LIDAR Based Forest Classification for Stand Mapping User's Manual

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October, 2008

Funded by Bureau of Land Management and Precision Forestry Cooperative

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Sullivan, A.A (2008). *LIDAR based forest stand delineation in natural forests* .M.Sc thesis, Univ. of Washington, Seattle, Wa, USA. 72 p.

Appendix 1- User's guide for LIDAR based Stand Delineation

About this User's Manual- This manual is designed for use with ArcMap 9.2. There are three additional software packages that can be downloaded for free from the world wide web. This user's manual and required programs are designed for the Windows operating system.

Programs Required:

- ArcMap 9.2
- SPRING 4.x
- FUSION- Current Version
- Hawth's tools

Data:

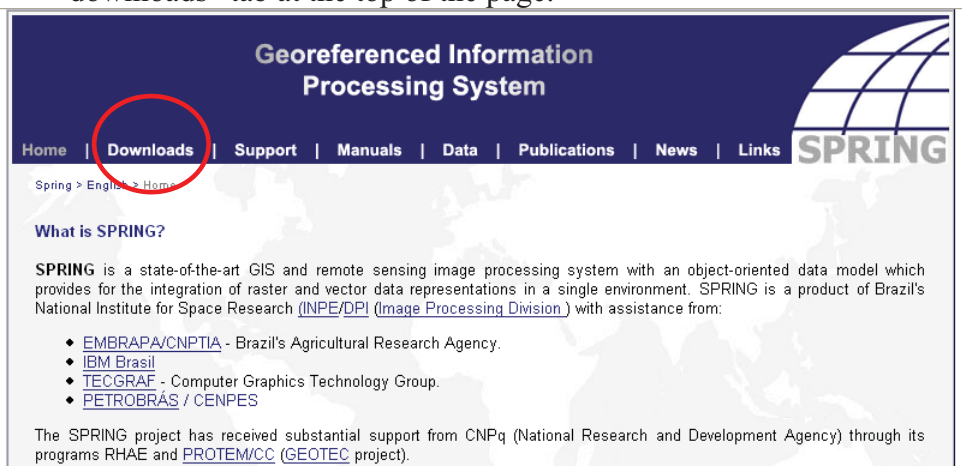
- The data used in the tutorial is the FUSION example data. It is available for download at http://forsys.cfr.washington.edu/fusion/fusionlatest.html
  This data is courtesy of Robert J. McGaughey at the Forest Service Pacific Northwest Research Station.

Part I - Downloads:

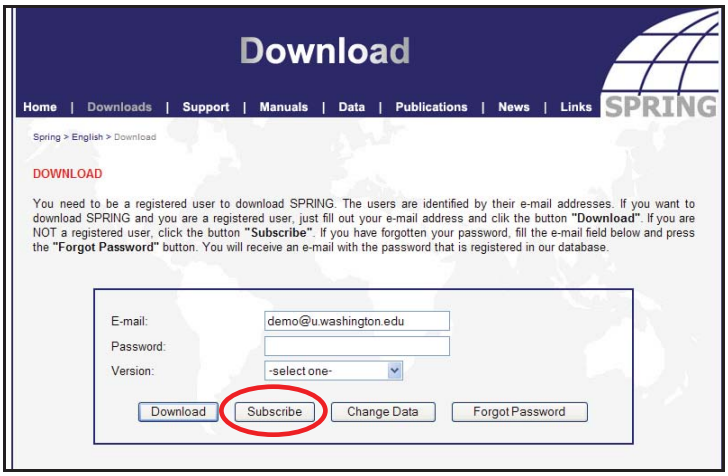
1.1 SPRING- This software was developed by Brazil's National Institute for Space Research as a "a state-of-the-art GIS and remote sensing image processing system with an object-oriented data model which provides for the integration of raster and vector data representations in a single environment." (SPRING website). SPRING is available for download in English at: http://www.dpi.inpe.br/spring/english/index.html.

To set up SPRING on your computer, please follow these steps.

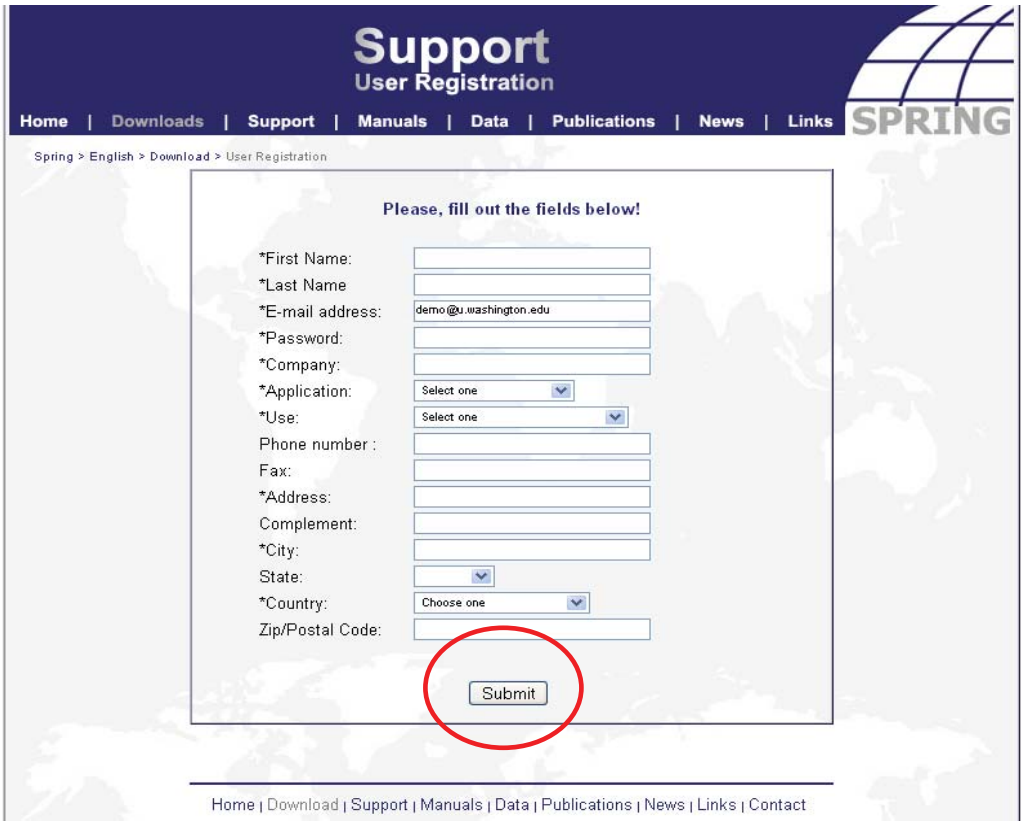
1. Go to http://www.dpi.inpe.br/spring/english/index.html and click on the "downloads" tab at the top of the page.



2. On the "Download" page you will be asked to register before you can download the software. Please enter a valid email address and click on the "Subscribe" button.



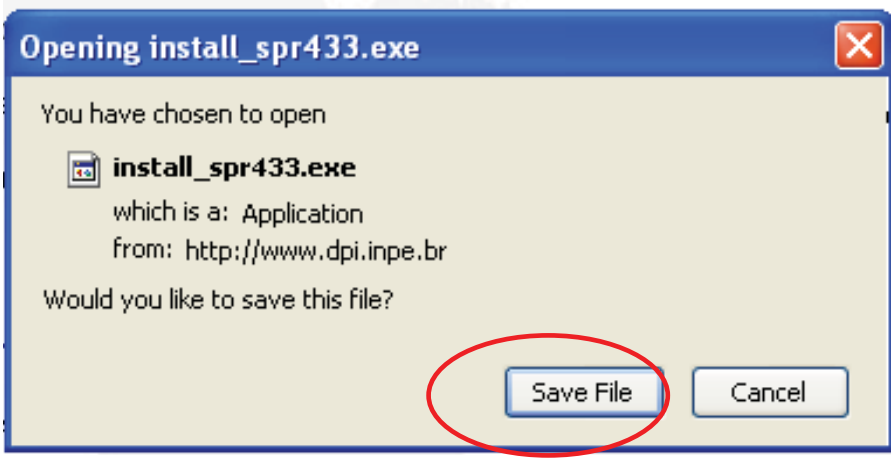
3. The following screen will appear, please fill out the required information and click



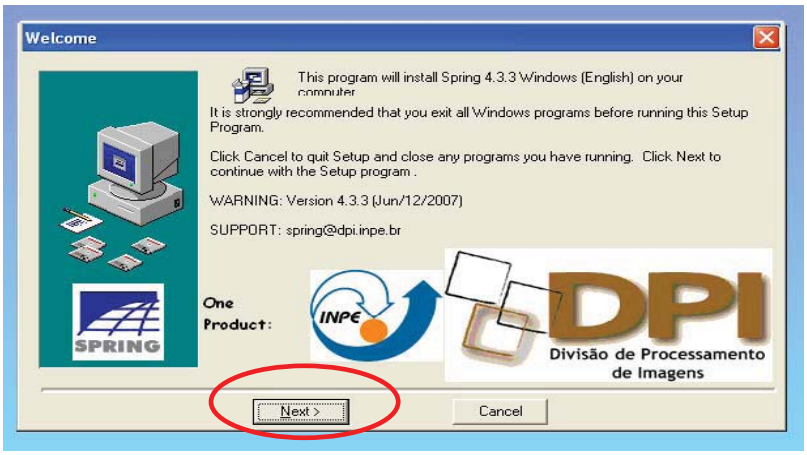
4. You will now be able to download the current version of SPRING. Go back to the download page and enter your email and password and choose the correct version for your operating system and click "Download."

5. From this screen choose the “Install.exe” from one of the download sites. Make sure to choose the version in English!

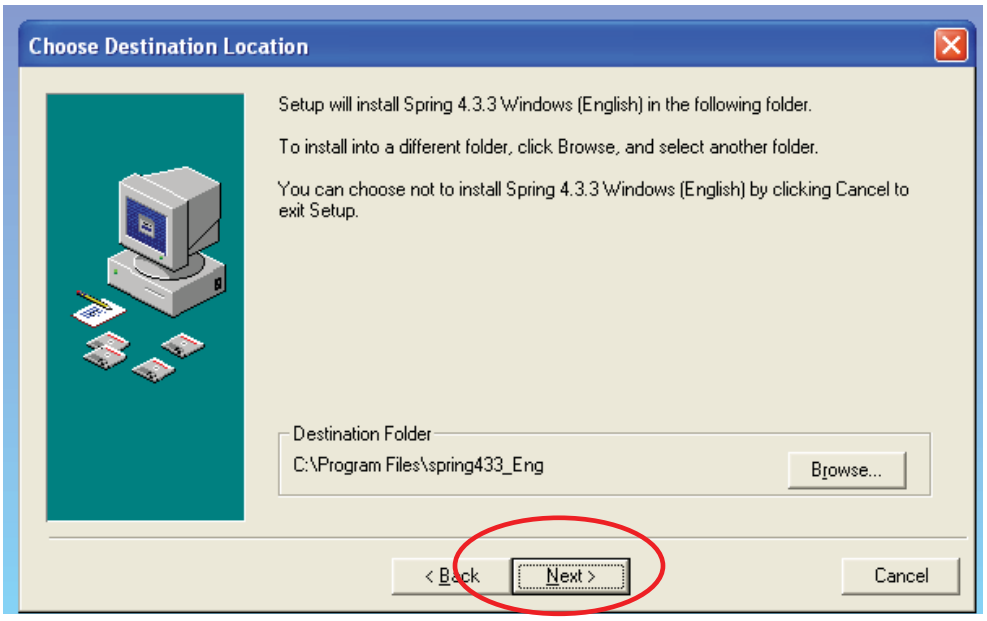
6. Choose to “Save File” and specify where to save the install_spr433.exe file to.



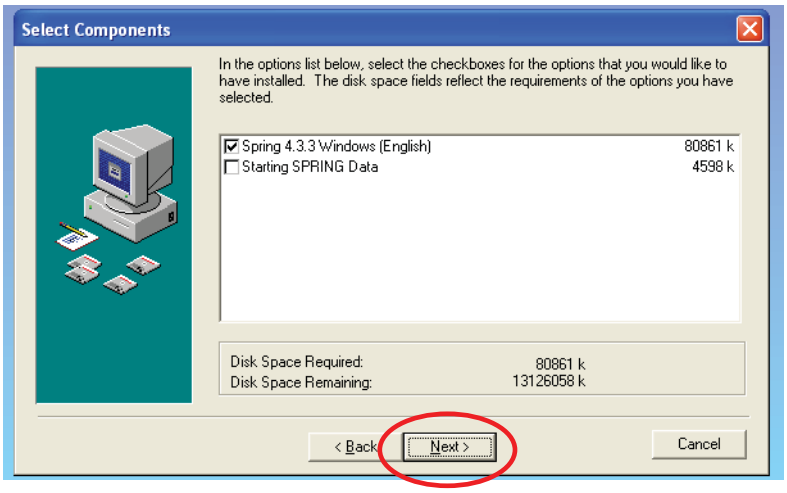
7. Once the file has downloaded, run the install_spr433.exe from the directory where it was saved. Click “Next” to start the install.



8. Click “Next” to accept the license agreement.
9. Choose the directory where you would like to install SPRING, and click “Next” to start the install.



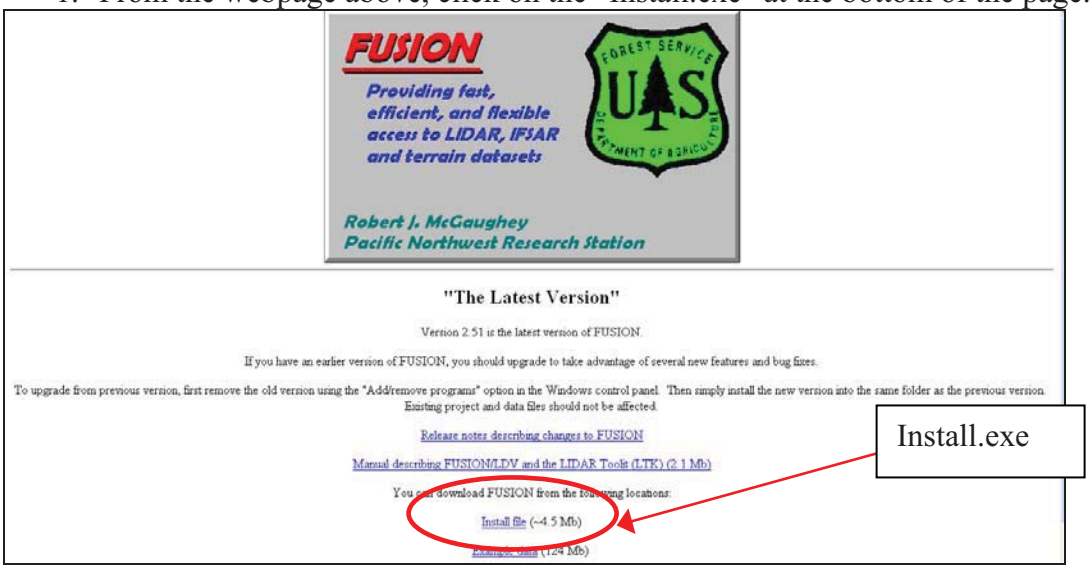
10. Choose to only install the SPRING program, and click “Next.”



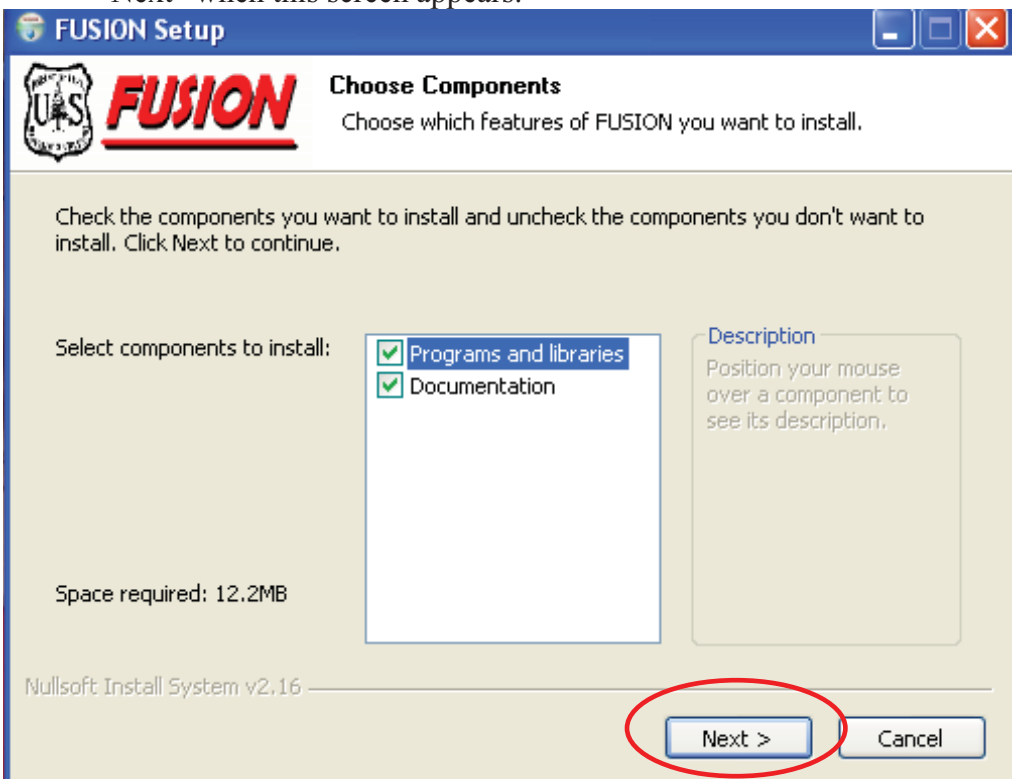
11. Click "Next" on the following screen and the install will begin. Once the install is complete, click on the "Finish" button and you will exit the install wizard. The SPRING program has a desktop shortcut or can be accessed through the Start->All Programs->SPRING.
12. You have now completed the installation of SPRING.

1.2 FUSION- FUSION was developed by Robert McGaughey at theUSFS Pacific Northwest Research Station. This program is primarily a viewing tool for LIDAR data, but also provides basic analysis that is important to the foundation of this project. The current version of FUSION can be found at: http://forsys.cfr.washington.edu/fusion/fusionlatest.html this website is updated by the developers of FUSION and will contain the latest public release of FUSION.

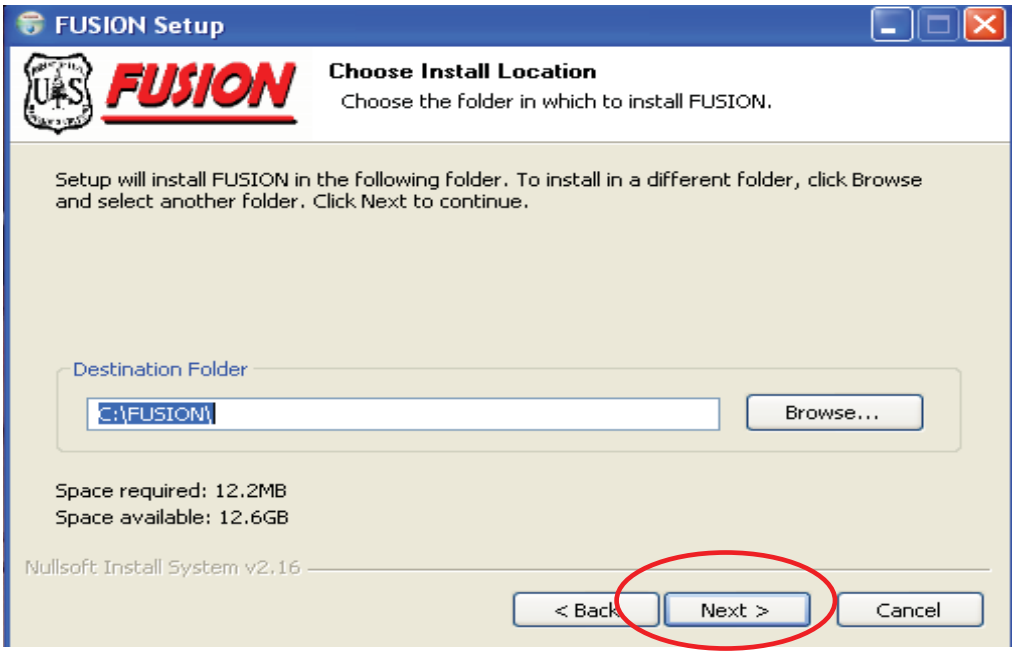
1. From the webpage above, click on the "Install.exe" at the bottom of the page.



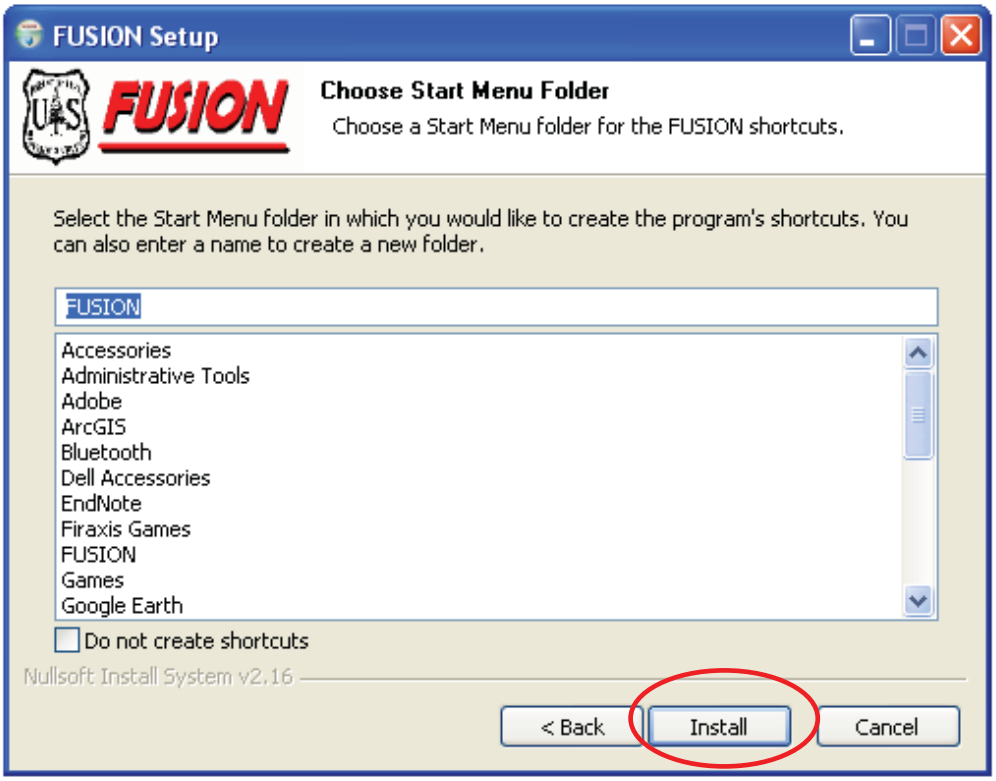
2. Choose to save the file and choose the destination directory.
3. Run the FUSION_Install.exe from the directory in which it was saved. Click on "Next" when this screen appears.



4. Choose the directory you would like FUSION installed (Recommended to use defaults). Click "Next."



5. Choose the Start menu folder you would like the FUSION shortcut to reside in, then click "Install"



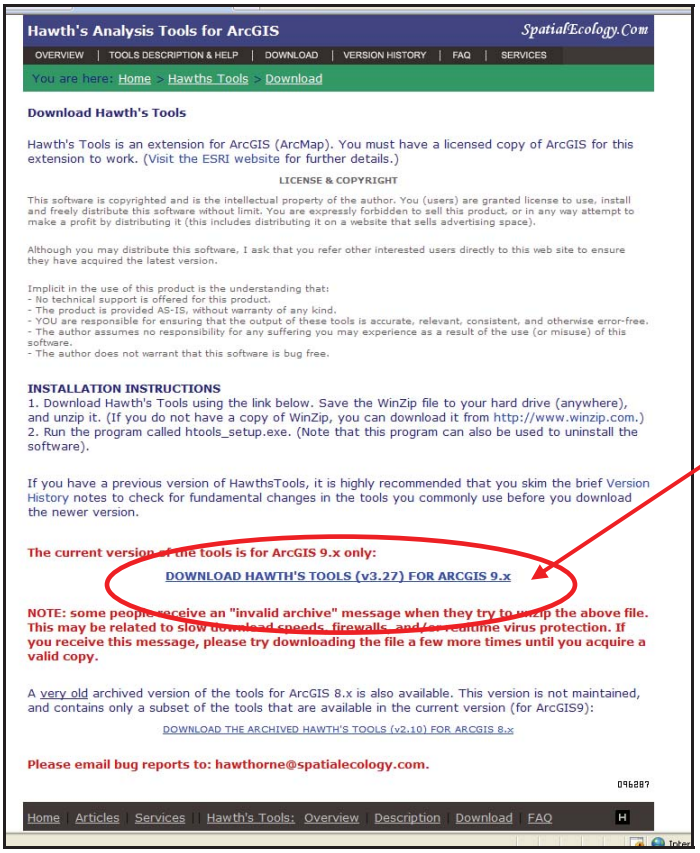
6. This will start the install process, this may take several minutes. When it is finished, click “Finish” to exit the installation.
7. You have now completed the install of FUSION.

Hawth’s Tools- This program is a set of ecology analysis tools that are packaged as an extension for use in ArcMap. The software is free and can be downloaded at http://www.spatialecology.com/htools/download.php . This extension will be used later in the tutorial for accuracy assessment.

To set up this extension:

1. Go to the link above and click on “Download Hawth’s Tools.” Follow the installation instructions below.

Installation Instructions: (From website)
1. Download Hawth's Tools using the link below. Save the WinZip file to your hard drive (anywhere), and unzip it. (If you do not have a copy of WinZip, you can download it from http://www.winzip.com.)
2. Run the program called htools_setup.exe. (Note that this program can also be used to uninstall the software).



Part II- Generation of Raster Data

This portion of the manual is comprised of two sections. The first will lead you through the process of dealing with the raw LIDAR products and work within FUSION. The second section will focus on the analysis within ArcMap. The final products of this section will be three raster datasets that will then be used in SPRING.

Section 1- Working with FUSION command lines

Software needed:

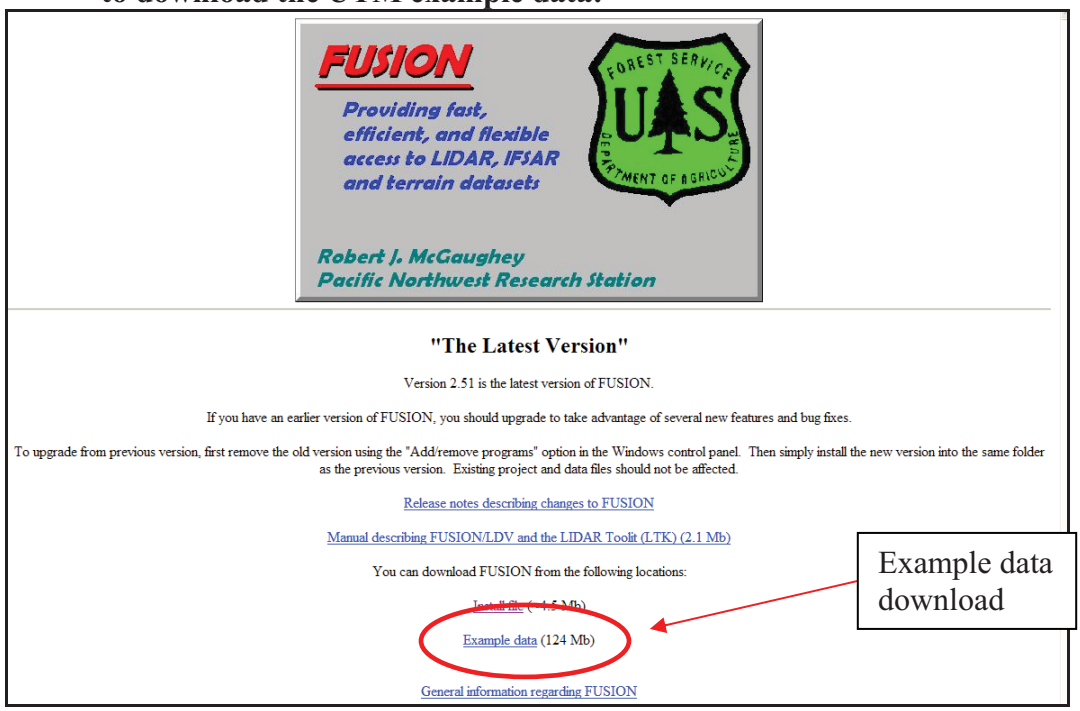
- FUSION (see downloads section)

Data Required:

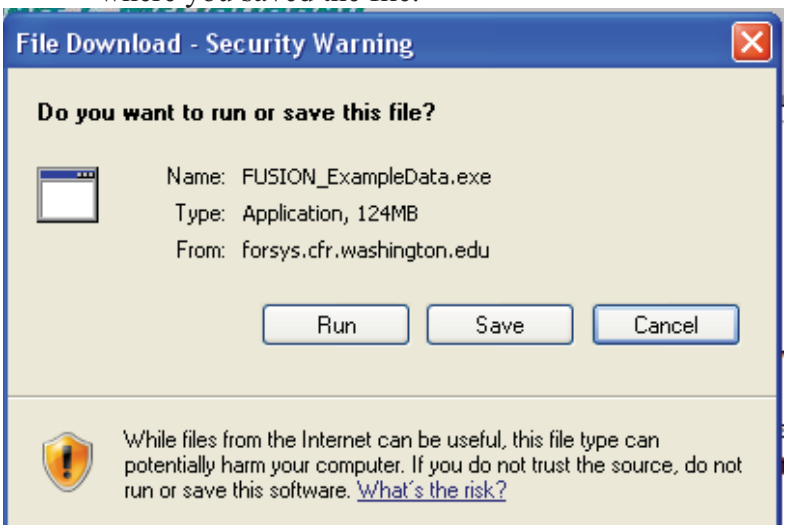
- Ground Model (demo_4800K_UTM.dtm)
- LIDAR points (demo_4800K_UTM.lda)
- Aerial Photograph (demo_4800K_UTM.jpg and demo_4800K_UTM.jpgw)

Data for this section:

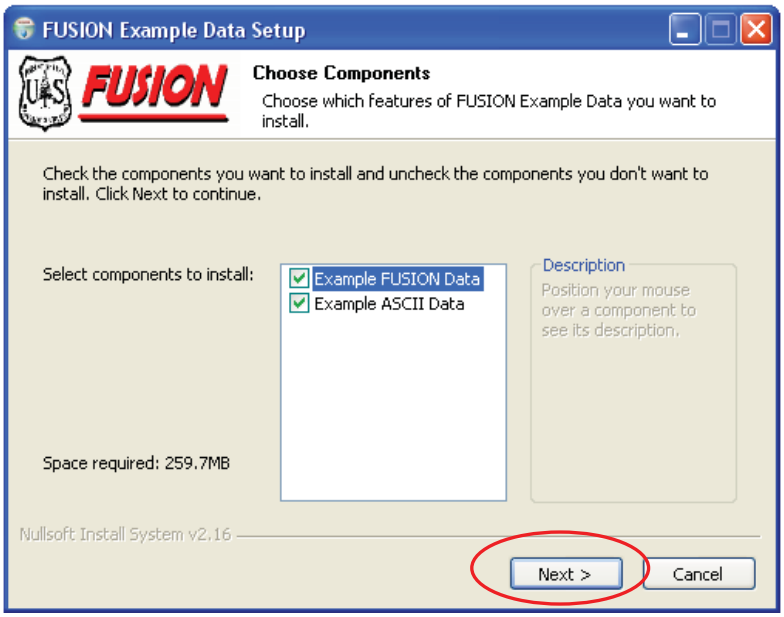
1. Download the example data from http://forsys.cfr.washington.edu/fusion/fusionlatest.html which is the same page where you downloaded the FUSION software. Click on example data. **Make sure to download the UTM example data!**



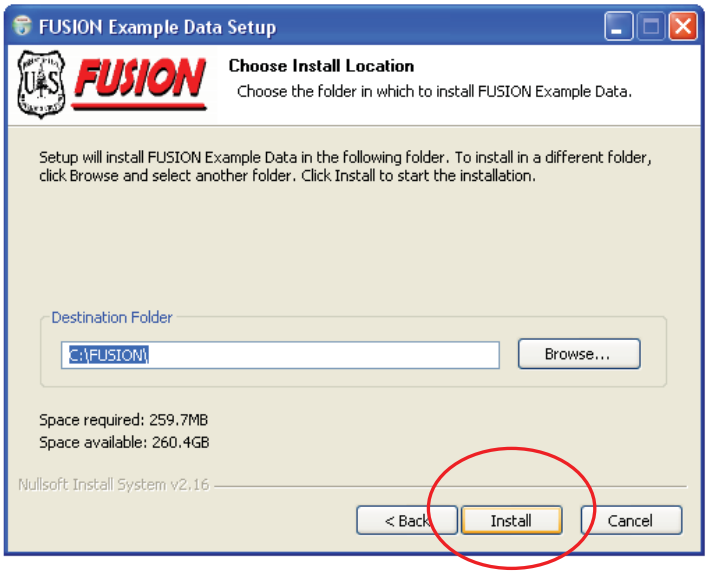
2. Choose "Run" or "Save" from the pop up menu, if you chose to save it, remember where you saved the file.



3. Choose to download both components, and click “Next.” (maybe change this when Bob updates webpage)



4. Choose the directory to install the example data. Then click “install.”

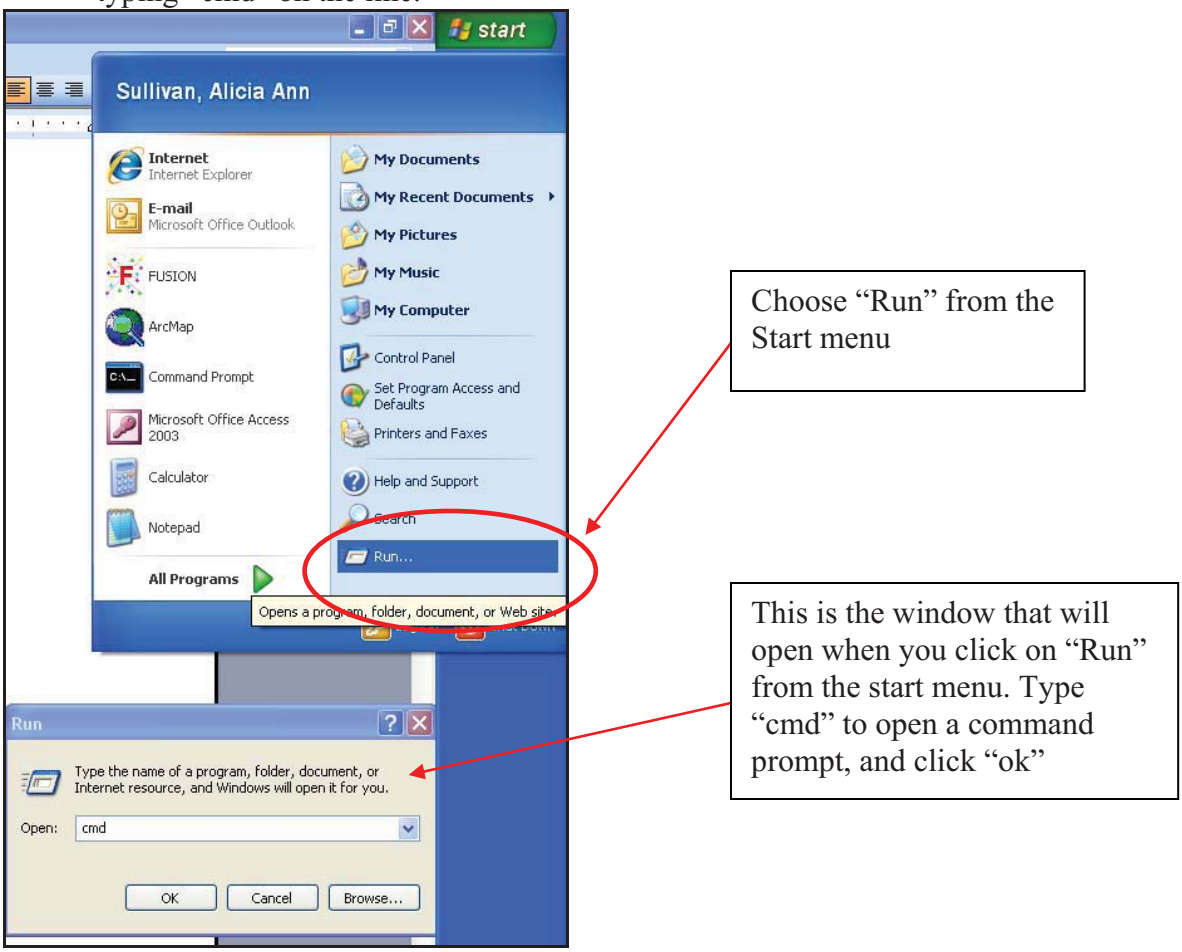


5. The install will run and when it is finished, click “finish” and you now have successfully downloaded the example data. The next portion of this section will be working with raw LIDAR points.

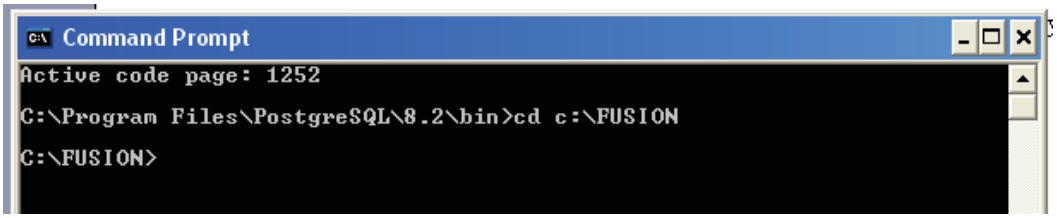
Working with the FUSION batch files:

This portion of the process will involve the use of command prompts and batch files. All of the batch programs are located in the C:\FUSION directory of the computer, unless otherwise specified during download. The default will be to run these programs out of the C:\FUSION directory, which will require all of the data that is called by the batch file to be in that directory, the outputs will also be put there. It is also possible to set the environmental variables on the machine to allow for data processing in other directories, this manual does not cover how to do this. The FUSION manual has detailed descriptions of each tool and the variables available. This manual will focus on the tools needed for this process. Make sure that the example dataset being used is in the UTM projection, this will cause problems later in the tutorial if using the incorrect datasets. All UTM datasets will have "UTM" somewhere in the file name.

1. Open a command prompt window from the Start menu, by selecting "Run" and typing "cmd" on the line.



2. The command prompt window will open. At the prompt, type "cd c:\FUSION" and press "enter" to change the directory to the location of the batch programs.



3. Now we are ready to work with the batch files in FUSION. The files that will be used in this step are the raw LIDAR points (**demo_4800K_UTM.lda**) and the bare ground model (**demo_4800K_UTM.dtm**). Make sure that these files are in the C:\FUSION directory on your computer.

FUSION batch file tools:
The tools need for this tutorial are described in the following section. The FUSION user's manual gives a more complete description of the tool and the available switches. The tools are presented in chronological order for this method.

1. Percent Cover Calculation:

The first step is to use the Cover batch program in FUSION to create a percent cover estimation for the study area. The description from the FUSION user's manual is: *"Cover* computes estimates of canopy closure using a grid. Output values for cover estimates range from 0.0 to 100.0 percent. Canopy closure is defined as the number of returns over a specified height threshold divided by the total number of returns within each cell. In addition, *Cover* can compute the proportion of pulses that are close to a bare-ground surface model to help assess canopy penetration by the laser scanner. With the addition of an upper height limit, *Cover* can compute the proportion of returns falling within specific height ranges providing estimates of relative vegetation density for various height strata." (McGaughey, R.J., 2007).

General syntax:
Cover [switches] groundfile coverfile heightbreak cellsize xyunits zunits coordsys zone horizdatum vertdatum datafile1

The syntax that will be used for this data set:
Cover demo_4800K_UTM.dtm demo_cover_89916m_utm.dtm 2 8.9916 m m 1 10 2 2 demo_4800K_UTM.lda

Explanation of Syntax: The cell size of this analysis is based on 1/50 acre. 8.9916m by 8.9916m is approximately 1/50th of an acre and a common area used in forest inventory. The data is in meters and projected in UTM NAD 1983 NAVD88 zone 10 north, which explains the rest of the syntax (see FUSION user's manual for more information).

1. Copy and paste the syntax give above into the command prompt window and press “enter”. This will start the batch program, and may take a while to run depending on your computer. Status information will be displayed as the program runs.

```
Command Prompt
Active code page: 1252

C:\Program Files\PostgreSQL\8.2\bin>cd c:\fusion

C:\FUSION>Cover  demo_4800K_UTM.dtm demo_cover_89916m_utm.dtm 2 8.9916 m m 1 10 2 2 demo_4800K_UTM.l
da
Cover v1.30 (FUSION v2.60) (Built on Dec  4 2007 09:19:40)
Command line: Cover  demo_4800K_UTM.dtm demo_cover_89916m_utm.dtm 2 8.9916 m m 1 10 2 2 demo_4800K_U
TM.lda
Run started: Wed Apr 02 13:54:13 2008
Using 1 data files:

   demo_4800K_UTM.lda: 4859996 points
Canopy cover layer file produced:
   demo_cover_89916m_utm.dtm    Apr 2, 2008 @ 1:54 PM
Run finished: Wed Apr 02 13:54:16 2008 (elapsed time: 3 seconds)
Done

C:\FUSION>_
```

DTM2TIF Tool:
The second step for the percent cover dtm will be to create a geo tiff file from the dtm. This will create the final product to be used in SPRING and will allow for the percent cover image to be viewed in ArcMap. This step will use the DTM2TIFF tool in FUSION. This tool will also be used to create the stem density and average height geo tiff files later in the tutorial.

General syntax:
DTM2TIF [switches] inputfile [outputfile]

The syntax that will be used for this data set is:
DTM2TIF demo_cover_89916m_utm.dtm demo_cover_89916m_utm.tif

1. Copy and paste the syntax give above into the command prompt window and press “enter”. This will start the batch program, and may take a while to run depending on your computer. Status information will be displayed as the program runs.

```
Command Prompt

C:\FUSION>DTM2TIF demo_cover_89916m_utm.dtm demo_cover_89916m_utm.tif
DTM2TIF v1.00 (FUSION v2.60) (Built on Dec  4 2007 09:18:09)
Command line: DTM2TIF demo_cover_89916m_utm.dtm demo_cover_89916m_utm.tif
Run started: Wed Apr 02 14:14:59 2008
TIF image file produced:
   demo_cover_89916m_utm.tif    Apr 2, 2008 @ 2:14 PM
TIF world file produced:
   demo_cover_89916m_utm.tfw    Apr 2, 2008 @ 2:14 PM
Run finished: Wed Apr 02 14:14:59 2008 (elapsed time: 0 seconds)
Done

C:\FUSION>
```

Explanation of Output: This generates a geo tiff file from the demo_cover_89916m_utm.dtm that was created in the previous step. There are two files output from this process, a tiff image file (.tif extension) and a world file (.tfw extension). Both files will have the same name but be distinguished by the extensions, any changes to the file name must be made on both files or the geo tiff will not function correctly. It is

important to note that **BOTH** of these files must be moved when moving this file around in order to preserve the functionality of the geo tiff.

2. Canopy Maxima- Generation of the canopy maxima points is a two step process that requires the use of the Canopy Model tool and the Canopy Maxima tool in FUSION.

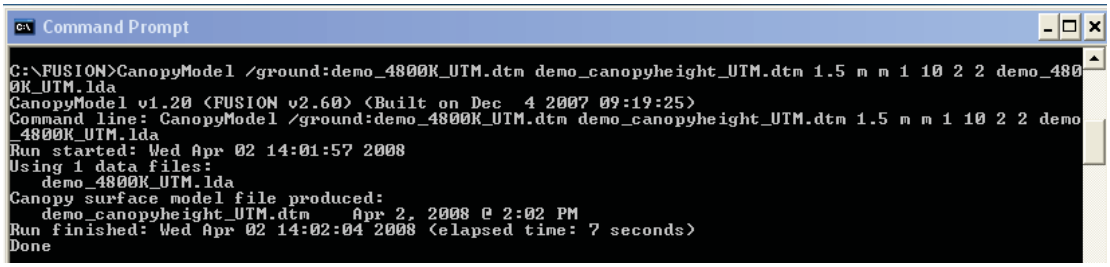
Canopy Model Tool-
The second program that will be used in this process is the Canopy model tool. This tool uses the raw LIDAR points (**demo_4800K_UTM.lda**) and the ground surface model (**demo_4800K_UTM.dtm**) to create a model of the surface of the canopy. The ground model is used to "subtract the ground elevations from the return elevations to produce a canopy height model" (McGaughey, R.J., 2007). The canopy height model is an intermediate step to producing the canopy maxima points.

General Syntax:
CanopyModel [switches] surfacefile cellsize xyunits zunits coordsys zone horizdatum vertdatum datafile1

The syntax that will be used for this data set:
CanopyModel /ground:demo_4800K_UTM.dtm demo_canopyheight_UTM.dtm 1.5 m m 1 10 2 2 demo_4800K_UTM.lda

Explanation of Syntax: The ground switch is needed to create a canopy height model. The cell size is 1.5 meters, which is approximately 5 feet. The data is in meters and projected in UTM NAD 1983 NAVD88 zone 10 north, which explains the rest of the syntax (see FUSION user's manual for more information).

1. Copy and paste the syntax give above into the command prompt window and press "enter". This will start the batch program, and may take a while to run depending on your computer. Status information will be displayed as the program runs.



Canopy Maxima Tool-
The next step in FUSION is to generate the canopy maxima points using the Canopy Maxima tool. This tool uses a variable analysis window to identify local maxima points as well as information about crown height and width. The output of this process is a

comma separated value file (.csv) that will need to be manipulated in the FUSION GUI program before returning to the command line analysis. This process will be covered in subsequent sections. This tool uses the Canopy Height Model produced in the previous step.

*** Note about Canopy Maxima***
Methods for finding canopy maxima with LIDAR is a relatively new and changing process. The user should be aware that at the time of this manual being written, there are several tools that are available to find canopy maxima and depending on the purpose of the project, this tool may not be the best. The FUSION canopy maxima tool was chosen for this project and manual due to the availability of the tool and its ability to process large areas. However, this choice was made with the awareness that the canopy maxima tool underestimates the true maxima in forest stands. Currently, this tool will work well for either young stands or mature stands based on the parameters that are set. Mixed forest areas such as the example data pose a problem in that it will provide very good stem density information for one stand type and not the others. For more information about the methodology used in the Canopy Maxima tool see:

> Kini, A.U. & Popescu, S.C. (2004, September, 16). *Treevaw: A versatile tool for analyzing forest canopy LIDAR data- A preview with an eye towards the future.* Paper presented at the 2004 ASPRS Images to Decisions: Remote sensing for GIS applications conference, Kansas City, MO.

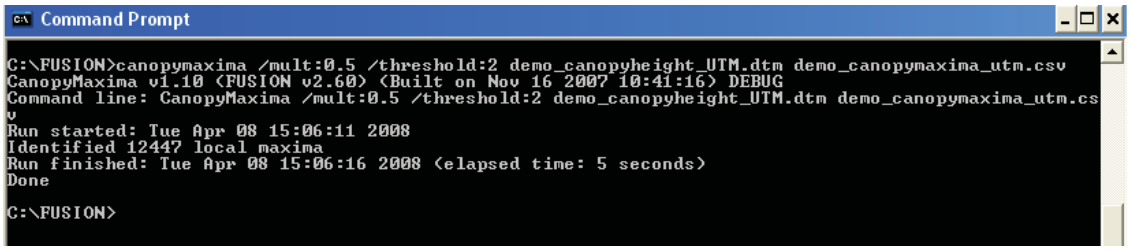
With that said, this project is interested in creating a density layer that represents the densities of stands relative to one another, not an absolute count of trees per acre. The information generated about stem density in this method will not accurately represent the conditions on the ground, but will provide a data layer that will act as a relative measure of density between stands for the image segmentation in SPRING.

General Syntax:
CanopyMaxima [switches] inputfile outputfile

The syntax that will be used for this data set:
CanopyMaxima /mult:0.5 /threshold:2 demo_canopyheight_UTM.dtm demo_canopymaxima_utm.csv

Explanation of Syntax: The choice of these switches and the values here are specific for this dataset. It is likely that for each data acquisition, there will need to be adjustments made to these values. The values were chosen for this dataset because it produced the best results for comparison of densities between stands (see note above).

1. Copy and paste the syntax give above into the command prompt window and press “enter”. This will start the batch program, and may take a while to run depending on your computer. Status information will be displayed as the program runs.



2. A file called demo_canopymaxima_UTM.csv will be located the C:/FUSION directory. This file contains the information for each canopy maxima pint. This file will be used in the next section to produce the stem density and average height data layers.

Section 2- Working with FUSION GUI

This section will be a brief departure from the FUSION command line interface used in the previous section. Once the needed files are created, the command lines will be used again to produce the final two data layers, stem density and average height.

Software needed:

- FUSION (see downloads section)

Data Required:

- Canopy maxima file from previous section (demo_canopymaxima_utm.csv)

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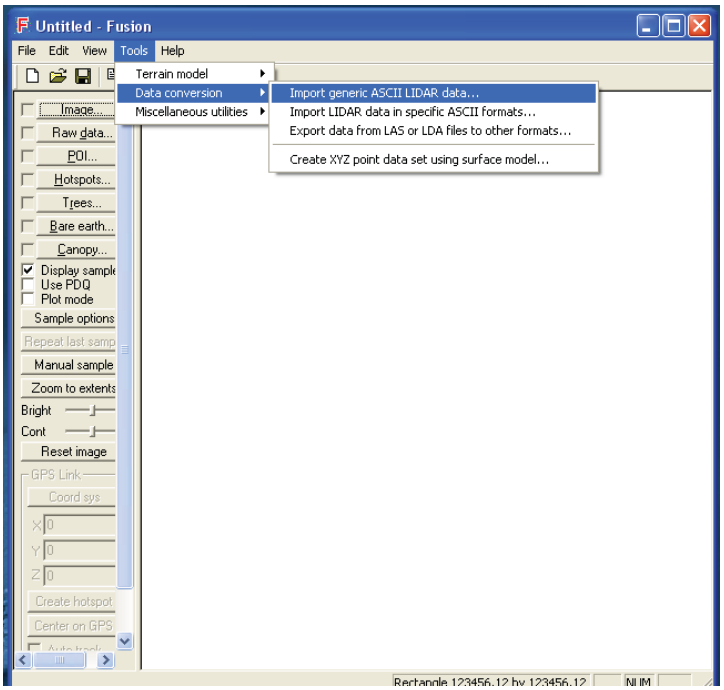
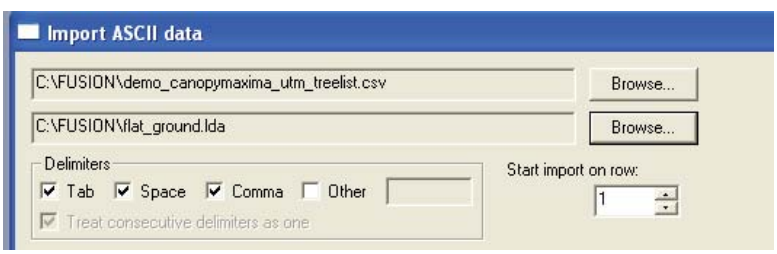
1. Open the FUSION GUI in Start -> Programs -> FUSION.

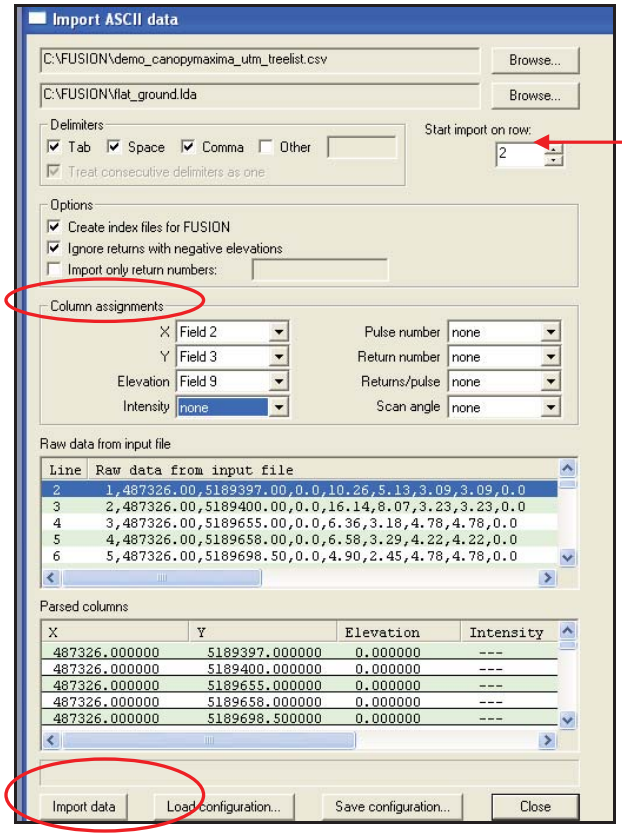
When the program opens go to the top menu bar and open Tools -> Data Conversion -> Import generic ASCII LIDAR data.



2. This will open a dialogue box for importing ASCII and CSV files. This tool will be used to create "point clouds" from the canopy maxima file that represent a flat ground model and the canopy maxima points. To do this, the canopy maxima .csv file must be converted into two .lda files.
3. To create the flat ground model, click on the first "Browse" button and navigate to the demo_canopymaxima_utm.csv file. Click on the second "Browse" button and give the output file a name of "demo_flat_ground.lda" in the C:\ FUSION directory.



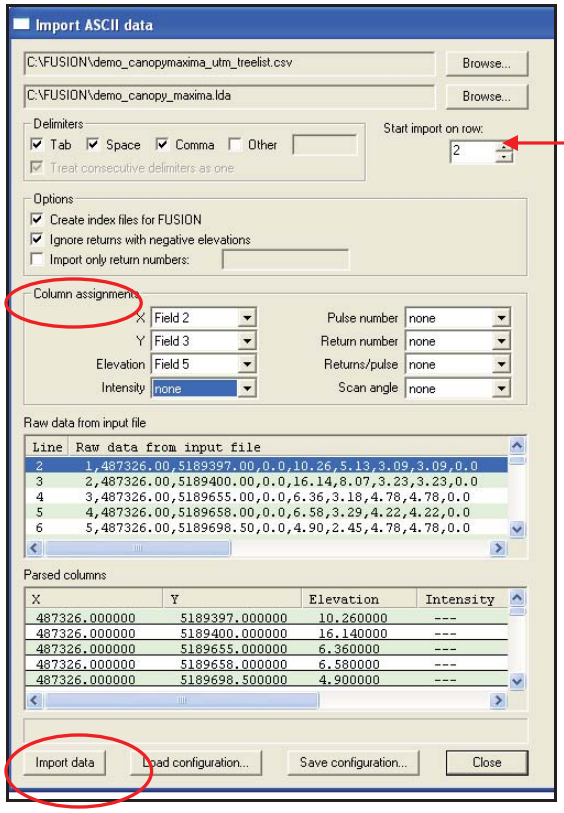
4. The next step is to set the parameters for the import of the data. In the "Start on import row" type 2. This will start the data below the column headers. In the "Column assignments" dialogue box Set X to "field 2", Y to "field 3" and Elevation to "field 9" the remaining fields should be set to "none". (Setting the elevation to field 9, or 0 will create a flat surface when taken through the future steps.) Click on "Import data" and then close when the import is complete.



Start import on row

This will create the .lda for the flat ground surface.

5. Repeat this process for the canopy maxima points to create an .lda file for the canopy points. Open Tools -> Data Conversion -> Import generic ASCII LIDAR data.
6. Click on the first “Browse” button and navigate to the demo_canopymaxima_utm.csv file. Click on the second “Browse” button and give the output file a name of “demo_canopy_maxima.lda” in the C:\ FUSION directory.
7. The next step is to set the parameters for the import of the data. In the “Start on import row” type 2. This will start the data below the column headers. In the “Column assignments” dialogue box Set X to “field 2”, Y to “field 3” and Elevation to “field 5” the remaining fields should be set to “none”. (Setting the elevation to field 5, uses the height of the canopy maxima points) Click on “Import data” and then close when the import is complete.



Start on import row

This will create the .lda file for the canopy maxima points.

8. The demo_flat_ground.lda and demo_canopy_maxima.lda files will now be used in the command line interface of FUSION for the final analysis.
9. Open a command line as described in the previous section, and change the directory to C:\FUSION to start the next portion.

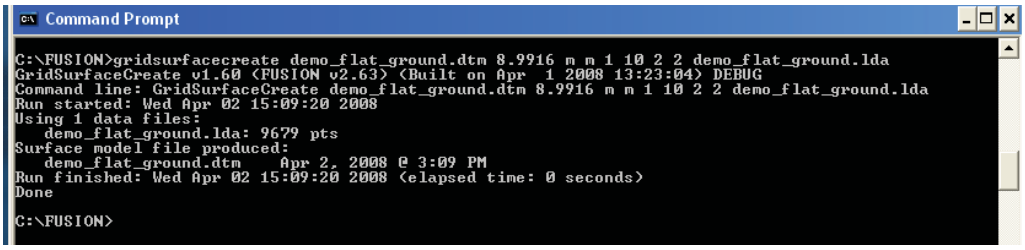
1. Grid Surface Create:

This tool will be used to produce the flat ground surface from the demo_flat_ground.lda file just created. The importance of this flat ground model relates to the next tool that will be used called Grid Metrics. Grid Metrics is generally used on raw LIDAR datasets and uses the ground model to normalize the data. Since the data has already been normalized through the production of the Canopy Height model, this is not necessary and the flat ground model is used as a trick to make the Grid Metrics tool work properly for this application.

General Syntax:
GridSurfaceCreate [switches] surfacefile cellsize xyunits zunits coordsys zone horizdatum vertdatum datafile1
The syntax that will be used for this data set:
GridSurfaceCreate demo_flat_ground.dtm 8.9916 m m 1 10 2 2 demo_flat_ground.lda

Explanation of Syntax: The data is in meters and projected in UTM NAD 1983 NAVD88 zone 10 north, (see FUSION user's manual for more information).

1. Copy and paste the syntax give above into the command prompt window and press "enter". This will start the batch program, and may take a while to run depending on your computer. Status information will be displayed as the program runs.



2. Grid Metrics:

This tool will create the two final data layers; stem density per pixel and average height per pixel using the points from the demo_canopy_maxima.lda. This tool has several other functionalities that are detailed in the FUSION manual. For this exercise, the min points, and raster switches will be used. The final output will be two .dtm layers for mean and count that will be converted to geo tiff files using the DTM2TIF tool.

General Syntax:
GridMetrics [switches] groundfile heightbreak cellsize outputfile datafile1

The syntax that will be used for this data set is:
GridMetrics /minpts:1 /raster:count,mean demo_flat_ground.dtm 2 8.9916 demo_gridmetrics demo_canopy_maxima.lda

Explanation of Syntax:
The /minpts switch controls the minimum number of points that have to be in a cell to have metrics computed, this sets it to a minimum of 1. The /raster switch creates .dtm files for the count of points in a cell (stem density) and the average value for the points in the cell (in this case, height). The heightbreak is set to 2 and the cell size is set to the standard 8.9916 for the output cell size.

1. Copy and paste the syntax give above into the command prompt window and press "enter". This will start the batch program, and may take a while to run depending on your computer. Status information will be displayed as the program runs.

```
Command Prompt

C:\FUSION>GridMetrics /minpts:1 /raster:count,mean demo_flat_ground.dtm 2 8.9916 demo_gridmetrics de
mo_canopy_maxima.lda
GridMetrics v1.90 (FUSION v2.63) (Built on Apr  2 2008 10:43:52)
Command line: GridMetrics /minpts:1 /raster:count,mean demo_flat_ground.dtm 2 8.9916 demo_gridmetric
s demo_canopy_maxima.lda
Run started: Wed Apr 02 15:56:48 2008
   demo_canopy_maxima.lda: 9679 points
   Total first returns used for cover calculation: 9679 points

Grid metrics file produced:
   demo_gridmetrics_first_returns_density_only_elevation_stats.csv    Apr 2, 2008 @ 3:56 PM
ASCII raster grid header file produced:
   demo_gridmetrics_first_returns_density_only_elevation_stats_ascii_header.txt    Apr 2, 2008 @ 3:5
6 PM
Point count file produced:
   demo_gridmetrics_first_returns_density_only_elevation_count.dtm    Apr 2, 2008 @ 3:56 PM
Mean value file produced:
   demo_gridmetrics_first_returns_density_only_elevation_mean.dtm    Apr 2, 2008 @ 3:56 PM
Run finished: Wed Apr 02 15:56:49 2008 (elapsed time: 1 seconds)
Done

C:\FUSION>
```

DTM2TIF Tool:

This tool has been described in the earlier section of this manual, so only the syntax needed for this section will be provided. This tool converts dtm files to geo tiff files with the associate world file.

General Syntax:
DTM2TIF [switches] inputfile [outputfile]

The syntax that will be used for this data set:
Stem density:
DTM2tif demo_gridmetrics_first_returns_density_only_elevation_count.dtm demo_stem_density.tif
Average Height:
DTM2tif demo_gridmetrics_first_returns_density_only_elevation_mean.dtm demo_avg_height.tif

```
Command Prompt

C:\FUSION>DTM2tif demo_gridmetrics_first_returns_density_only_elevation_count.dtm demo_stem_density.
tif
DTM2TIF v1.00 (FUSION v2.60) (Built on Dec  4 2007 09:18:09)
Command line: DTM2TIF demo_gridmetrics_first_returns_density_only_elevation_count.dtm demo_stem_dens
ity.tif
Run started: Wed Apr 02 16:05:40 2008
TIF image file produced:
   demo_stem_density.tif    Apr 2, 2008 @ 4:05 PM
TIF world file produced:
   demo_stem_density.tfw    Apr 2, 2008 @ 4:05 PM
Run finished: Wed Apr 02 16:05:40 2008 (elapsed time: 0 seconds)
Done

C:\FUSION>DTM2tif demo_gridmetrics_first_returns_density_only_elevation_mean.dtm demo_avg_height.tif

DTM2TIF v1.00 (FUSION v2.60) (Built on Dec  4 2007 09:18:09)
Command line: DTM2TIF demo_gridmetrics_first_returns_density_only_elevation_mean.dtm demo_avg_height
.tif
Run started: Wed Apr 02 16:05:50 2008
TIF image file produced:
   demo_avg_height.tif    Apr 2, 2008 @ 4:05 PM
TIF world file produced:
   demo_avg_height.tfw    Apr 2, 2008 @ 4:05 PM
Run finished: Wed Apr 02 16:05:50 2008 (elapsed time: 0 seconds)
Done

C:\FUSION>_
```

Congratulations! You are now finished with the data generation portion of this tutorial. The next step will be image segmentation and classification with SPRING.

The files that were generated in this part will be located in the C:\FUSION directory and will be needed for the next section.

Part III- Segmentation and Classification with SPRING

This portion of the tutorial will deviate from the step by step nature of the previous sections. Image classification is a process that is dependant on the individual analyst and there are multiple ways to segment, train and classify the same image. This section will use a tutorial developed by the US Fish and Wildlife Service in their remote sensing lab in Albuquerque, New Mexico.

Software needed:

- SPRING (see downloads section)

Data Required:

- Percent cover (demo_cover_89916m.tif)
- Stem density (stem_density.tif)
- Average height (avg_height.tif)

Other Downloads

- USFWS tutorial: http://www.fws.gov/data/documents/SPRING%20Manual%20022306.pdf

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Download for this section:

For this section a tutorial developed by the U.S. Fish and Wildlife Service will be used. This tutorial was chosen to be used in this manual because it covers the basic functionalities of SPRING and image classification. The tutorial is also basis for the method used in this project. The primary focus of this section of the manual will be as a guide through the USFWS tutorial and explanation of known problems with SPRING. The information in this section is intentionally vague. The parameters for segmentation, classes and training sites are subjective and will vary greatly depending on the goals and skill of the analyst. This section is meant to be a rough guide to object orientated classification using SPRING.

1. Download the USFWS SPRING tutorial from:
http://www.fws.gov/data/documents/SPRING%20Manual%20022306.pdf

2. Print or save the USFWS tutorial for use in the next section.

Section I: Guide through the USFWS SPRING tutorial:

This section will go through each part of the USFWS tutorial, numbers correspond to the tutorial sections.

2.1 Download and install SPRING- See download section of this manual
2.2 Acquire and Install ERDAS ViewFinder- Not necessary for this project.

2.3 Reproject and Resample Imagery with ERDAS ViewFinder- Not necessary, projections set in ArcMap

2.4 Create Database, Project Category and Import Image- Follow these instructions as is. Name the database and project relevant to the data. Set the bounds to the extent of the geo tiff images created in FUSION. Set the projection to UTM WGS84 zone 10 north. See note below about importing images into SPRING.

***Note about importing images-**
SPRING is very particular about the format of the files it will import. Geo tiff files with associated world files are necessary. In addition, the size of the geo tiff files and origin in the world file must match EXACTLY. Depending on the outputs that are generated from the FUSION analysis, there may need to be some adjustment to the size or origin information listed in the world file. There are several programs that manipulate the size of images, so this process will not be covered in this manual. To edit world files, simply open the .tfw files associated with the geo tiff files and edit them accordingly in notepad. It is also important that the geo tiff images have the projection defined before bringing them into SPRINg. This can easily be done through ArcMap in the data management -> projections ->define projection tool in the toolbox.
SPRING as released in the version for this manual will only accept geo tiff images. The functionalities shown in the File menu on the main SPRING menu do not work. There is no documentation as to why this occurs.*****

2.5 Create Segmentation- Follow these instructions as is. The values for similarity and area will vary depending on the purpose of the classification. Try several combinations to see the difference. For this dataset a similarity of 5 and area of 10 produce decent results.

2.6 Create Classes for Classification, Training Samples Collection- Again this section can be followed as is. Create class names that reflect the type of classification that is desired. The training sites will be dependant on the classes that are chosen. The aerial photograph of the study site (demo_4800K_UTM.jpg) may be helpful to determine classes and location of training sites.

2.7 Run Training Sample Analysis, Classification and Output Map- Follow instructions as is. If classification is not satisfactory, return to the previous section and edit the training or segmentation and re-run the classification.

2.8 Create Vector- Follow instructions as is. Save the shapefile to a directory relevant to the tutorial.

2.9 Export Thematic Map- The view the output shapefile, open ArcMap and add in the shapefile to a project with the demo_4800K_UTM.jpg image already loaded.

Note about shapefiles-** SPRING has a defect that adds 10,000,000 units to the Y coordinates of the output shapefile. This can be corrected by using the "Move" tool in the editor of ArcMap. Subtract 10,000,000 units from the Y axis and the shapefile for the classification should line up. **

2.10 Add Projection, Reproject, Load into GIS- Projection will need to be defined for the shapefile in ArcMap in the data management -> projections ->define

projection tool in the toolbox. The projection should be set to UTM NAD 1983 NADV 88 zone 10 north.

Part IV: Accuracy Assessment of Classified Images

This is the final section of the tutorial and briefly describes how to perform an accuracy assessment on classified images using a confusion matrix. For a full description of the theory and methods please see:

Congalton, R.G and K. Green (1999). Assessing the Accuracy of Remotely Sensed Data: Principles and Practices. Boca Raton, FL, Lewis Publishers.

Software needed:

- Hawth's Tools (see downloads section)
- ArcMap 9.2

Data Required:

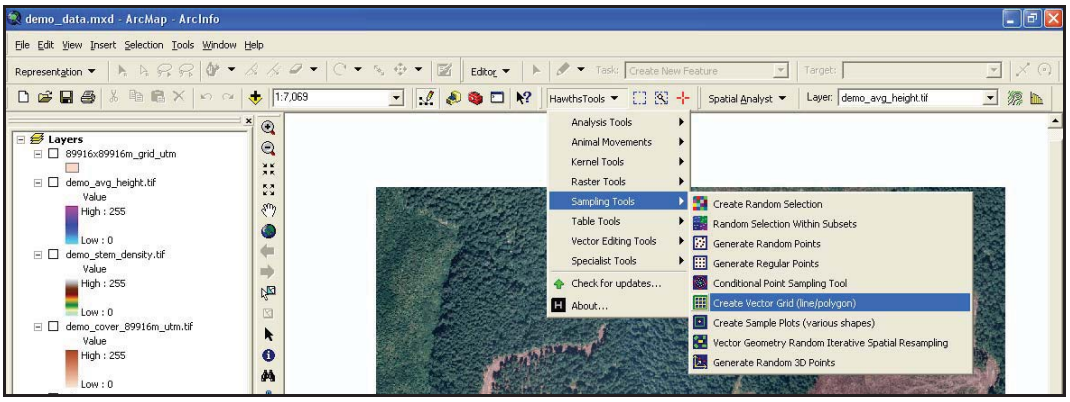
- Output of SPRING classification (shapefile)
- Aerial Photograph (demo_4800K_UTM.jpg and demo_4800K_UTM.jpgw)

Section I: Setting up a sampling grid and points

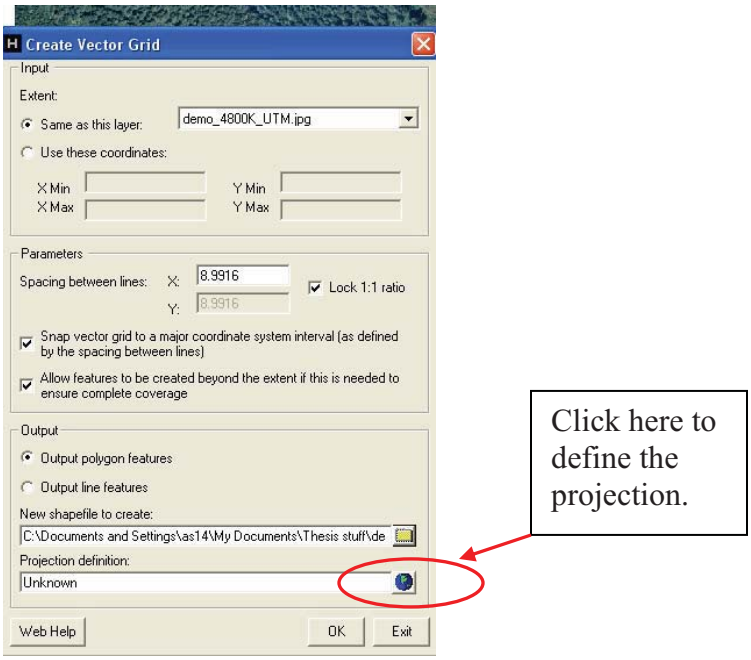
As mentioned in the introduction to this part, only the set up for the accuracy assessment will be covered. This is primarily because this is only one method of accuracy assessment for classifications and is also described in detail in Congalton and Green's book.

Create a Grid: In order to see the individual pixels, a grid must be created to distinguish pixels.

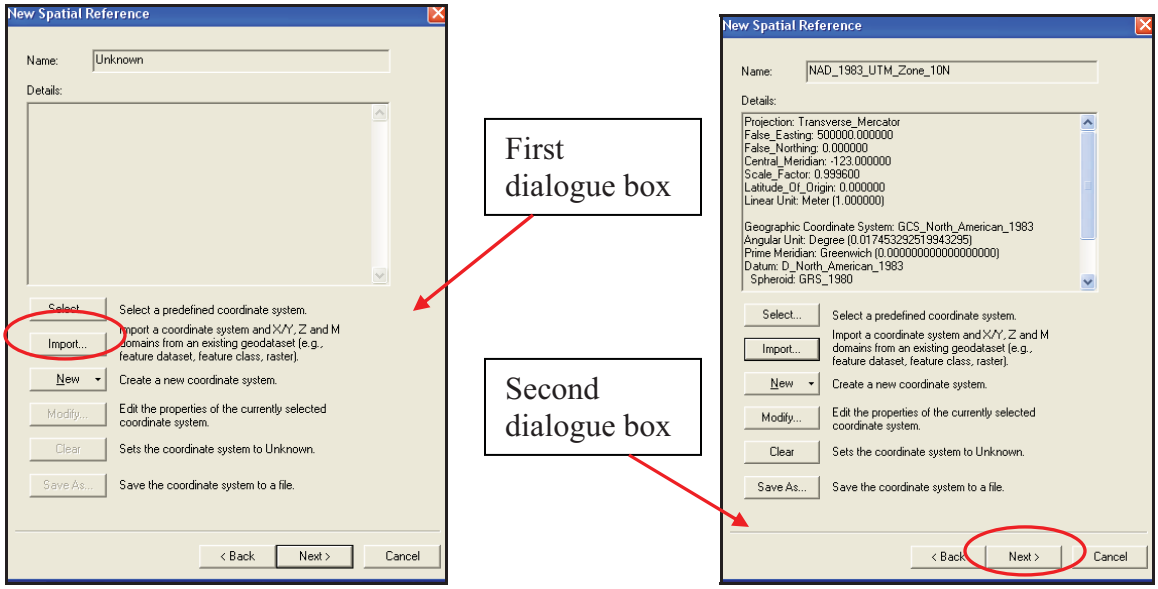
1. Open ArcMap with and navigate to the project used for the tutorial.
2. Open the extensions menu and turn on the toolbar for Hawths Tools
3. Open Hawths tools and navigate to Sampling tools-> Create Vector Grid



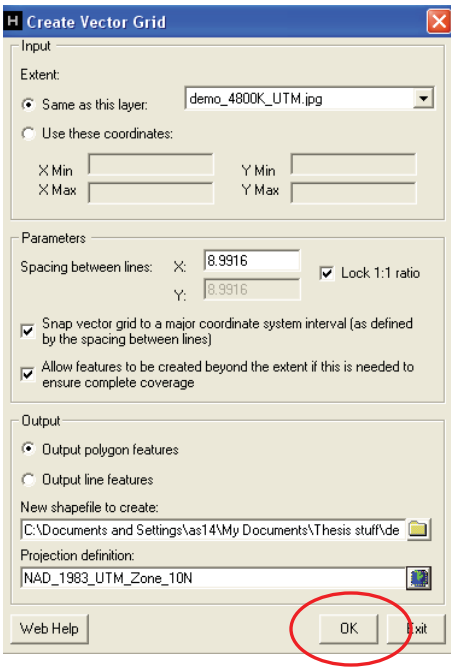
4. In the dialogue box that pops up, set the extent to the "Same as Layer" and choose the demo_4800K_UTM.jpg from the drop down menu. Under the "Parameters" section, set the spacing between lines to 8.9916, and uncheck the two boxes. Under "Output", choose the destination and name of the output grid. In this example it is called 89916_grid.shp. Click the button next to the "Projection Definition" to set the projection (see next step).



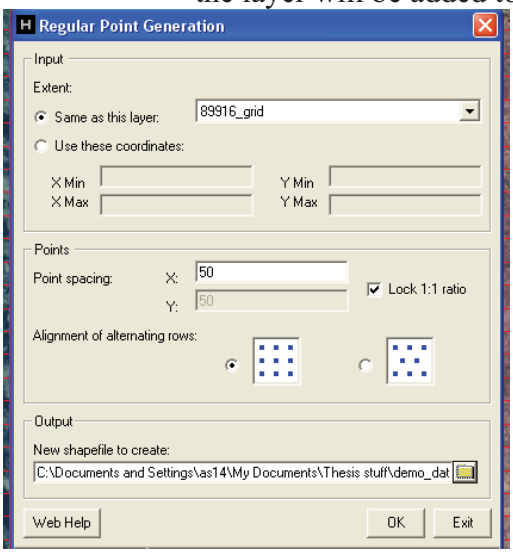
5. When the dialogue box below appears, choose “Import” and navigate to the folder where the demo_4800K_UTM.jpg file is on your computer. Select this file and click “add” the menu on the right will appear showing that the projection has been set to NAD_1983_UTM_Zone_10N. Click “Next” and then “Finish” on the next screen.



6. Once the projection is set, click “ok” from the Create Vector Grid menu to run the program. When the processing is finished, the layer will be added to the project.



7. To view the grid, double click on the grid layer and set the fill to "hollow", the line color to red and the outline width to 1.
8. To create the point layer that will be used to as the sampling grid for the accuracy assessment, open the Hawth's tools extension and navigate to Sampling tools -> Create a regular grid to open the tool.
9. In the "Input" section choose the Extent to be Same as the 89916_grid.shp layer from the drop down menu. In the "Points" section enter 50 for the point spacing. Choose the alignment of rows as follows and name the output file 50m_points.shp and click "ok". When processing is finished, the layer will be added to the project.



Section II – Accuracy Assessment

Now that the analysis grid and sample point layers have been created, the accuracy assessment can be performed on the classification. This process is dependant on the preferences of the analyst and data that is available. In the case of this tutorial, sample point spacing was chosen to give approximately 100 samples per class with extra points included to account for pixels that have multiple classes.

The basic concept of this accuracy assessment method is to compare the classification of the pixels that contain a sample point to the aerial photograph to determine if the classification is correct. The accuracy of this method is highly dependant on the analyst's ability to determine classes from aerial photographs. Each of the sample point pixels will then build the error matrix that will be the basis for calculating the user's accuracy, producer's accuracy, overall accuracy and KHAT (Congalton and Green, 1999).