



VegMeasure

VOLUME 2: IMAGE PROCESSING MANUAL



RESEARCH
PROGRAM ON
Livestock

TOOLS & GUIDELINES

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Tools & Guidelines

ICARDA's Tools & Guidelines series taps the Center's expertise to provide comprehensive advice and strategies that researchers can adopt to enhance agricultural productivity and overcome critical challenges affecting rural communities in the non-tropical dry areas.

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About ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world.

We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

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Introduction

VegMeasure is a Digital Vegetation Charting Technique (DVCT) that measures vegetation on the ground in a non-destructive manner. Just like quadrat sampling, it assesses vegetation cover to determine the ecological status of the study area. In particular, it allows rangeland ecologists to make meaningful classes to measure the percentage cover of foliage, litter and bare ground, as well as other categories of interest. However, DVCT is much quicker, more objective, and allows the derivation of additional metrics than traditional quadrat sampling. The colors recorded by digital cameras used in DVCT may be interpreted using VegMeasure computer software to create meaningful classes, such as dark brown soil, white litter, and green leaves, and the software allows the extraction of hue, calibration of thresholds, classification of K-means, and setting of brightness and green leaf algorithms. Large scale maps may be created with greater ease using this digital method and repeat monitoring tracks temporal changes in vegetation. DVCT is more accurate than subjective data collected by numerous field surveyors and a permanent digital record is generated that may be revisited.

It is important that certain field data collection procedures are followed when using this method, including an understanding of the required software. This manual series has been created to facilitate the use of DVCT: Volume 1 describes field data collection and Volume 2 teaches how to process the images using VegMeasure computer software. Volume 1 is intended to be used in the field to aid camera setup and field data collection, while Volume 2 is designed as an office-based manual, for image processing. This volume describes how to use the image positioning tool.

1. VegMeasure image positioning tool

The image positioning tool is important to set your camera type and generate usable Key Hole Markup Language (KML) files.

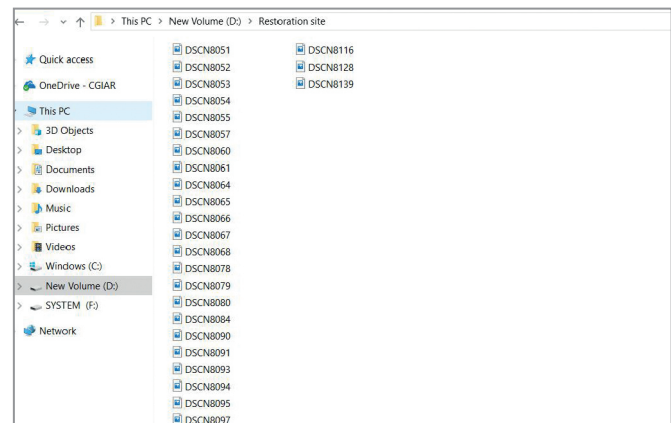
To bring your images into VegMeasure software, it is necessary to use the image positioning tool. This program identifies your camera and collates all files in a single operation, saving them in a format that is readable by VegMeasure. KML files, which contain spatial information, are read by many spatial programs. The files summarize longitude, latitude, elevation, GPS date and time, camera date and time, image name, and image path.

The following cameras are supported:

HTEC Inspire 4G
Nikon CoolPix AW100
Nikon CoolPix P510
Panasonic DMC-ZS10
Apple iPhone 4
Apple iPhone 5S
Samsung Galaxy S4
Samsung Galaxy Note 3

Step 1: Download images

It is helpful to save quadrat shots in a **dedicated folder** on your computer, with reference and landscape photos, and any photos taken at an angle stored in another, separate folder.



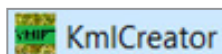
Step 2: Acquire access to and install the image positioning tool program

Contact Vegmeasure@gmail.com to obtain a license to the Image Positioning Tool software, which is a different program to the VegMeasure software. The program will be emailed to you, along with a set of instructions on how to run it. You will need to have administrator access to your computer, thus you may need to contact the IT department of your institution.

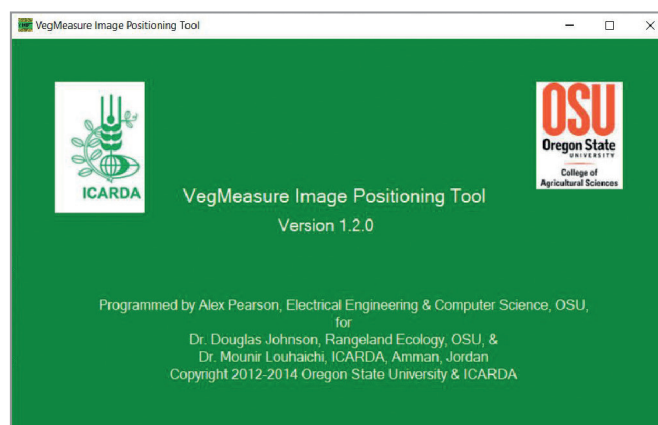
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Step 3: Run image positioning tool program

The program should be located in your program files under VegMeasure Image Positioning Tool. Click on the KmlCreator icon.

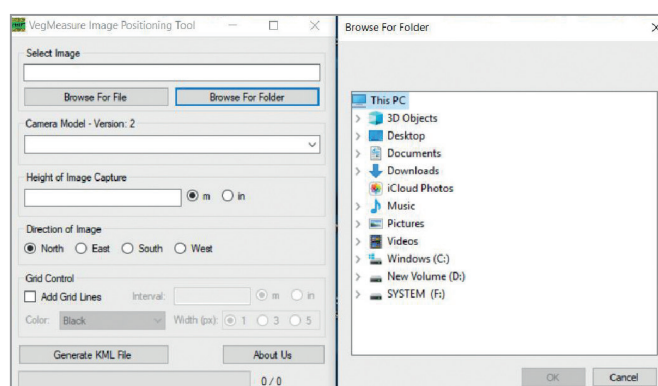


After the program opens, it will ask you to select the location of your files.



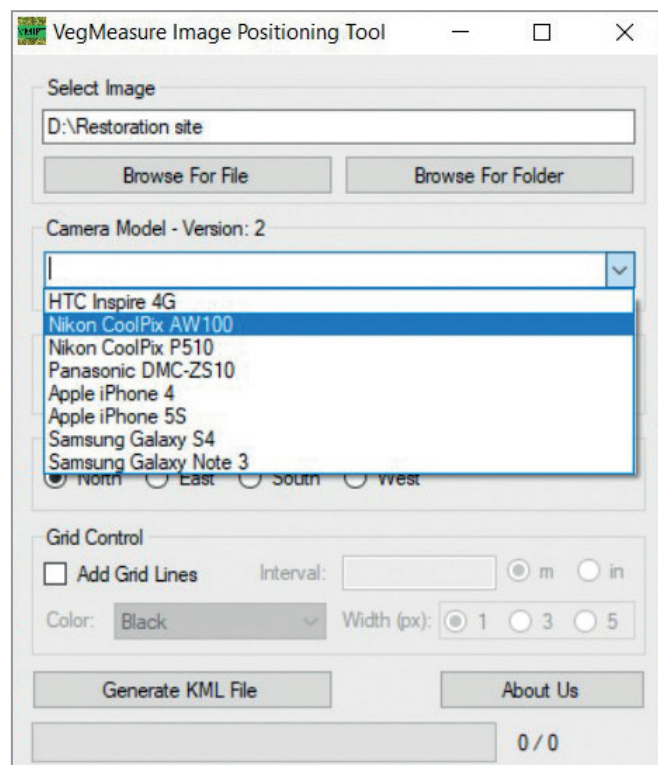
Step 4: Upload images

When the program opens, a window will appear (see screenshot right) asking for information required to produce the KML file. Firstly, click on **Browse for Folder** and then select the folder where your files are located.



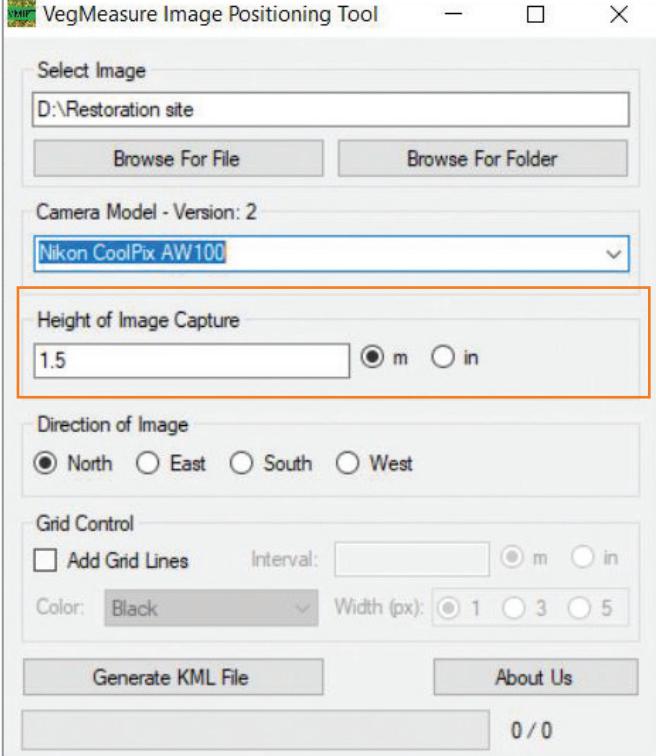
Step 5: Select the camera model

Choose your camera model from the drop-down list.



Step 6: Camera height

The height of the image is required to accurately scale the vegetation. Select the height at which the images were taken. *If images were taken at different heights, place the image files into height-specific folders.*



VegMeasure Image Positioning Tool

Select Image
D:\Restoration site
Browse For File Browse For Folder

Camera Model - Version: 2
Nikon CoolPix AW100

Height of Image Capture
1.5 ☒ m ☐ in

Direction of Image
☒ North ☐ East ☐ South ☐ West

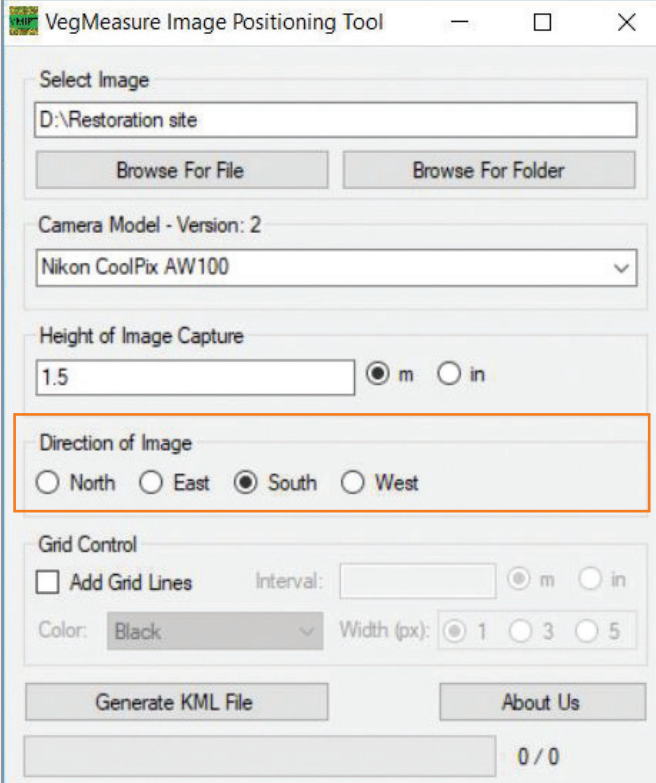
Grid Control
☐ Add Grid Lines Interval: ☒ m ☐ in
Color: Black Width (px): ☒ 1 ☐ 3 ☐ 5

Generate KML File About Us

0 / 0

Step 7: Select the direction of the image

The direction of the image is important to account for shadow effects. Select the direction from which the images were taken. *If the images were taken in different directions, place the image files into direction-specific folders.*



VegMeasure Image Positioning Tool

Select Image
D:\Restoration site
Browse For File Browse For Folder

Camera Model - Version: 2
Nikon CoolPix AW100

Height of Image Capture
1.5 ☒ m ☐ in

Direction of Image
☐ North ☐ East ☒ South ☐ West

Grid Control
☐ Add Grid Lines Interval: ☒ m ☐ in
Color: Black Width (px): ☒ 1 ☐ 3 ☐ 5

Generate KML File About Us

0 / 0

Step 8: Generate KML and summary files

Before you generate the KML file, there is an option to add a grid to the original image, for which it is possible to set grid size, and thickness and color of the grid lines. Clicking **Generate KML File** will trigger the software to process and create new files with the same name, in the same folder, albeit with a different extension (.kml). A summary file (.csv), titled "summary", will also be created in the same folder.

The screenshot shows the 'VegMeasure Image Positioning Tool' window. The 'Grid Control' section is highlighted with an orange box. It contains the following controls:

- ☒ Add Grid Lines
- Interval:
- ☒ m ☐ in
- Color:
- Width (px): ☒ 1 ☐ 3 ☐ 5

An orange arrow points to the 'Generate KML File' button.

The summary file contains GPS data for each image, comprising longitude, latitude, elevation, GPS date and time, camera date and time, and image name and path.

	Longitude	Latitude	Elevation	GPS Date/Time	Camera Date/Time	Image Name	Image Path
2	36.11983	31.73383	NaN	2018-04-23 7:12:14	4/23/2018 10:08	DSCN8051.JPG	D:\Restoration site\DSCN8051.JPG
3	36.11986	31.73382	NaN	2018-04-23 7:12:21	4/23/2018 10:08	DSCN8052.JPG	D:\Restoration site\DSCN8052.JPG
4	36.1199	31.73377	NaN	2018-04-23 7:12:30	4/23/2018 10:08	DSCN8053.JPG	D:\Restoration site\DSCN8053.JPG
5	36.11992	31.73376	NaN	2018-04-23 7:12:36	4/23/2018 10:08	DSCN8054.JPG	D:\Restoration site\DSCN8054.JPG
6	36.11996	31.73371	NaN	2018-04-23 7:12:46	4/23/2018 10:08	DSCN8055.JPG	D:\Restoration site\DSCN8055.JPG
7	36.12001	31.73364	NaN	2018-04-23 7:13:6	4/23/2018 10:09	DSCN8057.JPG	D:\Restoration site\DSCN8057.JPG
8	36.12007	31.73357	NaN	2018-04-23 7:13:31	4/23/2018 10:09	DSCN8060.JPG	D:\Restoration site\DSCN8060.JPG
9	36.12009	31.73352	NaN	2018-04-23 7:13:42	4/23/2018 10:09	DSCN8061.JPG	D:\Restoration site\DSCN8061.JPG
10	36.11995	31.73352	NaN	2018-04-23 7:16:9	4/23/2018 10:12	DSCN8064.JPG	D:\Restoration site\DSCN8064.JPG
11	36.11994	31.73355	NaN	2018-04-23 7:16:23	4/23/2018 10:12	DSCN8065.JPG	D:\Restoration site\DSCN8065.JPG
12	36.11994	31.73359	NaN	2018-04-23 7:16:35	4/23/2018 10:12	DSCN8066.JPG	D:\Restoration site\DSCN8066.JPG
13	36.11994	31.73362	NaN	2018-04-23 7:16:43	4/23/2018 10:12	DSCN8067.JPG	D:\Restoration site\DSCN8067.JPG
14	36.11992	31.73365	NaN	2018-04-23 7:16:53	4/23/2018 10:12	DSCN8068.JPG	D:\Restoration site\DSCN8068.JPG
15	36.11964	31.73391	NaN	2018-04-23 7:18:58	4/23/2018 10:15	DSCN8078.JPG	D:\Restoration site\DSCN8078.JPG
16	36.11967	31.73387	NaN	2018-04-23 7:19:8	4/23/2018 10:15	DSCN8079.JPG	D:\Restoration site\DSCN8079.JPG
17	36.11969	31.73385	NaN	2018-04-23 7:19:14	4/23/2018 10:15	DSCN8080.JPG	D:\Restoration site\DSCN8080.JPG
18	36.11979	31.7337	NaN	2018-04-23 7:20:0	4/23/2018 10:16	DSCN8084.JPG	D:\Restoration site\DSCN8084.JPG
19	36.11989	31.7335	NaN	2018-04-23 7:20:56	4/23/2018 10:16	DSCN8090.JPG	D:\Restoration site\DSCN8090.JPG
20	36.11982	31.73352	NaN	2018-04-23 7:21:15	4/23/2018 10:17	DSCN8091.JPG	D:\Restoration site\DSCN8091.JPG
21	36.11979	31.73358	NaN	2018-04-23 7:21:35	4/23/2018 10:17	DSCN8093.JPG	D:\Restoration site\DSCN8093.JPG
22	36.11977	31.73359	NaN	2018-04-23 7:21:44	4/23/2018 10:17	DSCN8094.JPG	D:\Restoration site\DSCN8094.JPG
23	36.11975	31.73363	NaN	2018-04-23 7:22:12	4/23/2018 10:18	DSCN8095.JPG	D:\Restoration site\DSCN8095.JPG
24	36.11973	31.73367	NaN	2018-04-23 7:23:14	4/23/2018 10:19	DSCN8097.JPG	D:\Restoration site\DSCN8097.JPG
25	36.11971	31.7337	NaN	2018-04-23 7:23:19	4/23/2018 10:19	DSCN8098.JPG	D:\Restoration site\DSCN8098.JPG
26	36.11966	31.73377	NaN	2018-04-23 7:23:29	4/23/2018 10:19	DSCN8099.JPG	D:\Restoration site\DSCN8099.JPG
27	36.11964	31.73379	NaN	2018-04-23 7:23:35	4/23/2018 10:19	DSCN8100.JPG	D:\Restoration site\DSCN8100.JPG
28	36.11959	31.73384	NaN	2018-04-23 7:23:44	4/23/2018 10:19	DSCN8101.JPG	D:\Restoration site\DSCN8101.JPG

2. Getting started

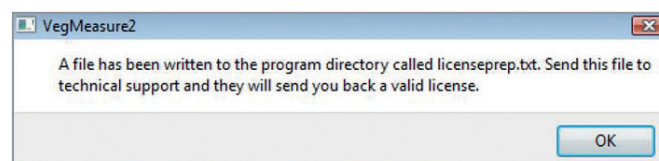
This chapter guides you through the installation and software basics.

This chapter provides an overview of the software, including how to install and run the program, specify input photos, preview images, and do basic image processing. The VegMeasure software is separate from that of the Image Positioning Tool, so it is necessary to install both programs to process images.

Installation and registration

Download the VegMeasure software from www.vegmeasure.org, unzip the files, and click on **VegMeasure.exe**. A dialogue box will appear; click **OK** to generate a new file in your folder titled **licenseprep.txt**.

Visit <http://www.vegmeasure.org/obtaining-vegmeasure-2-license/> to obtain a license for the software by filling in and uploading a text file proforma. You will receive an email from vegmeasure@gmail.com containing the **license.txt** file; save this in the VegMeasure folder, and then click **VegMeasure.exe** to open the program.



Name	Date modified	Type	Size
imageformats	1/11/2002 8:33 AM	File folder	
platforms	1/11/2002 8:33 AM	File folder	
ChilkatDotNet4.dll	11/23/2013 8:04 PM	Application extens	6,109 KB
icudt51.dll	11/23/2013 8:04 PM	Application extens	21,854 KB
icuin51.dll	11/23/2013 8:04 PM	Application extens	3,291 KB
icuuc51.dll	11/23/2013 8:04 PM	Application extens	1,933 KB
libgcc_s_dw2-1.dll	11/23/2013 8:04 PM	Application extens	533 KB
libstdc++-6.dll	11/23/2013 8:04 PM	Application extens	967 KB
libwinpthread-1.dll	11/23/2013 8:04 PM	Application extens	73 KB
license	1/11/2002 8:36 AM	Text Document	1 KB
licenseprep	1/11/2002 8:34 AM	Text Document	1 KB
Qt5Core.dll	11/23/2013 8:04 PM	Application extens	4,290 KB
Qt5Gui.dll	11/23/2013 8:04 PM	Application extens	4,349 KB
Qt5Widgets.dll	11/23/2013 8:04 PM	Application extens	6,006 KB
VegMeasure2	11/23/2013 8:04 PM	Application	1,305 KB
VegmeasureAccuracyAssessment	11/23/2013 8:04 PM	Application	1,488 KB

If you have problems running **VegMeasure2.exe**, right click and select **Run as an Administrator**.

Name	Date modified	Type	Size
imageformats	1/11/2002 8:33 AM	File folder	
platforms	1/11/2002 8:33 AM	File folder	
VegMeasure2	11/23/2013 8:04 PM	Application	1,305 KB
VegmeasureAccuracyAssessment	11/23/2013 8:04 PM	Application	1,488 KB
ChilkatDotNet4.dll	11/23/2013 8:04 PM	Application extens	6,109 KB
icudt51.dll	11/23/2013 8:04 PM	Application extens	21,854 KB
icuin51.dll	11/23/2013 8:04 PM	Application extens	3,291 KB
icuuc51.dll	11/23/2013 8:04 PM	Application extens	1,933 KB
libgcc_s_dw2-1.dll	11/23/2013 8:04 PM	Application extens	533 KB
libstdc++-6.dll	11/23/2013 8:04 PM	Application extens	967 KB
libwinpthread-1.dll	11/23/2013 8:04 PM	Application extens	73 KB
Qt5Core.dll	11/23/2013 8:04 PM	Application extens	4,290 KB
Qt5Gui.dll	11/23/2013 8:04 PM	Application extens	4,349 KB
Qt5Widgets.dll	11/23/2013 8:04 PM	Application extens	6,006 KB
license	02/08/2013 8:36 AM	Text Document	1 KB
licenseprep	02/08/2013 8:34 AM	Text Document	1 KB

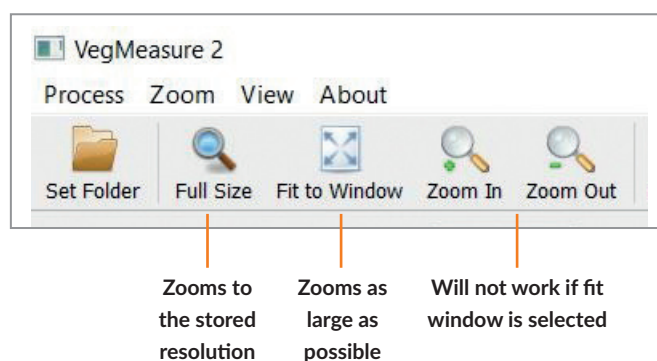
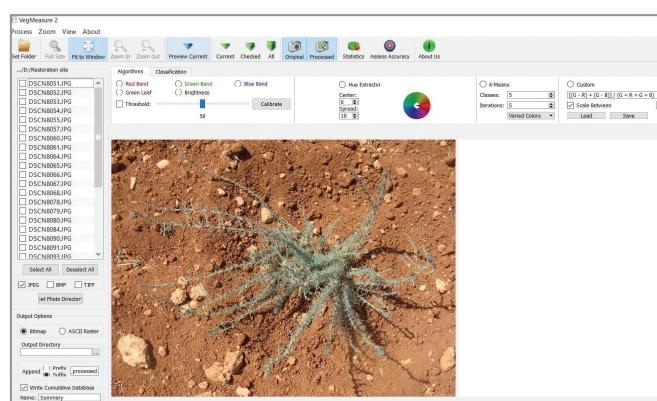
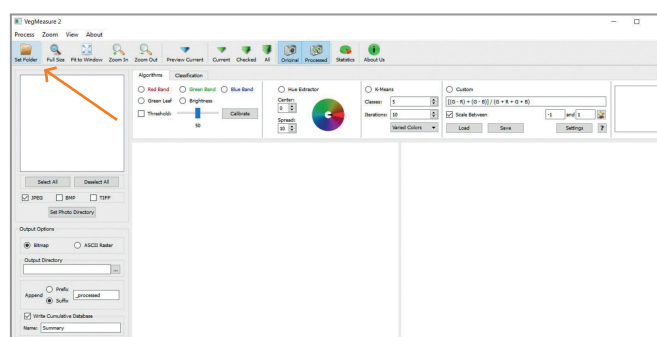
Software overview

This section shows how to specify input photos, preview images, process images, use basic program statistics, and set output specifications. Understanding these functions is important and forms a platform from which more advanced processing functions may be performed.

Clicking **VegMeasure2.exe** will open the program, and you will then specify the input photos. Ideally you will have already used the Image Positioning Tool described in Chapter 1 before performing this step, to ensure GPS data are associated with the image files.

Click **Set Folder** to specify the directory that contains the images for processing, select the appropriate folder, and click **OK**.

It is easier to create documents in the future when changes to the manual template are saved. To customize this manual, click **Set Folder** and select the checkboxes for the images you would like to process. When you click an image, a preview should appear.



It is possible to switch between the original and processed image, by clicking on **Original** or **Processed**. You will learn how to process in the following chapters.



After selecting an algorithm, select **Preview current** if **no output file is desired**.



After selecting an algorithm, select **Current** if an **output file is desired**.



Clicking **Checked** will automatically process the selected images.



Selecting **All** will process all images in the directory, regardless of whether they have been checked.



Selecting **Statistics** will give the proportion (percent) of pixels classified above and below the threshold.



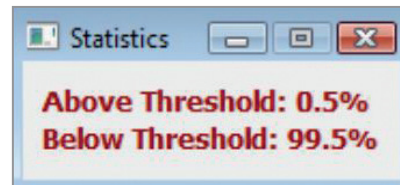
This is also stored in the .info file for the image.

Statistics output applies as follows:

Red text: small preview

Green text: full preview (exact)

Blue text: most recently saved processed image.



Output options for processed images may be specified, where:

Bitmap is identical to the preview

ASCII is a raster map

Append adds a prefix or suffix to the original file name

inf. writes statistics to the output file that has the same name as the input file

Write Cumulative Database creates a database with cumulative statistics for all photos.

A screenshot of the 'Output Options' dialog box. It contains several settings:

- Format:** Radio buttons for 'Bitmap' (selected) and 'ASCII Raster'.
- Output Directory:** A text field containing 'D:/Restoration site/Results' with a browse button (...).
- Append:** Radio buttons for 'Prefix' and 'Suffix' (selected). A text field next to 'Suffix' contains '_processed'.
- Write Cumulative Database:** A checked checkbox.
- Name:** A text field containing 'Summary'.

3. Image processing

This chapter explains the theories and concepts behind image classification.

In this chapter, algorithms and image processing techniques are described, and it is important that the concepts explained in this chapter are understood before conducting image classification. This chapter will describe the use of color bands in imagery, how to calculate green leaf cover, setting brightness, how to extract hue, and using and calibrating a threshold.

Red, green, and blue bands

Each pixel in the original image contains color information stored using the RGB (red, green, blue) index system that uses values from 0 to 255. For example, (0, 0, 0) represents black, and (255, 0, 0) represents pure red. Selecting the **Red Band** algorithm replaces the original RGB index at each pixel with its filtered red value (r, 0, 0), and the raster output will contain the red value r at each pixel. Selecting **Green Band** and **Blue Band** algorithms result in similar raster output.

Green leaf

The green leaf algorithm selects pixels that correspond to green living vegetation from conventional color photography. It uses ratios of the digital numbers for each of the three-color channels (Louhaichi et al. 2001¹) in the following formula:

$$\frac{(G - R) + (G - B)}{G + R + G + B}$$

where G, R, and B are the digital number of the respective color channel (0 to 255).

Brightness

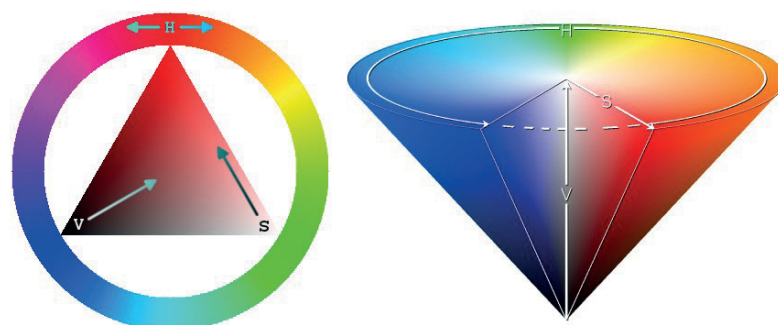
Brightness of a pixel with RGB values (r, g, b) is determined using the formula

$$\text{brightness} = 0.299 r + 0.587 g + 0.144 b$$

where values range from 0 to 255.

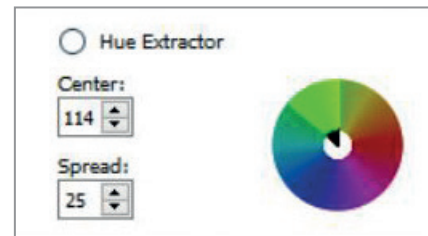
Hue extraction

In addition to the RGB color classification, colors may be described using the HSV (Hue-Saturation-Value) system. The following images illustrate the various components:



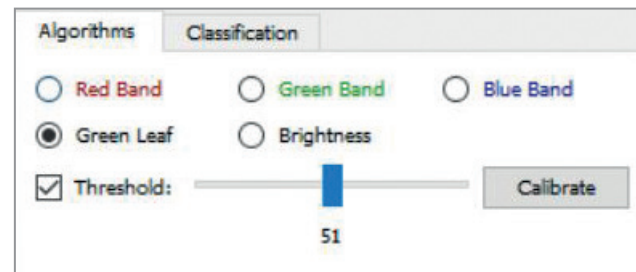
¹ Louhaichi, M., M.M. Borman and D.E. Johnson. 2001. Spatially located platform and aerial photography for documentation of grazing impacts on wheat. *Geocarto International* 16(1): 63-68.

Hue extraction allows filtering of colors in a particular color range. Hue values lie on a circle and range from 0 to 359, thus a hue of 0 is the same as a hue of 360. To use the algorithm, simply specify the hue range based on center and spread values. The preview wheel shows the specified region as a lighter color.



Using a threshold

A threshold may be helpful to determine how much of an image belongs to one of two classes. For example, how much of the image is bare ground and how much is plant matter. Setting a threshold will segment the data into two classes that are either above or below the threshold. Threshold values range from 0 to 100; however, because values of red, blue, and green bands range from 0 to 255, values must be scaled to the threshold range. After RGB values have been scaled, a threshold of 50 applied to the red band will classify each pixel as 0 or 1 depending on whether or not its red value is below or above 50, respectively.



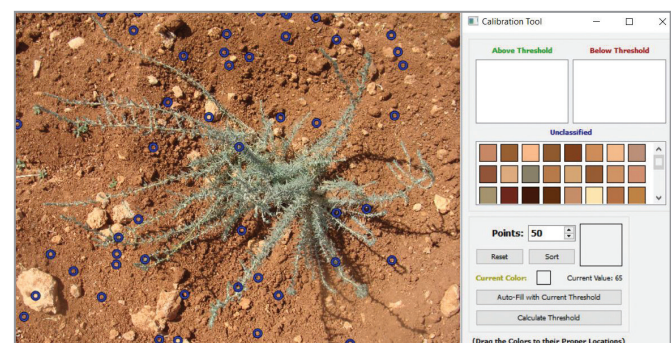
Thresholds may be applied to the red, green, and blue bands, green leaf, and brightness.

Calibrating a threshold

After selecting the desired attribute and value, the threshold is calibrated by clicking **Calibrate**. This selection opens a new window.

In the example (right), there are **50** Points (indicated by blue open circles); however, this number may be changed, and does not need to be the same as the threshold. If **Reset** is selected, a new set of points is generated. Colors represent points as follows:

- Blue:** Unclassified
- Green:** Above the threshold
- Red:** Below the threshold
- Yellow:** Currently selected.



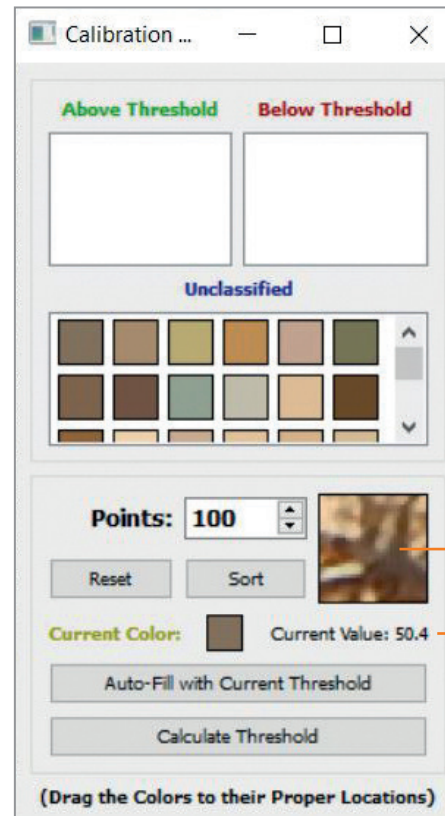
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The calibration tool zooms in and displays the value of the currently selected yellow point.

Colors may be reordered to facilitate easier viewing by either dragging the colors to the desired location or clicking **Sort** to arrange them in order of the current threshold value.

Points will be assigned to the **Above Threshold** and **Below Threshold** classifications after clicking **Auto-Fill with Current Threshold**.

When sorting is complete, click **Calculate Threshold** to determine the best threshold that fits the defined criteria.



Close up of
the yellow
selected
point

Threshold
value of the
current point

4. Image classification

This chapter describes classification techniques appropriate for different scenarios.

Image classification refers to the computer-assisted interpretation of digital remotely-sensed images. This chapter describes various classification techniques, some of which are supervised, where the researcher guides the classification process, or unsupervised, where similar values are grouped in silico. Understanding the advantages and disadvantages of each technique is important for selection of the most appropriate method for the scenario at hand. In either case additional image processing may be used to help determine which method is better for a given situation. It must be kept in mind that generated output (processed images) are simple attempts to represent what actually exists in the world and are never completely accurate.

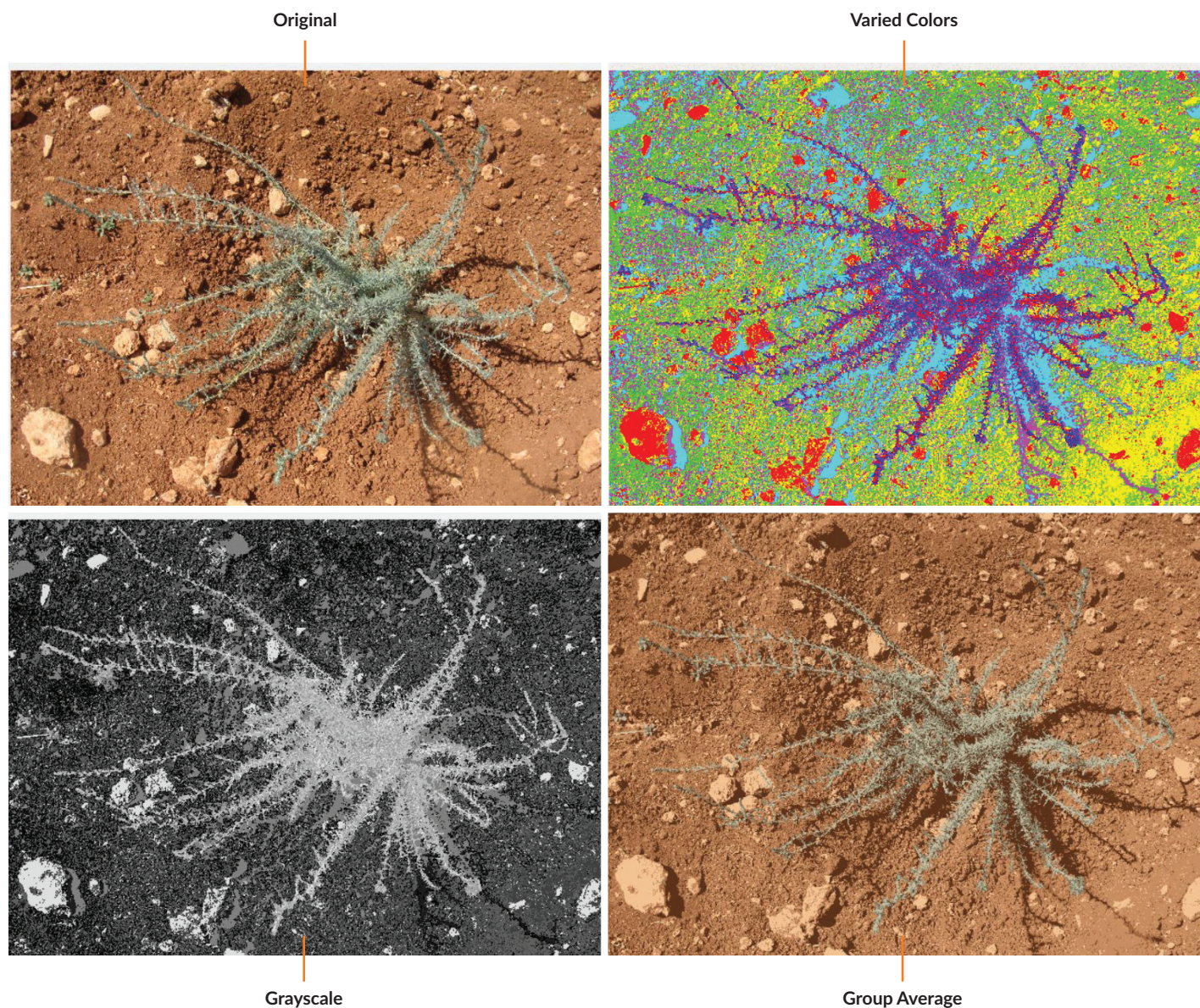
Unsupervised classification

This is a common classification technique used when little is known about the study area and for preliminary analysis. The technique does not require the user to specify any information about the features contained in the images. It uses cluster analysis to detect differences in reflectance values across a set of bands and creates a classification from typical reflectance patterns. The software does most of the processing on its own, generally resulting in more use categories than the user is interested in. This is the point where the user has to make decisions on which categories can be grouped together into a single category. To make these decisions, other materials from and knowledge of the area are useful. 'Ground truthing' what is seen in the digital image with what was actually present at the time the image was recorded makes this task more efficient and more accurate.

K-Means classification

The K-means algorithm automatically identifies groups of similar colors using an iterative process, where convergence may take many steps. The program runs until a specified number of steps has been completed or convergence has been reached, whichever comes first. The program will also indicate whether convergence was reached. The number of color classes to identify and the maximum number of iterations must be specified.

There are several options for the output image coloring scheme. **Varied colors** assign contrasting colors to each group to emphasize distinction among the groups, while **Monochrome** generates a grayscale image, where classes are evenly spaced between white and black. **Group Average**, which calculates average color per group, represents effective characterization of classification quality. If a raster map is chosen for the output, then cell values will simply be the group number.



Supervised classification

Supervised classification routines are based on training sites and areas of known ground cover assigned by the operator. They classify the image by assigning each pixel in the image to one of the land cover categories described by the training sites. Supervised classification allows for greater customization of the images, such as for ranges, values, and categories to allow cross comparison of values over time. This technique is helpful for observation of specific values or trends and may be conducted using predefined formulas in the software or by creating bespoke formulas.

In supervised classification, spectral signatures are developed from specified locations in the image. These specified locations are given the generic name 'training sites' and are defined by the user.

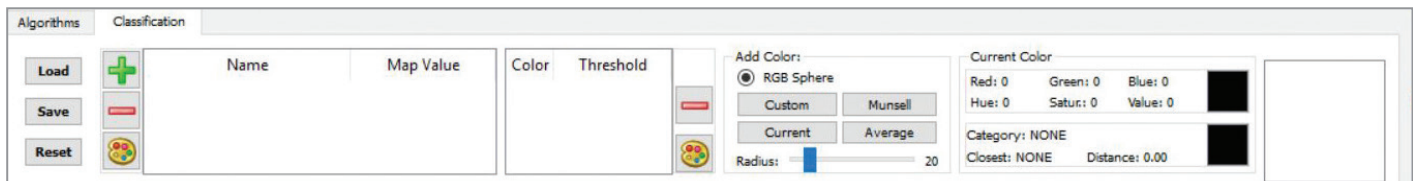
Basics

The next step in image processing is to add colors to each category, with respective thresholds that represent the maximum distance in RGB color space for a point to be classified in that category. For example, a color with RGB values (100, 150, 50) is added to the category with threshold 20, then any point with RGB values (r, g, b) will be classified as part of the category if the following is satisfied:

$$\sqrt{(r - 100)^2 + (g - 150)^2 + (b - 50)^2} \leq 20$$

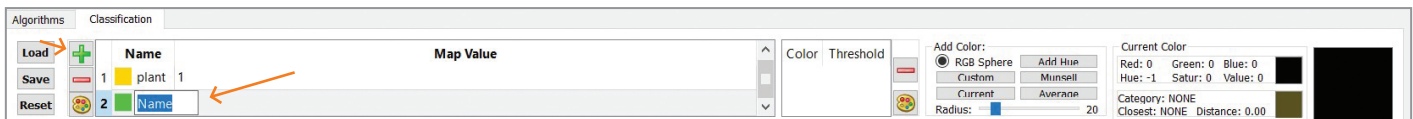
There are several ways to add colors to a category. The most basic is by clicking the **Custom** button that triggers a dialog box that asks for a color to be added to the current category. Many colors may be added to each category, and a point will be classified as part of that category if it falls within the respective thresholds.

Step 1: Click the Classification tab

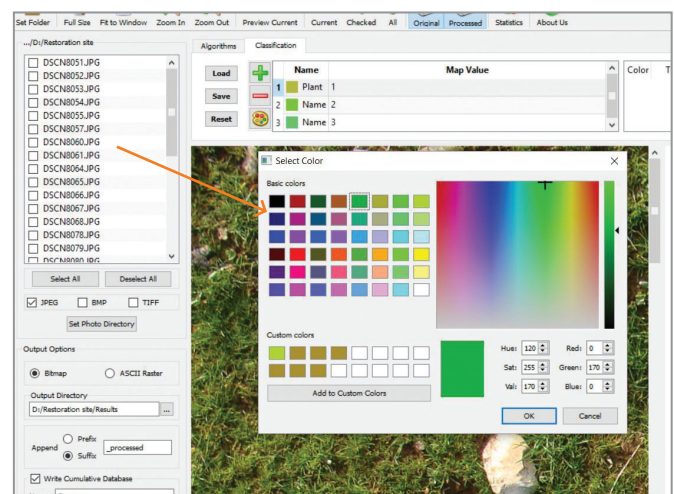


Step 2: Adding categories

The next step is to add the categories into which your image will be classified. To add a category to the list, click the green plus (+), and modify the name and category value by double clicking the item.

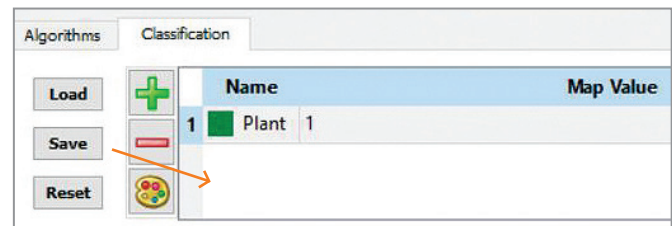
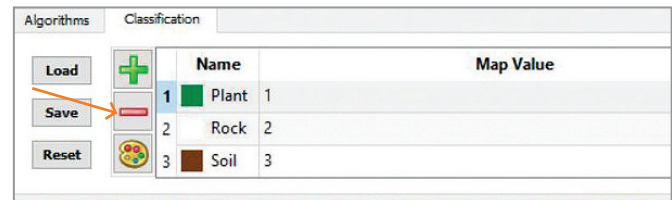


The category color may be changed by selecting the desired category and then clicking the palette button (🎨) to choose the color; click **OK**.



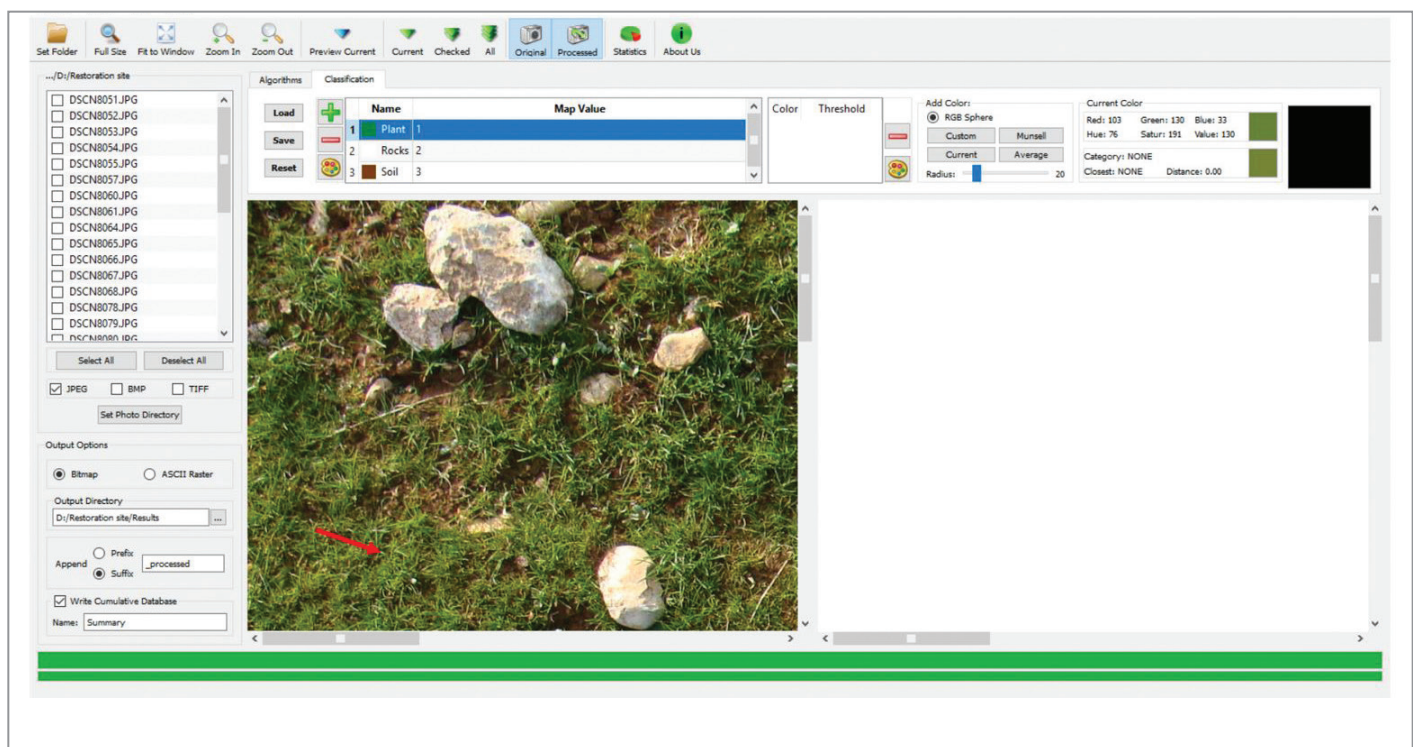
TOOLS & GUIDELINES

To remove a category, select the category, then click the red minus button (). The selected category will then be removed from the list.

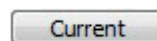


Step 3: Adding colors to categories (Getting colors from the image)

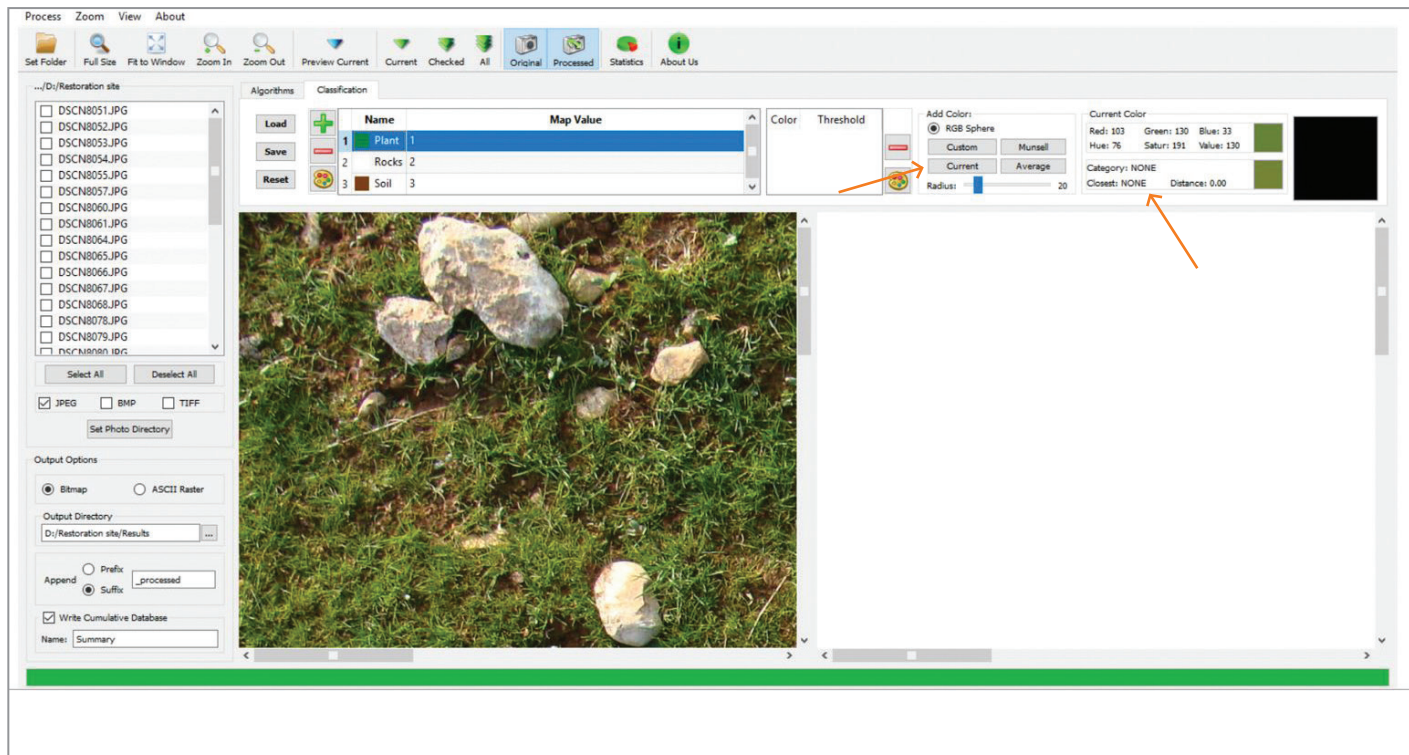
After selecting a category, the color of interest will be displayed on the right-hand side of the screen when the mouse is moved across the image.



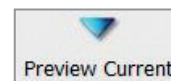
To add a color category of interest, select the **Current** button.



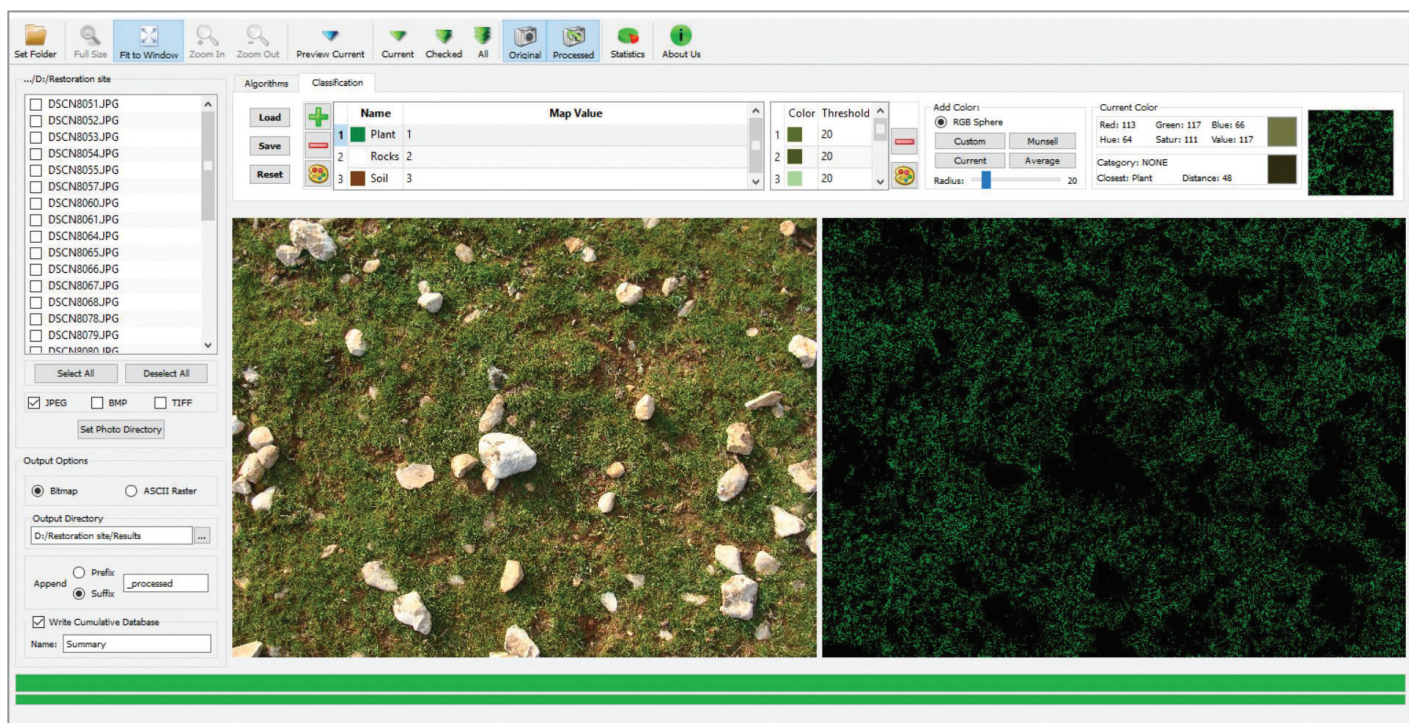
All pixels with similar R, G, B, Hue, Saturation values will be classified as part of this category and be allocated the same color.



To preview the classification, click on the **Preview Current** button. This button may be clicked at any time to update the display with the latest classification output.



Black refers to unclassified areas.



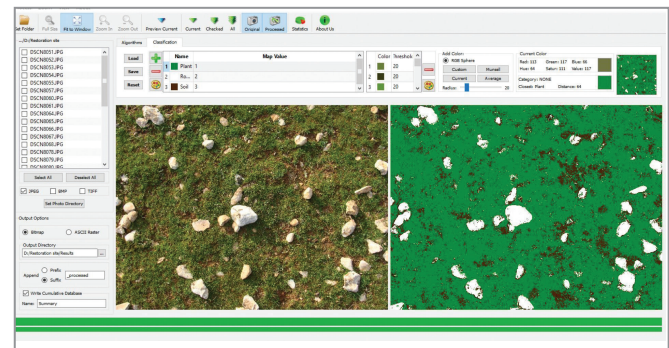
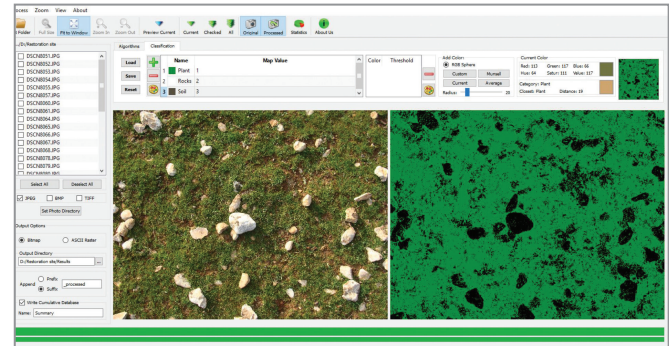
TOOLS & GUIDELINES

Another color may be included by clicking on the color, and then selecting **Current**.

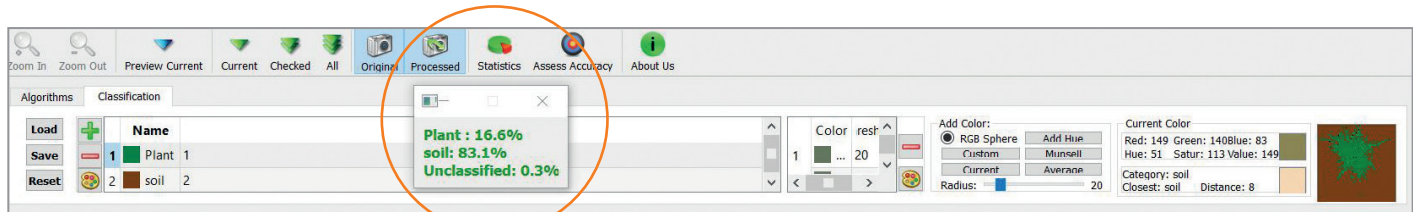
There is a greater area of unclassified vegetation, as indicated in **black**, in the first image. Following addition of soil as a class, the majority of the area is classified, and informative statistics may now be generated.

Please note that the **value of unclassified cells should not exceed 5%.**

Current



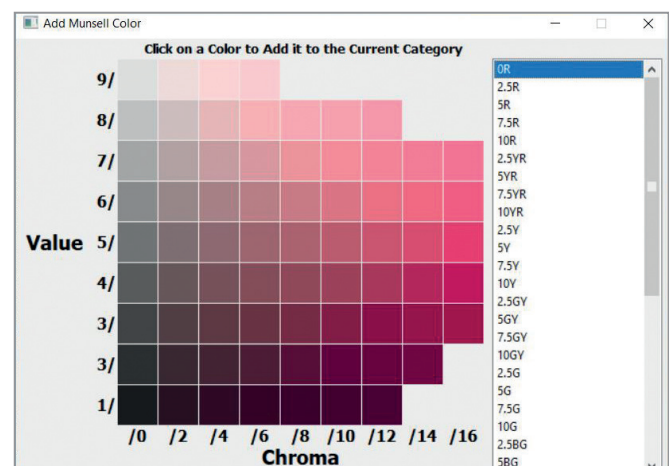
Click on the **Statistics** button to see the proportion (percent) of each class. The addition of more categories will reduce the proportion assigned to unclassified.



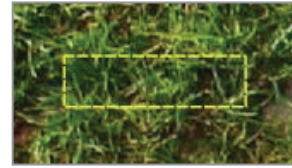
Clicking **Munsell Color** to add a value will open this window.

Munsell

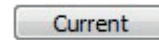
Clicking one of the colored boxes will add that color to the current category along with the current threshold.



It may be helpful to determine the average color of a region to help guide classification. Left click to drag a box around the desired region, and the color preview will display the average for the box as you drag.



Average color may be added by clicking the **Current** button.

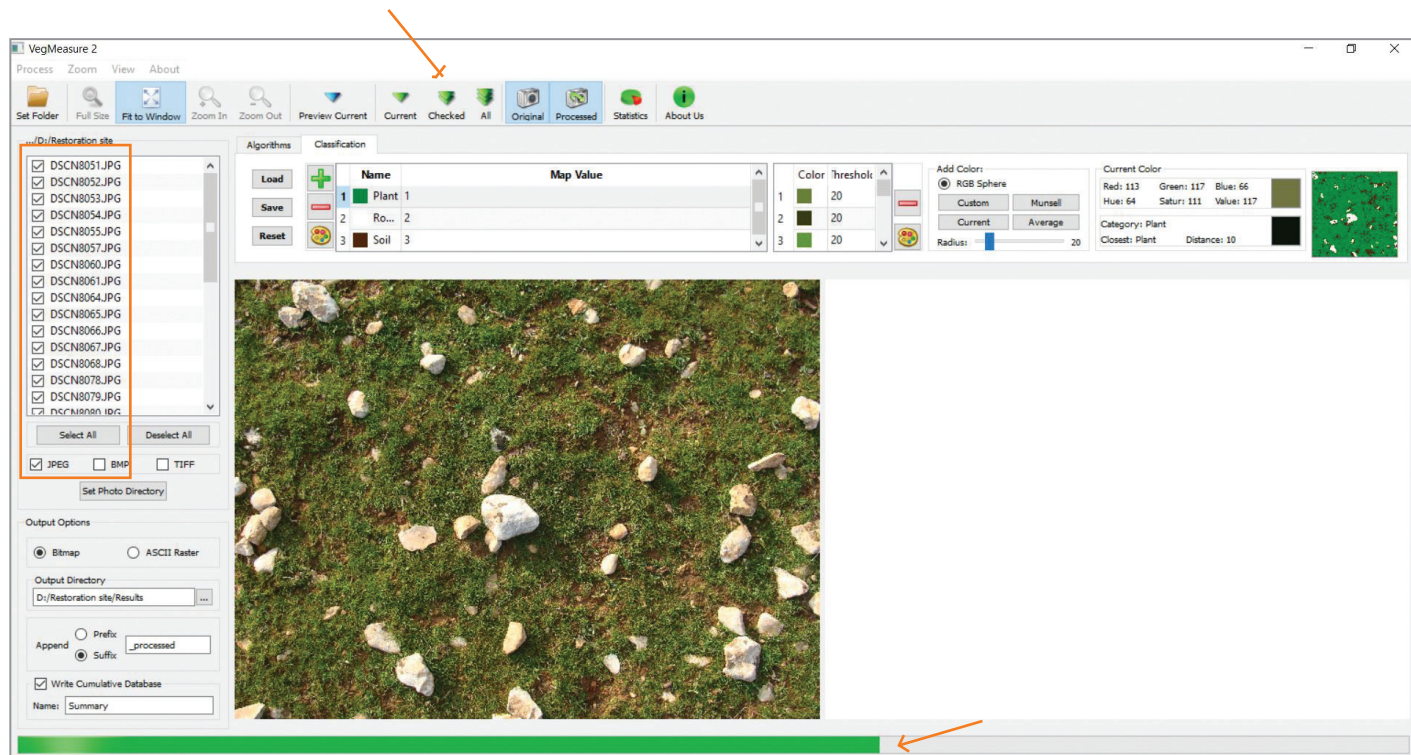


Step 4: Run the program for multiple selected images

By now, it may be desirable to apply your classifications to many images.

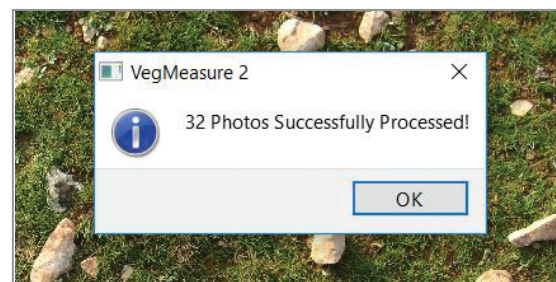
To do this, **check the images** you want to process on the left-hand side, and then click the **Checked** button.

The progress of image processing is displayed by a green bar at the bottom of the screen.



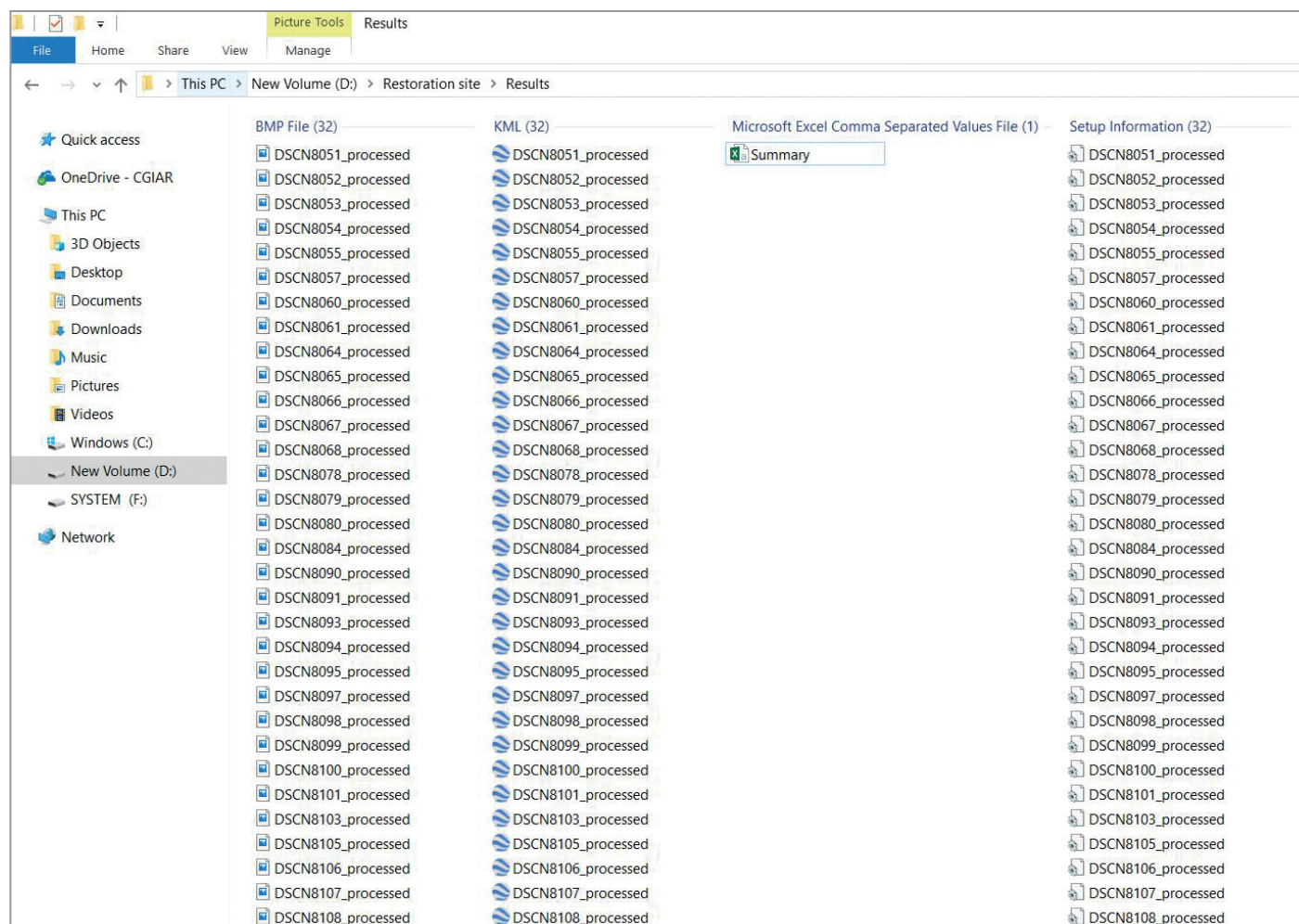
Once the process is complete, a dialogue box will appear stating the number of processed images.

Click **OK** to continue.



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While images are being processed, output files (.bmp, .kml, .inf) will be generated in the file that was specified previously. At the end of processing, a new summary file (.csv) will be created in the output folder.



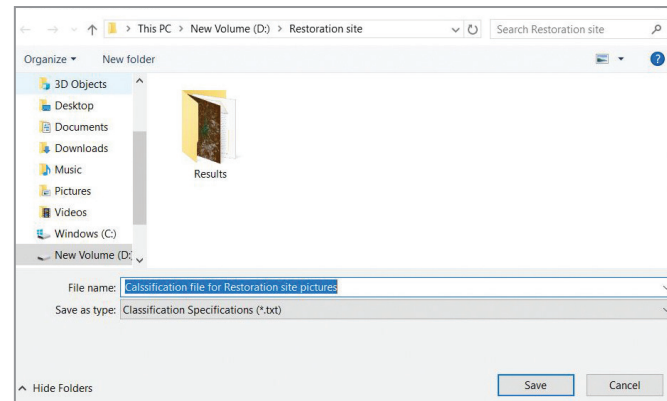
File name will be the original, plus the appended prefix and original image path.

Classification values for each category are listed in the summary file, including unclassified pixels.

File	Home	Insert	Page Layout	Formulas	Data	Review	View	Tell me what you want to do
Clipboard: Paste, Cut, Copy, Format Painter Font: Calibri, 11, Bold, Italic, Underline, Text Color, Background Color Alignment: Left, Center, Right, Justify, Merge & Center Number: General, Currency, Percentage, Decimals								
A1								
	A	B	C	D	E	F	G	
1	Original Image Name	Original Image Path	Plant	Rocks	Soil	Unclassified		
2	DSCN8051.JPG	D:/Restoration site/DSCN8051.JPG	79.1	5.8	14.5	0.6		
3	DSCN8052.JPG	D:/Restoration site/DSCN8052.JPG	74.9	19.7	5.1	0.3		

Step 5: Save settings

Click on the **Save** button, name the file, choose the directory then click save.



This button allows you to load saved classifications when needed.



Step 6: Add the GPS data

The GPS data must be added to the summary file, so that data values may be interpolated to create larger scale maps. These data may also be used in other analytical software for publishing.

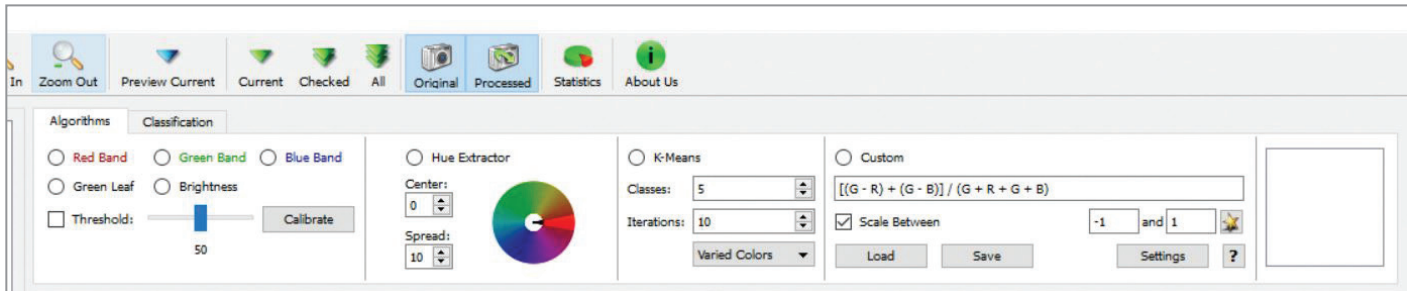
The images are ranked in the same order as the GPS data created using the VegMeasure Positioning Tool program. Thus, data created in the VegMeasure Positioning Tool program should be copied and pasted into the summary file.

summary5 - Excel															Hassan, Sawsan (ICARDA)	
File Home Insert Page Layout Formulas Data Review View Tell me what you want to do																
Clipboard		Font		Alignment		Number		Styles		Cells		Editing				
Cut Copy Paste Format Painter		Calibri 11 A A		Wrap Text Merge & Center		General \$ % ,		Normal Good Bad Neutral		Insert Delete Format		AutoSum Fill Sort & Find & Filter - Select - Clear				
H37																
A	B	C	D	E	F	G	H	I	J	K	L	M				
1	Longitude	Latitude	GPS Date/Time	Camera Date/Time	Image Name	Original Image Path	Original Image Name	Original Image Path	Plant	Rocks	Soil	Unclassified				
2	36.11983	31.733825	2018-04-23 7:12:14	4/23/2018 10:08	DSCN8051.JPG	D:/Restoration site/DSCN8051.JPG	DSCN8051.JPG	D:/Restoration site/DSCN8051.JPG	79.1	5.8	14.5	0.6				
3	36.119855	31.7338183	2018-04-23 7:12:21	4/23/2018 10:08	DSCN8052.JPG	D:/Restoration site/DSCN8052.JPG	DSCN8052.JPG	D:/Restoration site/DSCN8052.JPG	74.9	19.7	5.1	0.3				
4	36.119895	31.7337733	2018-04-23 7:12:30	4/23/2018 10:08	DSCN8053.JPG	D:/Restoration site/DSCN8053.JPG	DSCN8053.JPG	D:/Restoration site/DSCN8053.JPG	45.2	13.2	39.6	2				
5	36.119915	31.733755	2018-04-23 7:12:36	4/23/2018 10:08	DSCN8054.JPG	D:/Restoration site/DSCN8054.JPG	DSCN8054.JPG	D:/Restoration site/DSCN8054.JPG	51.4	11.3	35.3	2				
6	36.119955	31.7337083	2018-04-23 7:12:46	4/23/2018 10:08	DSCN8055.JPG	D:/Restoration site/DSCN8055.JPG	DSCN8055.JPG	D:/Restoration site/DSCN8055.JPG	30.9	23.1	45.1	0.9				
7	36.120013	31.733635	2018-04-23 7:13:6	4/23/2018 10:09	DSCN8057.JPG	D:/Restoration site/DSCN8057.JPG	DSCN8057.JPG	D:/Restoration site/DSCN8057.JPG	54.9	17.1	27.6	0.4				
8	36.120065	31.7335667	2018-04-23 7:13:31	4/23/2018 10:09	DSCN8060.JPG	D:/Restoration site/DSCN8060.JPG	DSCN8060.JPG	D:/Restoration site/DSCN8060.JPG	45.7	18.2	35.5	0.6				
9	36.120087	31.7335167	2018-04-23 7:13:42	4/23/2018 10:09	DSCN8061.JPG	D:/Restoration site/DSCN8061.JPG	DSCN8061.JPG	D:/Restoration site/DSCN8061.JPG	57.8	18.1	23.5	0.6				
10	36.11995	31.7335217	2018-04-23 7:16:9	4/23/2018 10:12	DSCN8064.JPG	D:/Restoration site/DSCN8064.JPG	DSCN8064.JPG	D:/Restoration site/DSCN8064.JPG	65.6	17	16.9	0.5				
11	36.119943	31.7335517	2018-04-23 7:16:23	4/23/2018 10:12	DSCN8065.JPG	D:/Restoration site/DSCN8065.JPG	DSCN8065.JPG	D:/Restoration site/DSCN8065.JPG	47.9	13.1	38.2	0.8				
12	36.11994	31.7335917	2018-04-23 7:16:35	4/23/2018 10:12	DSCN8066.JPG	D:/Restoration site/DSCN8066.JPG	DSCN8066.JPG	D:/Restoration site/DSCN8066.JPG	44.7	15.2	39.7	0.4				
13	36.119935	31.7336183	2018-04-23 7:16:43	4/23/2018 10:12	DSCN8067.JPG	D:/Restoration site/DSCN8067.JPG	DSCN8067.JPG	D:/Restoration site/DSCN8067.JPG	53.9	11.3	34.3	0.5				
14	36.119918	31.73365	2018-04-23 7:16:53	4/23/2018 10:12	DSCN8068.JPG	D:/Restoration site/DSCN8068.JPG	DSCN8068.JPG	D:/Restoration site/DSCN8068.JPG	62.4	10.1	26.7	0.8				
15	36.119638	31.7339083	2018-04-23 7:18:58	4/23/2018 10:15	DSCN8078.JPG	D:/Restoration site/DSCN8078.JPG	DSCN8078.JPG	D:/Restoration site/DSCN8078.JPG	88	8.3	2.8	0.9				
16	36.119672	31.7338683	2018-04-23 7:19:8	4/23/2018 10:15	DSCN8079.JPG	D:/Restoration site/DSCN8079.JPG	DSCN8079.JPG	D:/Restoration site/DSCN8079.JPG	34.4	11.3	53.7	0.6				
17	36.11969	31.7338483	2018-04-23 7:19:14	4/23/2018 10:15	DSCN8080.JPG	D:/Restoration site/DSCN8080.JPG	DSCN8080.JPG	D:/Restoration site/DSCN8080.JPG	72.2	13.3	13.6	0.9				
18	36.119793	31.7337017	2018-04-23 7:20:0	4/23/2018 10:16	DSCN8084.JPG	D:/Restoration site/DSCN8084.JPG	DSCN8084.JPG	D:/Restoration site/DSCN8084.JPG	39.6	15.1	45.2	0.1				
19	36.119893	31.7335033	2018-04-23 7:20:56	4/23/2018 10:16	DSCN8090.JPG	D:/Restoration site/DSCN8090.JPG	DSCN8090.JPG	D:/Restoration site/DSCN8090.JPG	53.5	12.1	33.9	0.5				
20	36.119823	31.733515	2018-04-23 7:21:15	4/23/2018 10:17	DSCN8091.JPG	D:/Restoration site/DSCN8091.JPG	DSCN8091.JPG	D:/Restoration site/DSCN8091.JPG	60.2	18	21.1	0.7				
21	36.119787	31.733575	2018-04-23 7:21:35	4/23/2018 10:17	DSCN8093.JPG	D:/Restoration site/DSCN8093.JPG	DSCN8093.JPG	D:/Restoration site/DSCN8093.JPG	44.9	13.9	41	0.2				
22	36.119773	31.733585	2018-04-23 7:21:44	4/23/2018 10:17	DSCN8094.JPG	D:/Restoration site/DSCN8094.JPG	DSCN8094.JPG	D:/Restoration site/DSCN8094.JPG	59	16.9	23.8	0.3				
23	36.119753	31.733625	2018-04-23 7:22:12	4/23/2018 10:18	DSCN8095.JPG	D:/Restoration site/DSCN8095.JPG	DSCN8095.JPG	D:/Restoration site/DSCN8095.JPG	37.7	16.1	46	0.2				
24	36.119725	31.7336733	2018-04-23 7:23:14	4/23/2018 10:19	DSCN8097.JPG	D:/Restoration site/DSCN8097.JPG	DSCN8097.JPG	D:/Restoration site/DSCN8097.JPG	56.2	19	24.2	0.6				
25	36.11971	31.733695	2018-04-23 7:23:19	4/23/2018 10:19	DSCN8098.JPG	D:/Restoration site/DSCN8098.JPG	DSCN8098.JPG	D:/Restoration site/DSCN8098.JPG	63.5	17.8	18.1	0.6				
26	36.119655	31.7337683	2018-04-23 7:23:29	4/23/2018 10:19	DSCN8099.JPG	D:/Restoration site/DSCN8099.JPG	DSCN8099.JPG	D:/Restoration site/DSCN8099.JPG	55.2	19.3	24.8	0.7				
27	36.119637	31.73379	2018-04-23 7:23:35	4/23/2018 10:19	DSCN8100.JPG	D:/Restoration site/DSCN8100.JPG	DSCN8100.JPG	D:/Restoration site/DSCN8100.JPG	63.4	11.1	24.9	0.6				
28	36.119592	31.7338417	2018-04-23 7:23:44	4/23/2018 10:19	DSCN8101.JPG	D:/Restoration site/DSCN8101.JPG	DSCN8101.JPG	D:/Restoration site/DSCN8101.JPG	52.7	19.2	27.4	0.7				
29	36.119525	31.7339167	2018-04-23 7:24:0	4/23/2018 10:20	DSCN8103.JPG	D:/Restoration site/DSCN8103.JPG	DSCN8103.JPG	D:/Restoration site/DSCN8103.JPG	44.6	12.3	42.5	0.6				

It is important to ensure the image names for each dataset are the same.

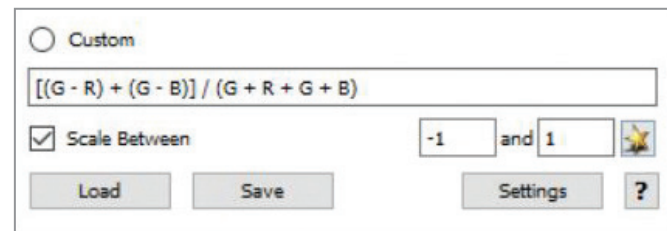
Create a custom formula

The user may specify a custom formula to allow for maximum flexibility. Formulas are entered in the **Custom** equation box, and may comprise the usual symbols and operators ([,], (,), {, }, +, -, *, /, ^, %) and variables R, G, B, H, S, and V that represent the red, green, and blue bands, hue, saturation, and value of the current color, respectively. Each cell in the original image will be processed using the specified formula.

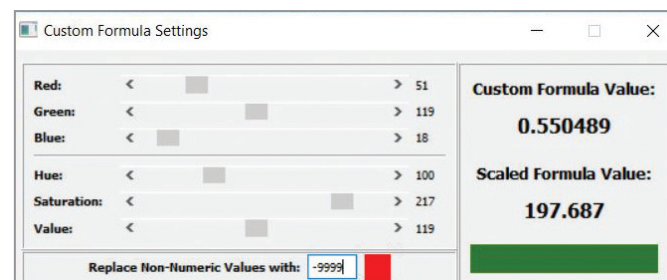


The scale bounds determine the range of output values, so that the output image may be properly colored (after proper scaling, output values range from 0 to 255).

To automatically calculate these bounds, press the button with a star (★), and the program will calculate the minima and maxima of your formula. To see these values, click the **Settings** button.



To see specific examples of your formula and ensure that it is correctly interpreted, click the **Settings** button, which will open a window for specification of RGB or HSV values that self-adjust when one value is specified. It is then possible to see the value calculated using your formula, and the scaled value. This window also allows you to determine how the program handles non-numeric values, such as division by zero.

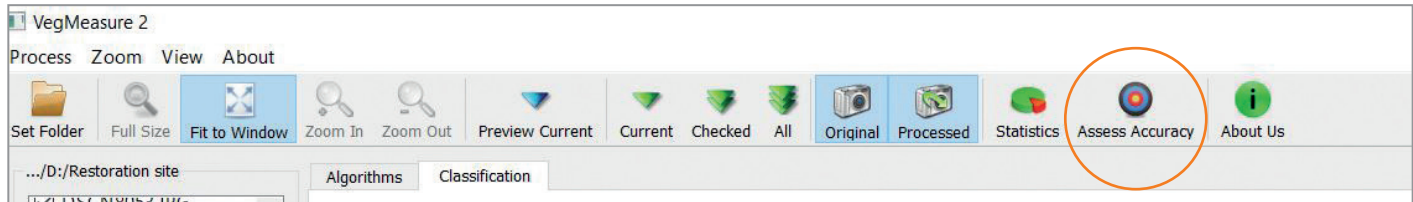


As an example, the custom formula corresponding to the red band 'R' must be scaled from 0 to 255. The custom formula that corresponds to the green leaf algorithm, $[(G - R) + (G - B)] / (G + R + G + B)$, must be scaled from -1 to 1, as seen in the first image on this page.

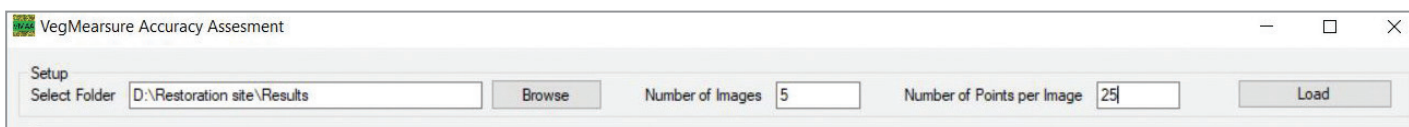
5. Accuracy assessment

This chapter explains how to use the Assess Accuracy tool in VegMeasure.

Classification is incomplete without an assessment of accuracy assessment, and the Assess Accuracy tool in VegMeasure computes an error matrix and a Kappa Index of Agreement for the processed images.



Click the **Assess Accuracy** button to open the tool, and then another window will open.

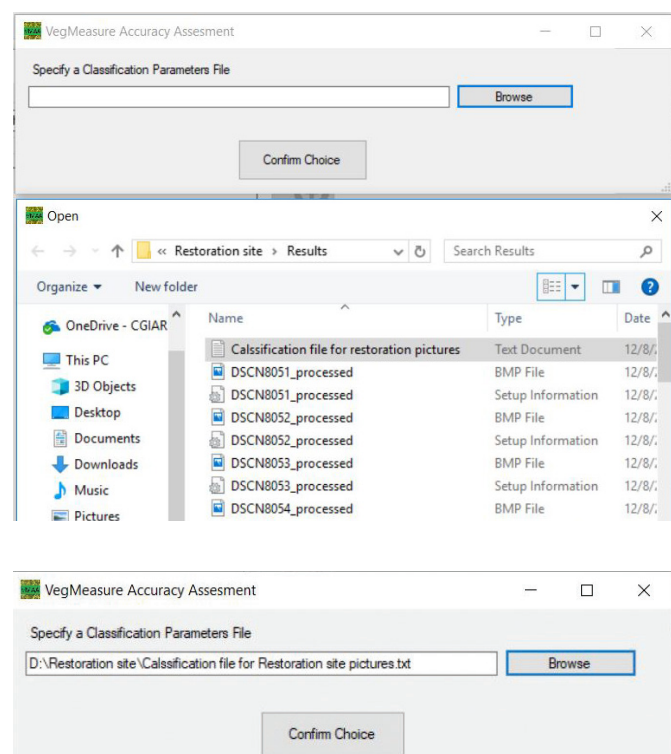


In this window, select the folder containing the processed images, enter the number of images and random points that will be reviewed for each image.

Then click **Load**.

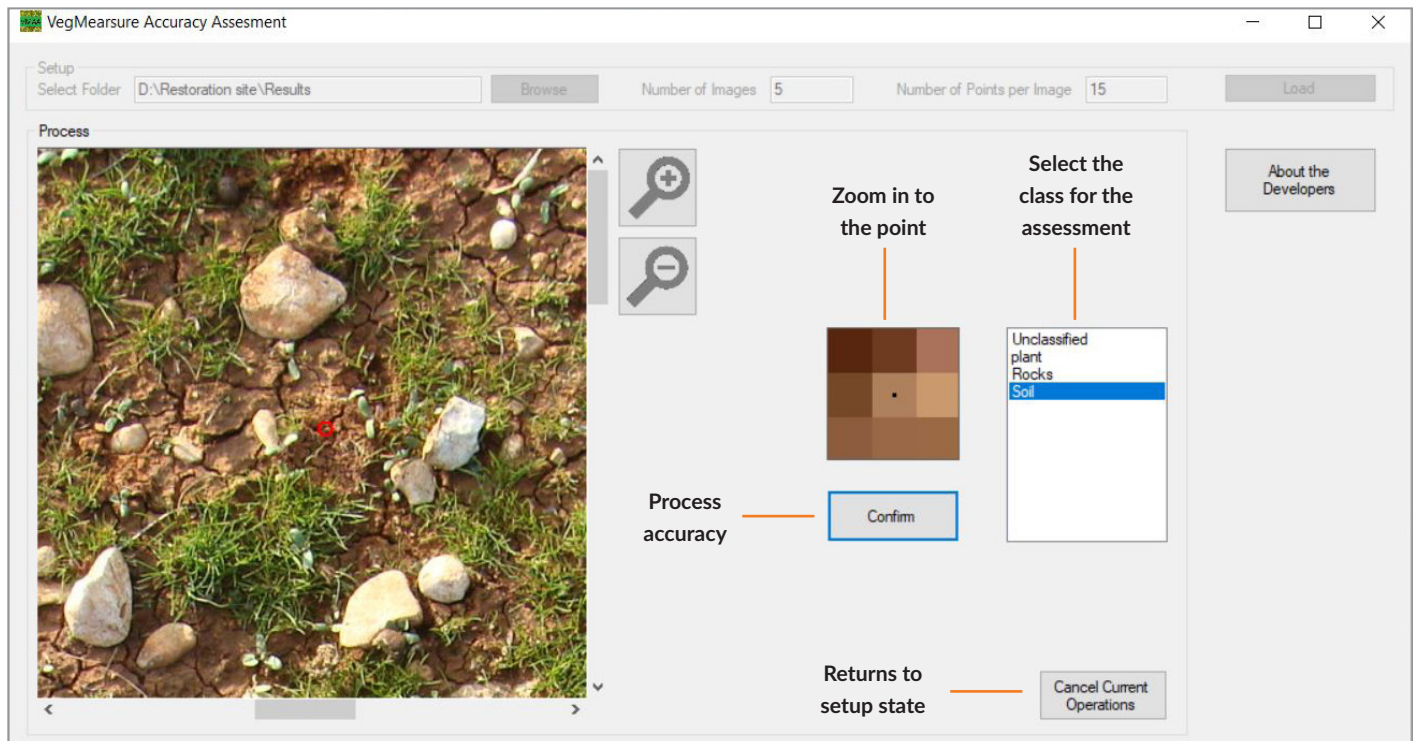
Find the **Parameters** file that was created in the folder in which the images with the .txt extension are located.

Load



TOOLS & GUIDELINES

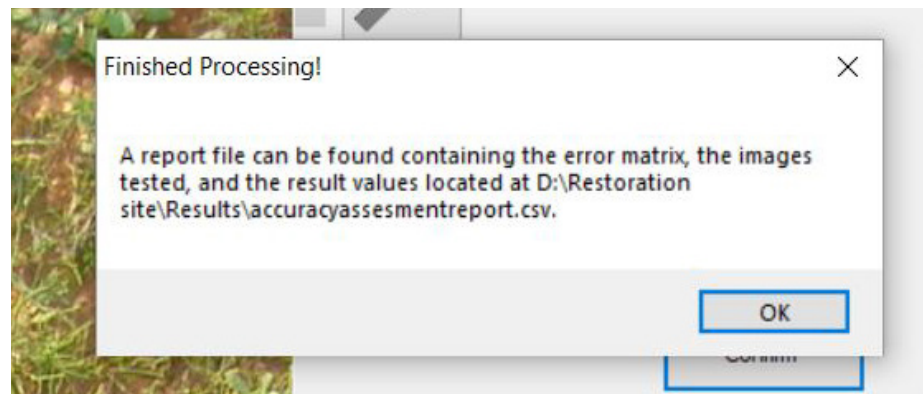
When the setup is complete, and the first image has loaded, the window will look like the screenshot below.



The images will be chosen randomly, based on the specified number of images, and the number of points specified will appear, where the active point is a **red** open circle and the other points are **yellow**.

Note that all the points may not show immediately, as the image may be large. Use the scroll bars and the zoom feature to navigate the image and preview all points.

Click **Confirm** to process the accuracy file, and a .csv file containing the accuracy results will be generated and located in the same file as the images.



	A	B	C	D	E	F	G
1	Images Used:						
2	D:\Restoration site\Results\DSCN8093_processed.bmp						
3	D:\Restoration site\Results\DSC09083_processed.bmp						
4	D:\Restoration site\Results\DSC09103_processed.bmp						
5	D:\Restoration site\Results\DSCN8094_processed.bmp						
6	D:\Restoration site\Results\DSCN8099_processed.bmp						
7							
8	Overall Accuracy:	93%					
9							
10	Producer's Index:						
11	Unclassified	NaN%					
12	plant	97.50%					
13	Rocks	100%					
14	Soil	89.39%					
15							
16	User's Index:						
17	Unclassified	0%					
18	plant	89.25%					
19	Rocks	88.18%					
20	Soil	92.86%					
21							
22							
23			Visual/Correction				
24			Unclassified	plant	Rocks	Soil	
25	Classified/Machine	Unclassified	0	0	0	2	
26		plant	0	39	0	9	
27		Rocks	0	0	2	9	
28		Soil	0	1	0	13	

In the example above, the **path name** displays the **image** being used.

Below this are statistics for the image, overall accuracy, and producer's and user's indexes, and an error matrix.

Overall accuracy: a minimum accuracy of 90% should be obtained; reduced accuracy is achieved by re-running the assessment with a higher number of points.

Error matrix (visual/correction): contains machine classifications along the vertical axis and user selected classes along the horizontal axis.

NaN%: indicates that no samples were reviewed in this category; therefore, the number of samples should be increased.



Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world. We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

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