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Environment Canada
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Fundy National Park
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Application of

User Manual for Forest Harvest Updates Using Landsat 7 Imagery

For a Test Area on the Acadian Peninsula, New Brunswick

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Under Contract to Fundy Model Forest
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1. INTRODUCTION

In early 2002, a project was undertaken which culminated in the production of a report titled *User Manual for Forest Harvest Updates Using Landsat 7 Imagery*. The purpose of this User Manual was to describe a method for updating forest harvest areas in New Brunswick using the Enhanced Difference Wetness Index derived from Landsat 7 satellite imagery.

To test the utility of the User Manual, a test area was used to apply the principles discussed in the document. This document will discuss the process and procedures that are outlined in the User Manual and tie them together with examples from the test area. There will also be a discussion on the final results generated from the Enhanced Difference Wetness Index and the model used to define different harvest types.

This document will follow the flow diagram shown in the User Manual, which is also shown on page 5 in this document.

The study area that was selected for this test was chosen by the Department of Natural Resources. The area is located in the northeast portion of New Brunswick and is known as the Acadian Peninsula. The extents of the study area are defined in the Georeferencing Report for *wetness.pix* located in the appendices portion of this documentation.

DATA

The data used for the test area were two Landsat 7 ETM images, and a number of Shapefiles that contained vector data. The satellite images were purchased from Radarsat International, and are defined by their date of acquisition. The first image was taken on August 12 2000, while the second image was taken on July 30 2001. Both images were acquired at track 10, frame 29 and have the same geographically extents. The images were larger than the intended study area, which resulted in a subset to be created that would confine the images to the extents of the intended study area. The images that were ordered from RSI had all image bands with them and arrived on CD in HDF format.

The HDF files were converted into PCI files by using the X-Pace CDLAND7 command. An explanation of this command and the parameters are discussed in section 2.2 of the User Manual. The pix files that were created as a result of this command are *august_12_00.pix* and *july_30_01.pix*.

The vector data that was made available from DNR consisted of 3 Shapefiles that contained roads and streams, the boundary of the study area, and forestry data.

SOFTWARE

The image processing software that was used to test the manual was PCI GEOMATICA v.8.1, and the GIS software used was ArcView 3.2.

Figure 1: Project Flow Chart describing the sequence of steps taken in project.

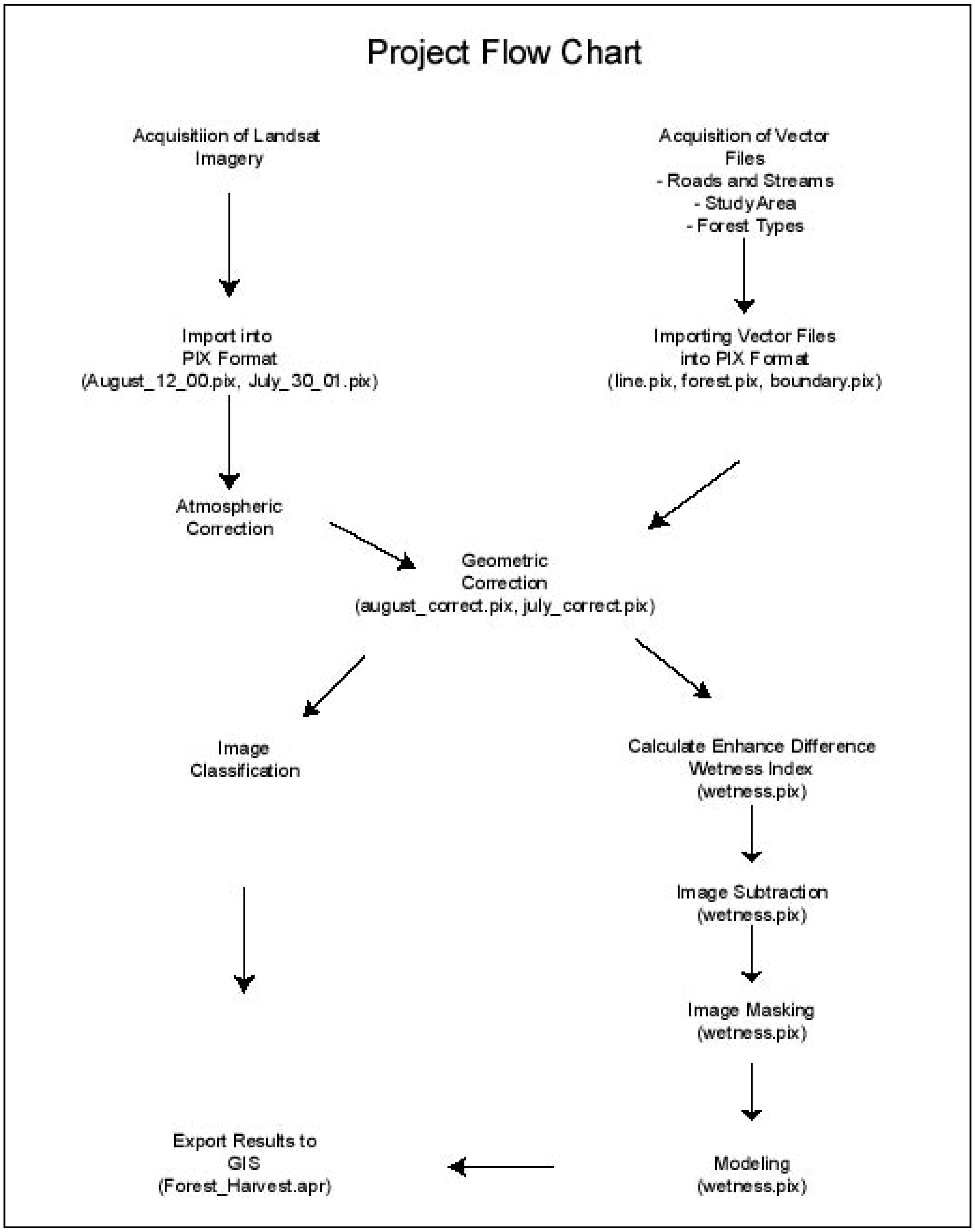


Figure 2: True Color Composite of Study Area (August 12, 2000).

Figure 3: True Color Composite of Study Area (July 30, 2001)

2. METHOD

2.1 Atmospheric Correction

As outlined in the User Manual in section 1.4, a number of X-Pace commands were used to minimize the scattering and absorption effects in the raw data by adjusting DN values based on algorithms in PCI. The atmospheric correction process was followed, as what is written in the User Manual with the exception of that band 1 was not included in the processing for either image. The reason for this was due to the spread of DN values for band 1 being poor due to overlap between reflectance values of water and land features. The atmospheric correction process was attempted with band 1, however the result was a very dark image. This is because the correction process uses a set of values that is known to readjust DN values of the image to match the known.

In a typical Landsat image, pixels representing a clear lake in band 1 should have a DN value of 2 or 3. In the Landsat image used for this test, the pixels that represented clear lakes had a DN value ranging from 64 to 70. Other Landsat images would typically have a DN value of 30 to 40 in Band 1. This is significantly higher than what would be expected. These values were higher than a number of different other features, such as forest and cleared areas. As a result, features with a lower DN value than water, would be assigned a new DN value close or if not 0 after the atmospheric correction process. For this reason, band 1 in both images was not included in the atmospheric correction process.

Figure 4: Histogram for Band 1 in august_sub.pix. Water features have a DN value ranging from 64 –70, while forested features are generally lower.

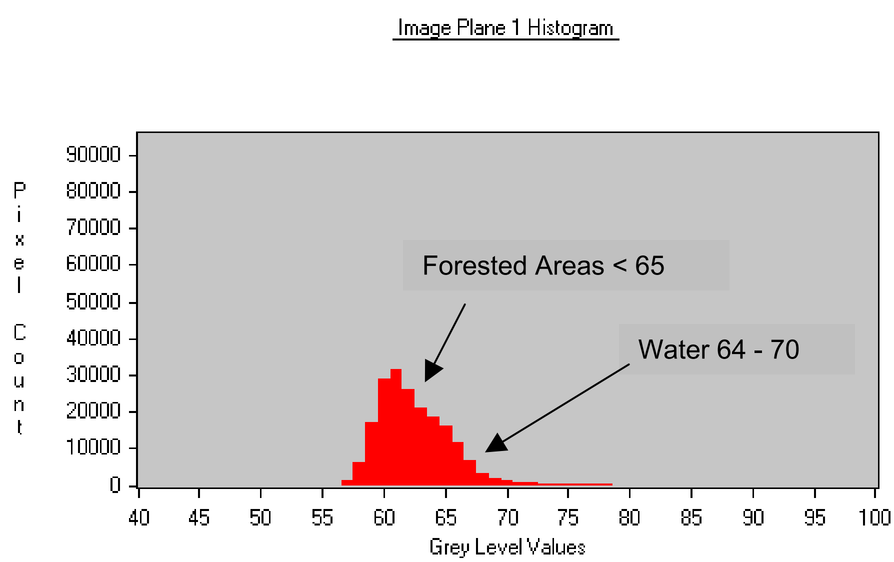
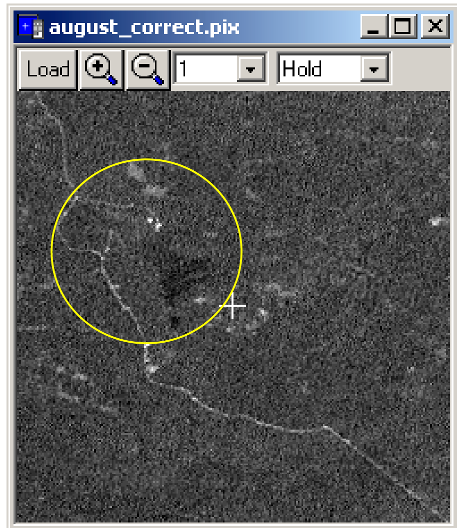
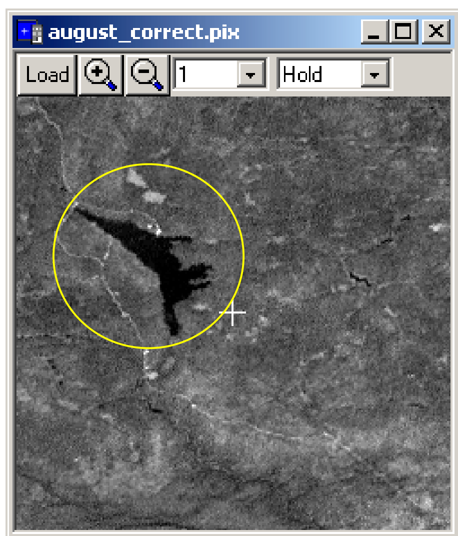


Figure 5: Comparison between Band 1 and Band 2 in the august.pix file. The first image is Band 1 and the area circled is a lake, which has similar DN values as the surrounding forested areas.



Band 1
August 12, 2000



Band 2
August 12, 2000

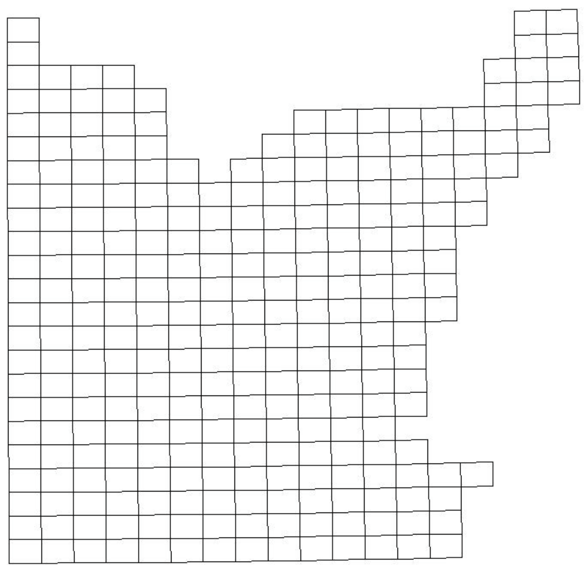
The results of the atmospheric correction process resulted in a number of new image channels being created. The *july_correct.pix* and *august_correct.pix* contain the results of the atmospheric correction process along with the geometric correction. A channel descriptor listing is available for these channels in the appendix portion of this document.

2.2 Vector Preparation

Before the geometric correction process, or any other analysis could begin, the vector data had to be converted into a format that could be read by PCI. The roads and streams shapefile was imported into PCI using the FIMPORT command in X-Pace (refer to page 12 in the User Manual). As a result, this generated an output file called *line.pix*, which contained a vector segment and no imagery.

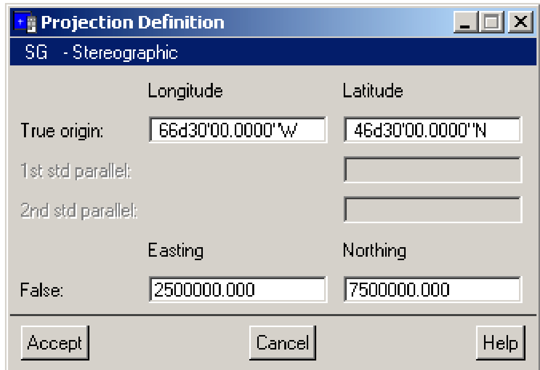
The shapefile that contained the boundary of the study area was made up of a number of borders representing 1:10000 map sheets. The coverage was simplified to reduce the number of vectors by creating a new shapefile that was made up of the outline from all of the map sheets. This new shapefile was then imported into PCI by using the FIMPORT command, creating a new pix file called *boundary.pix*.

Figure 6: The original boundary shapefile. This file contained too many unnecessary vectors.



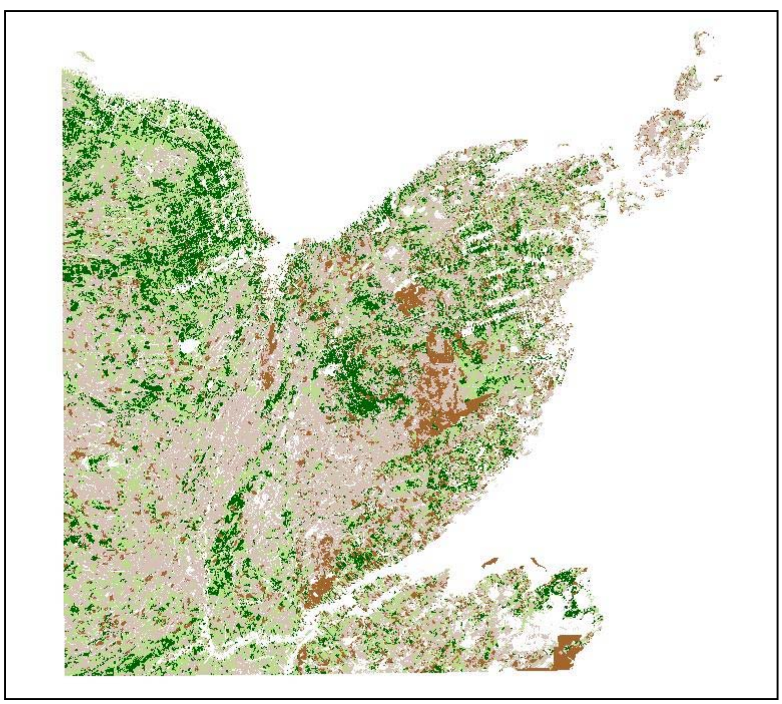
The pix files that were created must have the projection specified in the Utility Menu in the ImageWorks section of PCI. The projection that is used in New Brunswick is a Stereographic Projection that uses a True Origin for both latitude and longitude, and a false Easting and Northing. This task can be completed in the Utility window in ImageWorks. The georeference section for the image and vector portion of the file must be specified in order to be used for the geometric correction. The projection should be specified as Other, and then choose a Stereographic Projection. At this point the projection definition can be defined as shown in figure 7.

Figure 7: Defining the Projection Definition for a Stereographic Projection for New Brunswick.



The forestry data was handle differently as it needed to be converted into raster format opposed to vector. The *forest.shp* was loaded into ArcView and converted into raster dataset by converting it into a grid. The output grid size was set to 30 meters and the grid values were based on the gen_forest attribute. This attribute divided the polygons in 4 different classes: softwood, hardwood, mixed wood, and unknown. After the grid was created, it was then exported from ArcView into an ASCII raster file based on the value attribute. This ASCII raster file was then imported into PCI and then scaled down to an 8-bit image channel. Reference to this procedure can be made to section 2.3.1 in the User Manual.

Figure 8: Forestry data that was made available from the Department of Natural Resources.



2.3 Geometric Correction

The geometric correction process as described in section 1.5 of the User Manual, was done to geometrically reference the satellite images to a known dataset. The vector shapefile containing roads and streams was used to reference the images using PCI GCPWorks. This vector data, as mentioned in the previous section, now exists in a pix file (*line.pix*) and has the proper projection data. In order to assure better accuracy, a subset of both satellite images was created that was almost the same extent of the vector file. If the vector data had been the same extent as the full satellite scene, than it would have been possible to correct the entire image instead of a portion. As a result of this, two new pix files were created: *august_sub.pix* and *july_sub.pix*

The geometric correction process was applied to each image using the line.pix file as the corrected georeferenced dataset. A total of 25 GCP's was collected for each image, which was enough to ensure an evenly space distribution of GCP's.

A low RMS error was maintained throughout the collection of GCP's. The August image had an RMS error of 0.43 in the x direction, and 0.36 in the y direction. The July image was similar with an RMS error of 0.34 in the x direction and a 0.32 in the y direction. These values are below the recommended RMS value of 0.5.

When the registration was performed to disk, a 1st order transformation was used along with a Nearest Neighbor resampling method. This resampling method was chosen to ensure that the original DN values would be used in future analysis.

After the processing was completed, two new image files were created: *august_correct.pix* and *july_correct.pix*. The channel descriptor listing for these image files along with the GCP reports are included in the appendices portion of this document.

2.4 Creating Harvest Classification

This section of the paper is covered in section 3 of the User Manual. Before the TASSEL command could be executed in X-Pace, each image had to have three 32-bit channels added to them. The *august_correct.pix* and *july_correct.pix* each had three 32-bit image channels added to them. This task was done by using the add channels option in the utility menu in ImageWorks.

With the channels added, the TASSEL command (refer to Figure 22 in the User Manual) was executed to create a brightness, greenness, and wetness output channels for each image. These channels were then combine to form a new pix file called *wetness.pix*. The main reason that this was done was to be able to keep the wetness channels together to make the image subtraction process simpler, but also to keep each file size as small as possible.

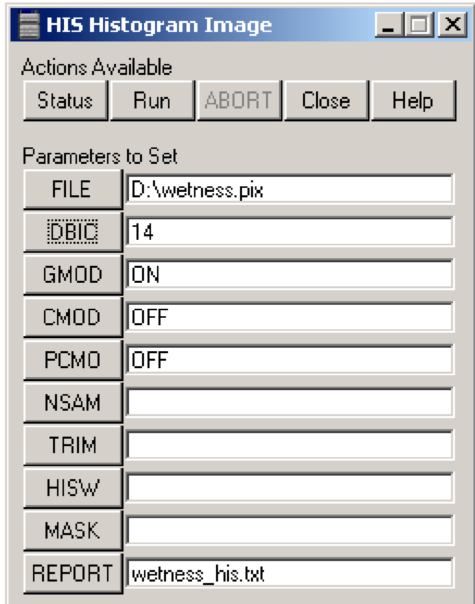
Subtracting the 2000 wetness channel from the 2001 wetness channel then performed the image subtraction process. This was accomplished by using the MODEL command in X-Pace (refer to Figure 27 in the User Manual). The output of this command was written into a new 32-bit channel in the *wetness.pix* file.

The next step was to then create an image mask to eliminate the clouds in the EWDI image channel. This step is necessary to eliminate areas that were affected by cloud and cloud shadow. A graphics mask was created that contained the areas affected by cloud and cloud shadow, and was saved to the *wetness.pix* file. The MAP command in X-Pace was then used to set the DN values that were affected to zero, to ensure that they would not be part of the forest harvest analysis in the modeling process. A detailed explanation of creating graphics mask and of the MAP command can be found in section 3.3 of the User Manual.

Following the creation of an image mask, the next step involved analyzing the data to determine the thresholds for partial and clear cuts. A histogram was generated using the HIS command in X-Pace. The HIS command allows the user to specify a pix file and a number of input channels, for which the system will generated histograms based on the input channels entered in the DBIC parameter. The results of the HIS command can be displayed on screen, or can be written to a text file. The HIS command is shown in figure 9.

The thresholds that were used for this model were taken from the previous work of Lynds and Allen. In their report they had made the observation that at 1.25 to 4 standard deviations from the mean represented areas that were partial cuts, and above 4 standard deviations represented clear cuts. The histogram that was generated for the EDWI channel generates statistics such as the min and max values, mean, and the standard deviation. The histogram is included in the appendices of this paper. The standard deviation for the EDWI channel is –8.273. The calculated values for 1.25 and 4 standard deviations is –10.341 and –33.092 respectively.

Figure 9: X-Pace HIS command used to generate histograms.



With the threshold values known, it was then possible to readjust the model that was written to meet the new criteria. The model that was used to generate the forest harvest channel is shown in figure 10.

Figure 10: Model used to calculate areas of partial and severe harvest based on tree type.

```
MODEL ON "d:\wetness.pix"
IF ( %14 <= -10.341) AND ( %14 > -33.092 ) AND ( %15 = 51 ) then
   %16 = 1;
elseif ( %14 <= -33.092 ) AND ( %15 = 51 ) then
   %16 = 2;
elseif ( %14 <= -10.341 ) AND ( %14 > -33.092 ) AND ( %15 = 153 ) then
    %16 = 3;
elseif ( %14 <= -33.092 ) AND ( %15 = 153 ) then
    %16 = 4;
elseif ( %14 <= -10.341 ) AND ( %14 >-33.092 ) AND ( %15 = 204 ) then
    %16 = 5;
elseif ( %14 <= -33.092 ) AND ( %15 = 204 ) then
    %16 = 6;
ELSE
    %16 = 0;
endif;
ENDMODEL
```

In the model shown above, there are a number of different values that are shown. The following table gives a description of each value used in the model.

Table 1: Description of values used in Model.

Value	Description
%14	Channel 14 containing EDWI with cloud mask
%15	Channel 15 containing FUNA forestry data
%16	Channel 16 is the output channel
51	DN value in forestry channel representing softwood
153	DN value in forestry channel representing mixed wood
204	DN value in forestry channel representing hardwood
-10.341	1.25 standard deviations from the mean in EDWI distribution
-33.092	4 standard deviations from the mean in EDWI distribution
0	Represents areas of no harvest in the output channel
1	Represents partial harvest of softwood in output channel
2	Represents severe harvest of softwood in output channel
3	Represents partial harvest of mixed wood in output channel
4	Represents severe harvest of mixed wood in output channel
5	Represents partial harvest of hardwood in output channel
6	Represents severe harvest of hardwood in output channel

After the model was executed, the results were written to an empty 8-bit channel. A mode filter was performed on this channel to eliminate speckle from the image. This was accomplished by using the FMO command in X-Pace. This command examines the image on a pixel-by-pixel basis, and will determine the output value based on the surrounding DN values. The user determines the size of the filter, and for this project a 3*3 filter size was used.

The result of the model was then exported from PCI into an ASCII raster format so that it could be viewed in ArcView. Other data such as true color composites of both satellite images, vector files, and harvest data were saved in an ArcView project called *Forest_Harvest.apr*.

3. RESULTS and CONCLUSIONS

For the intended study area, there was a significant amount of harvest identified from the output generated by the model. Table 2 summarizes the amount of harvested areas by the different forest types. The values shown in the table were generated after the mode filter was applied to the output.

The forest type that was harvested the most was softwood, which had a total of 9629.67 hectares. This total is a result of 7174.17 hectares classified as partial harvest and 2455.65 hectares classified as severe harvest.

Table 2: Forest Harvest Results by Category.

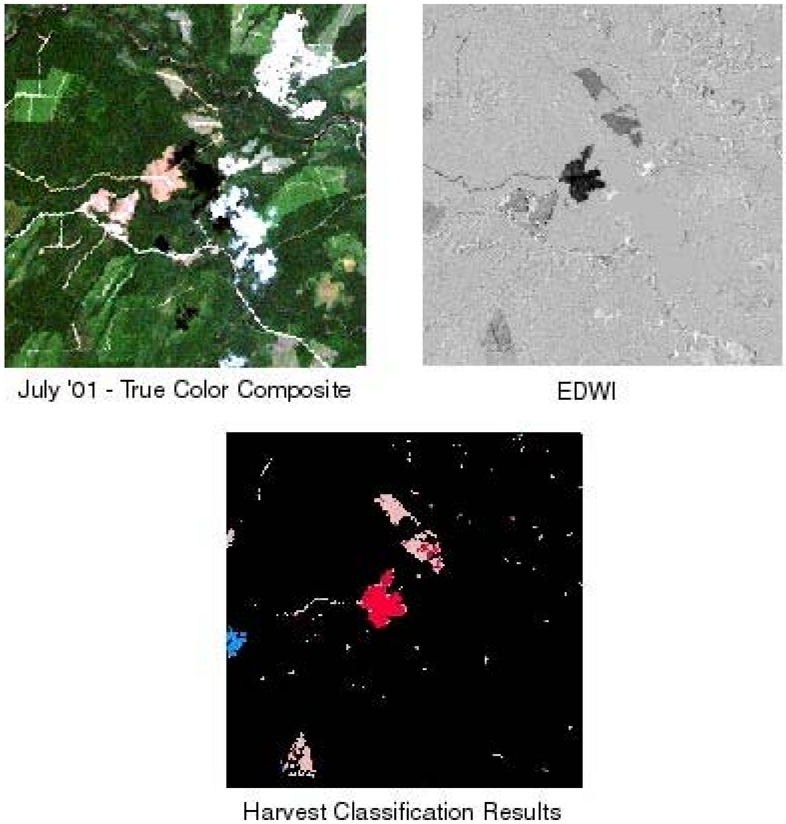
DN Value	Harvest Type	# of Pixels	Total Area (square meters)	Total Area (hectares)
0	None	21488998	19340098200	1934009.82
1	Partial Softwood	79713	71741700	7174.17
2	Severe Softwood	27285	24556500	2455.65
3	Partial Mixed wood	39834	32398200	3239.82
4	Severe Mixed wood	14384	12945600	1294.56
5	Partial Hardwood	23658	21292200	2129.22
6	Severe Hardwood	10380	9342000	934.2
	Total	21684252	2189844900	218984.49

Areas that were classified as mixed wood yielded the second highest amount of harvest, with a total of 4534.38 hectares. Of this total, 3239.82 hectares was classified as partial harvest, and 1294.56 hectares were classified as severe harvest. The remaining category, hardwood, had a total of 3063.42 hectares identified as either partial or severe harvest.

The output that was generated from the model has a number of small polygons that were not eliminated with the MODE filter. If a minimum size requirement were specified by Fundy Model Forest or DNR, than the final classification results would be less in overall area.

The following figure is a subset of the study area showing a true color composite, the EDWI, and the harvest classification. In the images, the areas that have been harvest are clearly visible. In the EDWI image, areas that have been cleared are darker than areas that have been partially cleared. The harvest classification shows that the different severity of forest harvest can be identified as a result of the model.

Figure 11: Verification of Results.



The accuracy of the harvest classes that are generated from the model is dependent on the thresholds used. The thresholds of 1.25 and 4 standard deviations were not examined in detail to verify if they represent the change from partial to clear-cut. Fieldwork and a closer look at the EDWI should be done to determine these thresholds, in order to improve upon the accuracy of the data produced.

It should be mentioned that in the FUNA forest classification, an unknown category was present which was not included in the modeling process. These areas could contain harvested forest areas that are not included in the final results. To increase accuracy, an updated forest classification should be made available prior to this type of project.

In conclusion, the final product produced from this project support the goal of producing accurate and qualitative results through Remote Sensing and GIS methods. As more time is invested in this subject area, determining annual forest harvest condition through change detection methods will become an effective means of arriving at the final goal.

4. DELIVERABLES

A number of products were produced as a result of this project. The following table provides a listing of files that are being submitted on CD-ROM with this documentation.

Table 3: Listing of Deliverables

File	Description
August_12_00.pix	Raw Image from CDLAND7 command
July_30_01.pix	Raw Image from CDLAND7 command
august_correct.pix	Atmospheric and Geometric Correction Completed
july_correct.pix	Atmospheric and Geometric Correction Completed
Wetness.pix	Contains EDWI, Cloud Image Mask, and Harvest Classification
line.pix	Road and streams stored as vector segment
forest.pix	FUNA polygon data converted to raster
boundary.pix	Boundary of Study area stored as vector segment
Forest_Harvest.apr	ArcView project containing final results

5. APPENDIX

Harvest Classification Model

```
MODEL ON "d:\wetness.pix"
IF ( %14 <= -10.341) AND ( %14 > -33.092 ) AND ( %15 = 51 ) then
   %16 = 1;
elseif ( %14 <= -33.092 ) AND ( %15 = 51 ) then
   %16 = 2;
elseif ( %14 <= -10.341 ) AND ( %14 > -33.092 ) AND ( %15 = 153 ) then
    %16 = 3;
elseif ( %14 <= -33.092 ) AND ( %15 = 153 ) then
    %16 = 4;
elseif ( %14 <= -10.341 ) AND ( %14 >-33.092 ) AND ( %15 = 204 ) then
    %16 = 5;
elseif ( %14 <= -33.092 ) AND ( %15 = 204 ) then
    %16 = 6;
ELSE
    %16 = 0;
endif;
ENDMODEL
```

Histogram Report for EDWI Image Channel in Wetness.pix

```
1
HIS     Histogramming Database Image            V8.1 EASI/PACE  13:43 12Apr2002
D:\wetness.pix                          [S   14FIC    4402P    4926L] 09Apr2002
    7 [32R] MODEL   Source= %7 = (%6 - %3)                              09Apr2002
 11907040 +                                  *
          |                                  *
          |                                  *
          |                                  *
  8930280 +                                  *
          |                                  *
          |                                  *
          |                                  *
  5953520 +                                  *
          |                                  *
          |                                  *
          |                                  *
  2976760 +                                  **
          |                                 ***
          |                                 ****
          |000000000000000000000000000011249****63111000000000000000000000000
        0 +---------------------------------+--------------------------------+
  -0.1066004E+03               -0.8634052E+01                   0.8933229E+02
 Number of pixels plotted:  21684130   Cell width:    3.0614
 Minimum value in data:-0.1332673E+03  Pixels less than histogram min:        56
 Maximum value in data: 0.1301160E+03  Pixels more than histogram max:        66
 For all data: Mean:       -0.562  Standard Deviation:                 7.149
```

Georeference Report for Wetness.pix

```
PROREP  Georeference Segment Report            V8.1 EASI/PACE  15:31 15Apr2002

D:\wetness.pix                         [S   17FIC    4402P    4926L] 09Apr2002

   1:GEOref    Type:150 [Georeferencing        ]   Last Update: 17:17 09Apr2002
     Contents: Master Georeferencing Segment for File

 Georeference Units            :    SG          D000
 Projection                    :    Stereographic
 Datum - Ellipsoid             :    WGS 1984 (Global Definition) - WGS 84

 Upper Left  Corner            :         2495269.786 E         7679945.179 N
 Upper Right Corner            :         2627319.670 E         7679945.179 N
 Image Centre                  :         2561294.728 E         7606056.770 N
 Lower Left  Corner            :         2495269.786 E         7532168.361 N
 Lower Right Corner            :         2627319.670 E         7532168.361 N

 Pixel Size                    :              29.998 E              29.999 N

 Upper Left  Corner            :     66d33'49.35" W  Lon   48d07'05.38" N  Lat
 Upper Right Corner            :     64d47'07.97" W  Lon   48d06'20.12" N  Lat
 Image Centre                  :     65d41'05.55" W  Lon   47d27'03.25" N  Lat
 Lower Left  Corner            :     66d33'43.67" W  Lon   46d47'21.41" N  Lat
 Lower Right Corner            :     64d49'40.77" W  Lon   46d46'37.74" N  Lat

 True origin           :    66d30'00.0000"W 46d30'00.0000"N
 False: Easting/Northing:       2500000.00      7500000.00
```

Channel Descriptor Listing for Wetness.pix

```
CDL     Channel Descriptor Listing              V8.1 EASI/PACE  14:28
22Apr2002

D:\wetness.pix                          [S   20FIC    4402P    4926L]
09Apr2002

   1 [32R] Brightness - Tassel - August 12 2000
   2 [32R] Greeness - Tassel - August 12 2000
   3 [32R] Wetness - Tassel - August 12 2000
   4 [32R] Brightness - Tassel - July 30 2001
   5 [32R] Greeness - Tassel - July 30 2001
   6 [32R] Wetness _ Tassel - July 30 2001
   7 [32R] MODEL  :Source= %7 = (%6 - %3)
   8 [ 8U] July 30 2001 - Channel 1
   9 [ 8U] July 30 2001 - Channel 2
  10 [ 8U] July 30 2001 - Channel 3
  11 [ 8U] August 12 2000 - Channel 1
  12 [ 8U] August 12 2000 - Channel 2
  13 [ 8U] August 12 2000 - Channel 3
  14 [32R] EDWI with cloud mask applied
  15 [ 8U] FUNA Forestry Data in raster format
  16 [ 8U] Harvest Classification
  17 [ 8U] 3*3 Mode Filter applied to Harvest Classification
  18 [ 8U] PCE    :Red   component of channel:  17 using PCT segment:
  19 [ 8U] PCE    :Green component of channel:  17 using PCT segment:
  20 [ 8U] PCE    :Blue  component of channel:  17 using PCT segment:
```

Channel Descriptor Listing for august_correct.pix

```
CDL     Channel Descriptor Listing            V8.1 EASI/PACE  09:31
23Apr2002

D:\august_correct.pix                  [S   24BIC    4402P    4926L]
09Apr2002

   1 [ 8U] gcpwork:Registration Channel=1, file=D:\RAW PIX\august_sub
   2 [ 8U] gcpwork:Registration Channel=2, file=D:\RAW PIX\august_sub
   3 [ 8U] gcpwork:Registration Channel=3, file=D:\RAW PIX\august_sub
   4 [ 8U] gcpwork:Registration Channel=4, file=D:\RAW PIX\august_sub
   5 [ 8U] gcpwork:Registration Channel=5, file=D:\RAW PIX\august_sub
   6 [ 8U] gcpwork:Registration Channel=6, file=D:\RAW PIX\august_sub
   7 [ 8U] ATCOR1 :Reflectance Image from database file     2
   8 [ 8U] ATCOR1 :Reflectance Image from database file     3
   9 [ 8U] ATCOR1 :Reflectance Image from database file     4
  10 [ 8U] ATCOR1 :Reflectance Image from database file     5
  11 [ 8U] ATCOR1 :Reflectance Image from database file     6
  12 [ 8U] FAV    :   3 *   3 Average filter          DBIC:    7
  13 [ 8U] FAV    :   3 *   3 Average filter          DBIC:    8
  14 [ 8U] FAV    :   3 *   3 Average filter          DBIC:    9
  15 [ 8U] FAV    :   3 *   3 Average filter          DBIC:   10
  16 [ 8U] FAV    :   3 *   3 Average filter          DBIC:   11
  17 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    2
  18 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    3
  19 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    4
  20 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    5
  21 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    6
  22 [32R] RTR    :SMOD:NONE (0.30*C1+0.28*C17+0.47*C18+0.56*C19+0.51
  23 [32R] RTR    :SMOD:NONE (-0.28*C1-0.24*C17-0.54*C18+0.72*C19+0.0
  24 [32R] RTR    :SMOD:NONE (0.15*C1+0.20*C17+0.33*C18+0.34*C19-0.71
```

Channel Descriptor Listing for july_correct.pix

```
CDL     Channel Descriptor Listing              V8.1 EASI/PACE  09:31
23Apr2002

D:\July\July_correct.pix                [S   24BIC    4402P    4926L]
09Apr2002

   1 [ 8U] gcpwork:Registration Channel=1, file=D:\RAW PIX\july_subse
   2 [ 8U] gcpwork:Registration Channel=2, file=D:\RAW PIX\july_subse
   3 [ 8U] gcpwork:Registration Channel=3, file=D:\RAW PIX\july_subse
   4 [ 8U] gcpwork:Registration Channel=4, file=D:\RAW PIX\july_subse
   5 [ 8U] gcpwork:Registration Channel=5, file=D:\RAW PIX\july_subse
   6 [ 8U] gcpwork:Registration Channel=6, file=D:\RAW PIX\july_subse
   7 [ 8U] ATCOR1 :Reflectance Image from database file     2
   8 [ 8U] ATCOR1 :Reflectance Image from database file     3
   9 [ 8U] ATCOR1 :Reflectance Image from database file     4
  10 [ 8U] ATCOR1 :Reflectance Image from database file     5
  11 [ 8U] ATCOR1 :Reflectance Image from database file     6
  12 [ 8U] FAV    :   3 *   3 Average filter          DBIC:    7
  13 [ 8U] FAV    :   3 *   3 Average filter          DBIC:    8
  14 [ 8U] FAV    :   3 *   3 Average filter          DBIC:    9
  15 [ 8U] FAV    :   3 *   3 Average filter          DBIC:   10
  16 [ 8U] FAV    :   3 *   3 Average filter          DBIC:   11
  17 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    2
  18 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    3
  19 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    4
  20 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    5
  21 [ 8U] ATCOR2 :Adjacency reflectance image fromTM   channel=    6
  22 [32R] RTR    :SMOD:NONE (0.30*C1+0.28*C17+0.47*C18+0.56*C19+0.51
  23 [32R] RTR    :SMOD:NONE (-0.28*C1-0.24*C17-0.54*C18+0.72*C19+0.0
  24 [32R] RTR    :SMOD:NONE (0.15*C1+0.20*C17+0.33*C18+0.34*C19-0.71
```