negative9 < -25))
repl all expect with expect + 1 for (positive9 > 225 and (negative9 > -100
and negative9 < -75))
repl all expect with expect + 1 for (positive9 > 375 and negative9 > -25)

*** selected cells

*** repl all expect with expect + 1 for sel1id > -1 or sel2id > -1
*** repl all expect with expect + 1 for sel1 < 50 or sel2 < 150
*** repl all expect with expect - 1 for sel1 > 200 or sel2 > 300
*** repl all expect with expect + 2 for (sel3aid>-1 or sel3bid > -1 or
sel3cid > -1)
repl all expect with expect + 2 for (sel3a < 51 or sel3b < 126)

*** aspen stands

set filter to aspensize != 0

repl all expect with expect + 1 for aspensize < 100
repl all expect with expect - 1 for aspensize > 200


repl all expect with expect + 1 for (aspennear > 75 and aspennear < 225)
repl all expect with expect - 1 for aspennear < 50
```

```
*** selected cells and lodgepole pine and aspen combined
set filter to eco_sec = "MUP"

repl all expect with expect + 2 for (lpine_p > 35 and lpine_p < 70 and sel2 <
101)
repl all expect with expect - 1 for (lpine_p > 35 and lpine_p < 70 and sel2 >
200)
repl all expect with expect + 1 for (aspen_p != 0 and aspen_p < 35 and sel2 <
101)



set filter to eco_sec = 'MUP'

*** remove all expect in swamps, lakes and rivers
*** kristi: is this real? sites occur in swamps?

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with 0 for in_wet = 'SWAMP'
*** maybe remove the zeroing of swamps?

***     assigns potential class to potential


set filter to eco_sec= 'MUP'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2 or expect = 3 or expect = 4
repl all exp_class with 'MH' for expect = 6 or expect = 5
repl all exp_class with 'H' for expect > 6
```

Clear Hills

```
***     NE model 8 Refined for Clear Hills (CLH) Ecosection
***         not cmt

***     July 19 2002 Kristi B updated for just CLH
***   November 22 Kristi B updated for including selected cells
***         December 13 Morley back to basic just wetlands, trails and
selected to start
***         January 27 Kristi B updated for including new FC and cell data


set filter to eco_sec='CLH'

***

repl all expect with 1

*** forest cover

set filter to in_lkrv = ' ' and eco_sec='CLH'
repl all expect with expect + 1 for aspen_p > 50
repl all expect with expect - 1 for bspr_p != 0
repl all expect with expect + 1 for (lpine_p < 45 and aspen_p!=0)
repl all expect with expect - 1 for (Lpine_p != 0 or Aspen_p !=0)
*** repl all expect with expect - 1 for (agecls > 4 and hghtcls < 2)
```

```
*** these forest cover variables might be useful to try
repl all expect with expect + 1 for aspen_p = 100
repl all expect with expect - 1 for bspr_p > 80
*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'CLH'

*** repl all expect with expect + 2 for lakevs <= 100
*** Kristi maybe add this one if model doesn't perform
*** All removed when selected cells added to model.
repl all expect with expect + 1 for lakevs <= 600
*** repl all expect with expect + 1 for (rv_dbl <= 500 and rv_dbl >= 200)
*** repl all expect with expect - 1 for rv_dbl <= 100
*** repl all expect with expect + 1 for rv_int <= 250
repl all expect with expect + 1 for rv_sgl <= 200
*** repl all expect with expect + 1 for rv_sgl <= 400

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'CLH'

repl all expect with expect + 1 for (wetsm  <=100 or (wetsm<=300 and
wetlg<=300))
*** repl all expect with expect + 1 for wetsm <= 50
*repl all expect with expect + 1 for wetlg <= 200


*** eco and ethno features

set filter to eco_sec = 'CLH'

repl all expect with expect + 1 for eskers <= 300
repl all expect with expect + 1 for trails <= 400
repl all expect with expect + 2 for trails <= 100


*** selected cells

*** repl all expect with expect + 2 for ((Sel1id > 0) or (Sel2id > 0))
*** repl all expect with expect + 1 for (Sel2id > 0)
*** repl all expect with expect + 1 for ((Sel1id > 0) and (Sel2id > 0))
repl all expect with expect + 1 for ((Sel1id < 0 and Sel1 < 25) or (Sel2id <
0 and Sel2 < 25))
repl all expect with expect + 1 for (Sel2 < 200)

*** cell and slope values

repl all expect with expect - 1 for slope < 2 and not (sel1id > -1 or
sel2id>-1 or sel3aid>-1 or sel3bid>-1 or sel3cid>-1 or Sel1 < 25 or Sel2 <
25)

*** positive and negative 7 values:

repl all expect with expect + 1 for ((positive7 > 30 and positive7 < 90) and
(negative7 > -70 and negative7 < -60))
repl all expect with expect - 1 for ((positive7 < 20) and (negative7 > -70
and negative7 < -60))
```

```
repl all expect with expect + 1 for ((positive7 > 50 and positive7 < 120) and
(negative7 > -40 and negative7 < -30))

repl all expect with expect + 1 for ((positive7 > 70 and positive7 < 110) and
(negative7 > -30 and negative7 < -20))
repl all expect with expect - 1 for ((positive7 < 20) and (negative7 > -30
and negative7 < -10))

repl all expect with expect + 1 for ((positive7 > 30 and positive7 < 110) and
(negative7 > -20 and negative7 < -10))

repl all expect with expect + 1 for ((positive7 > 30 and positive7 < 120) and
(negative7 > -10))
repl all expect with expect - 1 for ((positive7 < 20) and (negative7 > -10))

*** Positive and negative 9 values

repl all expect with expect + 1 for ((positive9 > 400 and positive9 < 600)
and (negative9 > -500 and negative9 < -400))

repl all expect with expect - 1 for ((positive9 < 150) and (negative9 > -150
and negative9 < -125))

repl all expect with expect + 1 for ((positive9 > 150 and positive9 < 200)
and (negative9 > -125 and negative9 < -100))
repl all expect with expect - 1 for ((positive9 < 100) and (negative9 > -125
and negative9 < -100))

repl all expect with expect + 1 for ((positive9 > 150 and positive9 < 250)
and (negative9 > -75 and negative9 <-50))
repl all expect with expect - 1 for ((positive9 < 100) and (negative9 > -75
and negative9 <-50))

repl all expect with expect + 1 for ((positive9 > 150) and (negative9 > -50
and negative9 <-25))
repl all expect with expect - 1 for ((positive9 < 50) and (negative9 > -50
and negative9 <-25))

repl all expect with expect + 1 for ((positive9 > 100) and (negative9 > -25))
repl all expect with expect - 1 for ((positive9 < 100) and (negative9 > -25))

*** aspen stand size polygons

set filter to aspensize != 0

repl all expect with expect + 1 for aspensize  < 50

set filter to aspensize < 100
repl all expect with expect - 1 for aspennear > 300

*** remove all expect in swamps, lakes and rivers
*** kristi: is this real? sites occur in swamps?
*** 2.8% of site points in this eco_sec occur in swamps

set filter to eco_sec = 'CLH'
repl all expect with 0 for in_wet = 'SWAMP' and not type = "SITE"
repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with 0 for slope > 9 and not type = 'SITE'
```

```
***     assigns potential class to potential


set filter to eco_sec= 'CLH'
repl all exp_class with 'L' for expect < 1
repl all exp_class with 'M' for expect = 1 or expect = 2
repl all exp_class with 'MH' for (expect > 2 and expect < 6)
repl all exp_class with 'H' for expect > 5
```

Etsho Plateau

```
***     NE model 8 Refined for Etsho Plateau (ETP) Ecosection

***     July 3 2002 Kristi B


set filter to
set filter to eco_sec='ETP'

***

repl all expect with 1

*** forest cover


set filter to agecls > 2 and in_wet = ' ' and in_lkrv = ' ' and eco_sec='ETP'

*** aspen added to reduce low pot sites but check it later
repl all expect with expect + 1 for aspen_p > 90
repl all expect with expect + 1 for bspr_p >= 90
*** repl all expect with expect + 1 for cotton_p > 50
*** repl all expect with expect + 1 for lpine_p > 50
*** repl all expect with expect + 1 for wspr_p > 60
repl all expect with expect + 1 for s_p >= 90

repl all expect with expect + 1 for (hghtcls = 0 and in_wet=' ')

*** this added to reduce number of low pot sites
repl all expect with expect + 1 for agecls >= 5


*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'ETP'

repl all expect with expect + 3 for lakemd <= 100
repl all expect with expect + 1 for lakelg <= 200
repl all expect with expect + 1 for lakelg <= 600
repl all expect with expect + 2 for rv_dbl <= 200
*** rv_int doesn't seem to covary in this ecosec
*** repl all expect with expect - 1 for rv_int <= 100
*** repl all expect with expect + 1 for rv_int <= 550 and rv_int >= 700
repl all expect with expect + 1 for rv_sgl <= 200

*** wetlands
```

```
set filter to in_wet = ' ' and eco_sec = 'ETP'

*** may want to check if welands are a good variable


repl all expect with expect + 1 for wetlg <= 300 or wetsm <= 100

*** eco and ethno features

set filter to eco_sec = 'ETP'

repl all expect with expect + 1 for eskers <= 400
repl all expect with expect + 1 for eskers <= 300
repl all expect with expect + 2 for trails <= 200
** repl all expect with expect + 1 for bgc_zone = 'AT'

*** remove all expect in swamps, lakes and rivers
*** kristi: is this real? sites occur in swamps?

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with expect - 1 for in_wet = 'SWAMP'


***     assigns potential class to potential


set filter to eco_sec= 'ETP'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2 or expect = 3
repl all exp_class with 'MH' for expect =4 or expect = 5
repl all exp_class with 'H' for expect >= 6
```

Petitot Plains

```
***     NE model 8 Refined for Petitot Plain (PEP) Ecosection

***     July 3 2002 Kristi B


set filter to
set filter to eco_sec='PEP'

***

repl all expect with 1

*** forest cover

set filter to for_age > 2 and for_hght > 1 and in_wet = ' ' and in_lkrv = ' '
and eco_sec='PEP'
repl all expect with expect + 1 for aspen_p > 70
repl all expect with expect + 1 for bspr_p > 30
repl all expect with expect + 1 for cotton_p > 50
repl all expect with expect + 1 for lpine_p > 50
****** repl all expect with expect + 1 for wspr_p > 60

repl all expect with expect + 1 for bgc_zone = 'SWB' and for_age > 5
```

```
*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'PEP'

repl all expect with expect + 1 for lakevs <= 200 or lakesm <= 500 or lakemed
<= 500 or lakelg<= 300
repl all expect with expect + 1 for rv_dbl <= 400
repl all expect with expect + 1 for rv_int <= 300
repl all expect with expect - 1 for rv_int <= 50
repl all expect with expect + 1 for rv_sgl <= 100

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'PEP'

repl all expect with expect + 1 for wetlg <= 100 or wetsm <= 300

*** eco and ethno features

set filter to eco_sec = 'PEP'

*** remove ecotone because its not an item anymore Jun 18 02 kb
*** repl all expect with expect + 1 for ecotone <= 100
repl all expect with expect + 1 for eskers <= 300
repl all expect with expect + 1 for trails <= 300
repl all expect with expect + 1 for trails <= 100
** repl all expect with expect + 1 for bgc_zone = 'AT'

*** remove all expect in swamps, lakes and rivers
*** kristi: is this real? sites occur in swamps?

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with 0 for in_wet = 'SWAMP'


***     assigns potential class to potential


set filter to eco_sec= 'PEP'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2
repl all exp_class with 'MH' for expect =3
repl all exp_class with 'H' for expect > 3
```

Peace Lowlands

```
***     NE model 8 Refined for Peace Lowlands, Peace River Basin (PEL)
Ecosection

***     July 3 2002 Kristi B
***         July 29 Kristi B


set filter to
set filter to eco_sec='PEL'

***
```

```
repl all expect with 1

*** forest cover
*** Forest cover doesn't vary with sites in this ecosection

*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'PEL'

repl all expect with expect + 1 for (lakevs <= 200 and lakevs<=600)
repl all expect with expect + 1 for lakesm <= 600
repl all expect with expect + 1 for lakemed <= 600
*** repl all expect with expect + 1 for rv_dbl <= 400
repl all expect with expect + 1 for rv_int <= 600
repl all expect with expect - 1 for rv_int <= 200
repl all expect with expect + 1 for rv_sgl <= 200

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'PEL'

repl all expect with expect + 1 for wetlg <= 400

*** eco and ethno features

set filter to eco_sec = 'PEL'


repl all expect with expect + 1 for trails <= 300
repl all expect with expect + 1 for trails <= 100


*** remove all expect in swamps, lakes and rivers
*** kristi: is this real? sites occur in swamps?

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with 0 for in_wet = 'SWAMP'


***     assigns potential class to potential


set filter to eco_sec= 'PEL'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2
repl all exp_class with 'MH' for expect =3
repl all exp_class with 'H' for expect > 3
```

Muskwa Foothills

```
***     NE model 8 Refined for Muskwa Foothills (MUF) Ecosection
***         not cmt

***     July 3 2002 Kristi B


set filter to
set filter to eco_sec='MUF'
```

```
***

repl all expect with 1

*** forest cover

***   repl all expect with expect + 1 for aspen_p > 70
repl all expect with expect + 1 for bspr_p = 100
***   repl all expect with expect + 1 for cotton_p > 50
***   repl all expect with expect + 1 for lpine_p > 50
*** repl all expect with expect + 1 for wspr_p > 60

repl all expect with expect + 1 for agecls = 0  and hghtcls = 0

*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'MUF'

repl all expect with expect + 2 for lakevs <= 200 or lakesm <= 500
repl all expect with expect + 1 for rv_dbl <= 400
repl all expect with expect + 1 for rv_int <= 200

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'MUF'

repl all expect with expect + 1 for wetlg <= 100 or wetsm <= 400

*** eco and ethno features

set filter to eco_sec = 'MUF'


repl all expect with expect + 1 for trails <= 300
repl all expect with expect + 1 for trails <= 100


*** remove all expect in swamps, lakes and rivers

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with 0 for in_wet = 'SWAMP'


***     assigns potential class to potential


set filter to eco_sec= 'MUF'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2
repl all exp_class with 'MH' for expect =3
repl all exp_class with 'H' for expect > 3
```

Halfway Plateau

```
***     NE model 8 Refined for Halfway Plateau (HAP) Ecosection
***         not cmt

***     July 10 2002 Kristi B
***         July 18 2002 Kristi B revised for using isolated finds


set filter to
set filter to eco_sec='HAP'

***

repl all expect with 1

*** forest cover

*** removed in_wet from filter as 11 sites were SWAMP

set filter to agecls > 2 and hghtcls > 1 and in_lkrv = ' ' and eco_sec='HAP'
*** repl all expect with expect + 1 for aspen_p > 70
repl all expect with expect + 1 for bspr_p > 30
*** repl all expect with expect + 1 for cotton_p > 50
repl all expect with expect + 1 for lpine_p > 35
repl all expect with expect + 1 for wspr_p > 35

repl all expect with expect + 1 for bgc_zone = 'SWB' and agecls > 5

*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'HAP'

repl all expect with expect + 2 for lakevs <= 200 or lakesm <= 200
repl all expect with expect + 1 for rv_dbl <= 400
*** repl all expect with expect + 1 for rv_int <= 300
*** repl all expect with expect - 1 for rv_int <= 50
repl all expect with expect + 1 for rv_sgl <= 400

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'HAP'
repl all expect with expect-1 for wetlg <= 400

*** eco and ethno features

set filter to eco_sec = 'HAP'

*** remove ecotone because its not an item anymore Jun 18 02 kb
*** repl all expect with expect + 1 for ecotone <= 100
*** repl all expect with expect + 1 for eskers <= 300
*** repl all expect with expect + 1 for trails <= 300
*** repl all expect with expect + 1 for trails <= 100
*** repl all expect with expect + 1 for bgc_zone = 'AT'

*** remove all expect in swamps, lakes and rivers
```

```
*** kristi: is this real? sites occur in swamps?

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
*** repl all expect with 0 for in_wet = 'SWAMP'


***     assigns potential class to potential


set filter to eco_sec= 'HAP'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2
repl all exp_class with 'MH' for expect =3
repl all exp_class with 'H' for expect > 3
```

Fort Nelson Lowlands

```
***     NE model 8 Refined for Fort Nelson Lowlands (FNL) Ecosection
***         not cmt

***     July 3 2002 Kristi B
***   Modified 22 July 2002 using buffer analysis on only FNL area


set filter to
set filter to eco_sec='FNL'

***

repl all expect with 1

*** forest cover

set filter to in_lkrv = ' ' and eco_sec='FNL'
repl all expect with expect + 1 for (aspen_p!=0 and s_p!=0) and (aspen_p +
S_p)>=80 and agecls > 2 and hghtcls > 1
repl all expect with expect + 1 for cotton_p <= 20
repl all expect with expect + 2 for (lpine_p != 0 and bspr_p != 0)
repl all expect with expect + 1 for s_p >= 55


*** rivers and lakes

set filter to in_lkrv = ' ' and eco_sec = 'FNL'
repl all expect with expect + 1 for lakemd<= 1200
repl all expect with expect + 2 for rv_dbl <= 200
repl all expect with expect + 1 for rv_sgl <= 200

*** wetlands

set filter to in_wet = ' ' and eco_sec = 'FNL'

repl all expect with expect + 1 for wetsm <= 400
*** repl all expect with expect - 1 for wetlg <= 100
repl all expect with expect + 1 for (wetlg <= 401 and wetlg >= 800)


*** eco and ethno features
```

```
set filter to eco_sec = 'FNL'

*** remove ecotone because its not an item anymore Jun 18 02 kb
*** No Eskers in FNL *** repl all expect with expect + 1 for eskers <= 300
repl all expect with expect + 2 for trails <= 100


*** remove all expect in swamps, lakes and rivers
*** kristi: is this real? sites occur in swamps?

repl all expect with 0 for in_lkrv = 'LAKE'
repl all expect with 0 for in_lkrv = 'RIVER'
repl all expect with 0 for in_wet = 'SWAMP'


***     assigns potential class to potential


set filter to eco_sec= 'FNL'
repl all exp_class with 'L' for expect < 2
repl all exp_class with 'M' for expect = 2 or expect = 3
repl all exp_class with 'MH' for expect = 4
repl all exp_class with 'H' for expect >= 5
```