GOAL: This notebook contains all the proceedires and code required to:

1. Load and view Microscene images.
2. Convert raw microscene data to reflectance data.

In future notebooks, we will:

3. Builds ROIs for the plants in the microscene image(s).
4. Exctract spectra from these regions to a spectral library file.
5. Build, train, test and save classification\detection models.
6. Load spectral libraries from multiple microscene collects.
7. Build, train, test and save classification\detection models from these multi-collect libraries.
8. Apply these models to Microscene images and rigorously evaluate accuracy.
9. Apply these models to UAS hyperspectral images and rigorously evaluate accuracy.

Locations that the user smay need to change or verify will be annoted by comments like:

<<<================================== You need to modify these to be the directory for the image you are working on
==================================>>>>

--- Code to be modified or checked here ---

<<<==

Part 0. Imports and data structures

You will need to change the dir names in the locations below.

In [78]:
```
# common imports
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from matplotlib import colors
import numpy as np
import os
# specific required imports
import spectral # for worinking with hyperspectral images and libraries
import pickle # for saving and loading data
import importlib # for reloading (importing a package after you modify it without h
```

```
import hyperspectral_gta_data as hsi_data # for importing \ sharing data
# imports from local files
from hsiViewer import hsi_viewer_array as hva
import microscene_functions as msf

# set the directory containing the image(s)

# <<<================================ You need to modify these to be the directory f
dir = 'C:/spectral_data/UPWINS/Microscene_Images/Allied_01_17_2025/NANO/100060_1_17
dir_dark = 'C:/spectral_data/UPWINS/Allied_02_14_2024/100040__dark_2015_06_04_18_02
# <<<================================================================================
```

In [79]:
```
# data sctructures - see: https://www.w3schools.com/python/python_classes.asp

class file_names:
    '''
    This class contains the filenames of the files of each type in the selected dir
    The supported classes are:
    - .JPG, typically high-resoluion RGB color image from a camera or GoPro, etc.
    - .png, typically an RGB color image created by the Headwall software when the
    - .hdr, a header file (a text file) containing the metadata for a hyperspectral
    - _dark.hdr, a header file (a text file) containing the metadata for a hyperspe
    NOTES:
    1. A dark image is an image that was acquired with the lenscap on. It will be s
    For each collection there should be a seperate folder with the dark image, coll
    2. This class has methods to search for files in the provided directories.  If
    '''
    def __init__(self, dir, dir_dark):
        '''Lists to hold the filenames for each type of file.'''
        self.dir =dir
        self.dir_dark = dir_dark
        self.jpg = []
        self.png = []
        self.hdr = []
        self.dark_hdr= []

    def find_files(self):
        '''This method seaches the given folders and searches for files of each typ
        # JPG images (usually from a camera or go pro)
        for file in os.listdir(self.dir):
            if file.endswith(".JPG"):
                fnames.jpg.append(os.path.join(dir, file))
        if len(fnames.jpg)==0:
            fnames.jpg.append('None')

        # png images (usually auto-created from the hyperspectral)
        for file in os.listdir(self.dir):
            if file.endswith(".png"):
                fnames.png.append(os.path.join(dir, file))
        if len(fnames.png)==0:
            fnames.png.append('None')

        # hdr files (header files)
        for file in os.listdir(self.dir):
            if file.endswith(".hdr"):
                fnames.hdr.append(os.path.join(dir, file))
```

```
        if len(fnames.hdr)==0:
            fnames.hdr.append('None')

        # dark hdr files (header files for dark images)
        for file in os.listdir(self.dir_dark):
            if file.endswith(".hdr"):
                fnames.dark_hdr.append(os.path.join(dir_dark, file))
        if len(fnames.dark_hdr)==0:
            fnames.dark_hdr.append('None')

    def print_all(self):
        '''This method prints all the filenames for each file type.'''
        print('JPG Images:')
        for fname in self.jpg:
            print('    '+fname)
        print('png Images:')
        for fname in self.png:
            print('    '+fname)
        print('hdr files:')
        for fname in self.hdr:
            print('    '+fname)
        print('dark hdr files:')
        for fname in self.dark_hdr:
            print('    '+fname)
```

Part 1. Loading dark image, hyperspectral image, and high-res image.

In [80]:
```
# get a list of all jpg images and header files (one header for each hyperspectral
# the results will be saved in an instance of the file_names structure

# create an instance of the file_names class
fnames = file_names(dir, dir_dark)
fnames.find_files()
fnames.print_all()
```

```
JPG Images:
    None
png Images:
    C:/spectral_data/UPWINS/Microscene_Images/Allied_01_17_2025/NANO/100060_1_17_202
5_2015_06_04_18_49_00\raw_0.png
hdr files:
    C:/spectral_data/UPWINS/Microscene_Images/Allied_01_17_2025/NANO/100060_1_17_202
5_2015_06_04_18_49_00\raw_0.hdr
dark hdr files:
    C:/spectral_data/UPWINS/Allied_02_14_2024/100040__dark_2015_06_04_18_02_27\raw_
0.hdr
```

You will need to verify that the filenames below are correct.

In [81]:
```
# here are the filenames located by the search
# <<<============================== You need to check that the filenames below are
fname_hres_jpg = fnames.jpg[0]
```

```
fname_png = fnames.png[0]
fname_dark_hdr = fnames.dark_hdr[0]
fname_dark = fname_dark_hdr[:-4] # usually same as header fname but without the .hd
fname_im_hdr = fnames.hdr[0]
fname_im = fname_im_hdr[:-4]# usually same as header fname but without the .hdr exe
# <<<============================================================================
print(f'fname_hres_jpg: {fname_hres_jpg}')
print(f'fname_png: {fname_png}')
print(f'fname_dark_hdr: {fname_dark_hdr}')
print(f'fname_dark: {fname_dark}')
print(f'fname_im_hdr: {fname_im_hdr}')
print(f'fname_im: {fname_im}')
```

```
fname_hres_jpg: None
fname_png: C:/spectral_data/UPWINS/Microscene_Images/Allied_01_17_2025/NANO/100060_1
_17_2025_2015_06_04_18_49_00\raw_0.png
fname_dark_hdr: C:/spectral_data/UPWINS/Allied_02_14_2024/100040__dark_2015_06_04_18
_02_27\raw_0.hdr
fname_dark: C:/spectral_data/UPWINS/Allied_02_14_2024/100040__dark_2015_06_04_18_02_
27\raw_0
fname_im_hdr: C:/spectral_data/UPWINS/Microscene_Images/Allied_01_17_2025/NANO/10006
0_1_17_2025_2015_06_04_18_49_00\raw_0.hdr
fname_im: C:/spectral_data/UPWINS/Microscene_Images/Allied_01_17_2025/NANO/100060_1_
17_2025_2015_06_04_18_49_00\raw_0
```

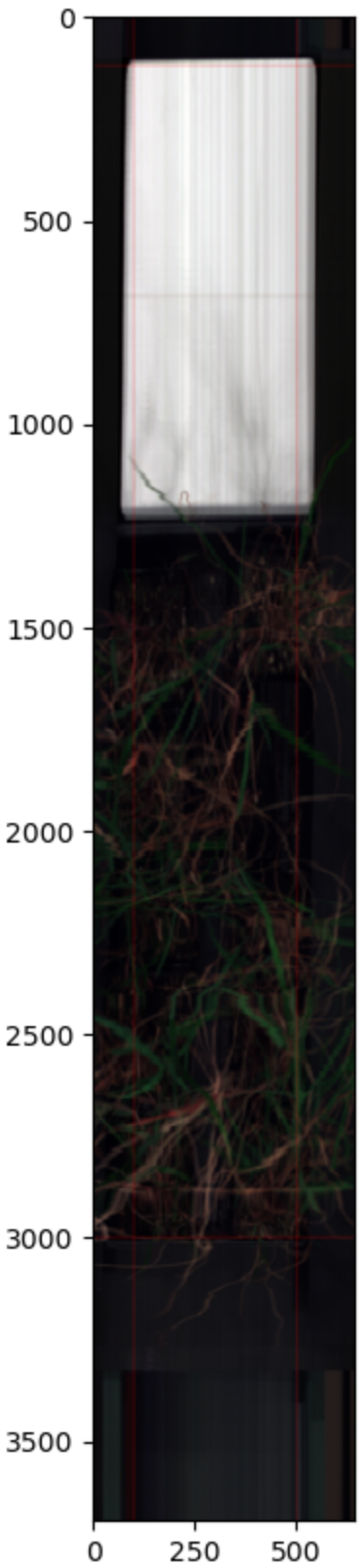
Part 2. Choose the bounds to crop the image so that:

- the upper (or lower) portion is the white reference square
- the white reference square extends the full width of the image after cropping

You will need to modify the crop_rows and crop_cols to create a good crop for your image.

In [82]:
```
# Choose rows and columns to define a crop of the image
# The cropped image should:
#    - the upper (or lower) portion is the white reference square
#    - the white reference square extends the full width of the image after croppin

# crop lines:
# <<<================================ Modify the crop range to match your image. ===
crop_rows = [120,3000]
crop_cols = [100,500]
# <<<============================================================================

# read the image into a numpy array
img = mpimg.imread(fname_png)
# creatre a red box on the image to show the crop area
for c in crop_cols:
    img[:,c,0] = 1.0
    img[:,c,1] = 0
    img[:,c,2] = 0
for r in crop_rows:
    img[r,:,0] = 1.0
```

```
    img[r,:,1] = 0
    img[r,:,2] = 0
# show the image with crop lines
plt.figure(figsize=(10,10))
plt.imshow(img)
plt.show()
```

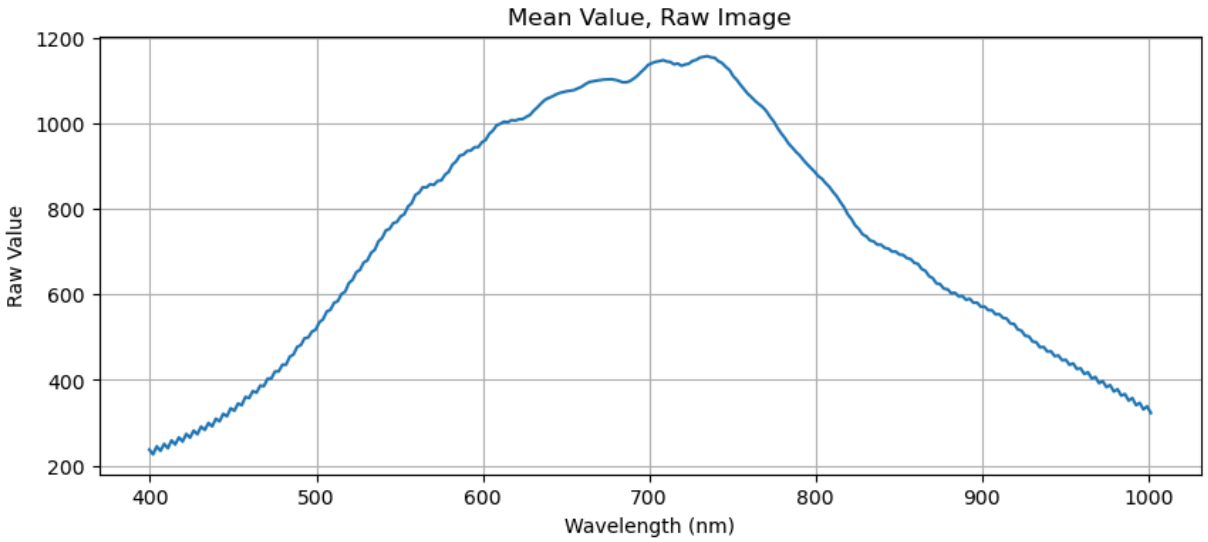


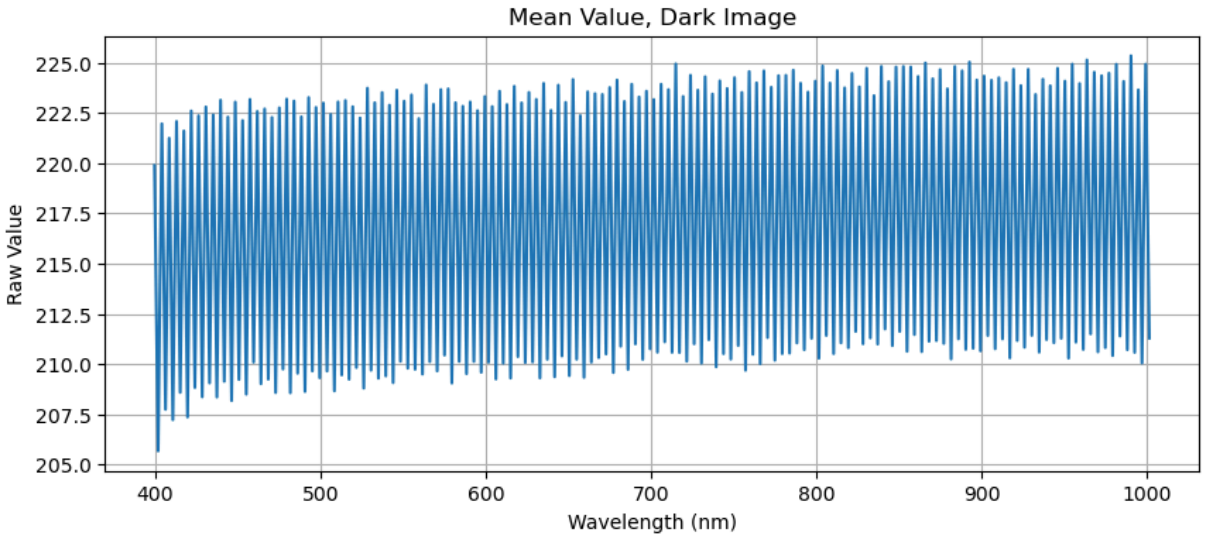
Part 3. Extract the white reference area (to use to convert the image to reflectance)

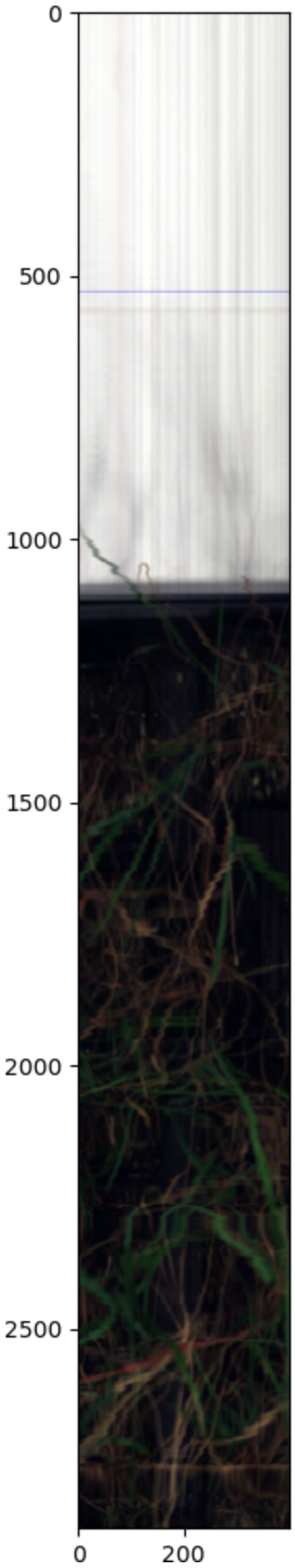
You will need to modify the rows for your white reference in your iamge to match your image.

In [83]:
```
# crop the hyperspectral image based on your drop ranges above
importlib.reload(msf)
# <<<============================== Modify the rows for your white reference in yo
white_ref_rows = [0,530]
# <<<=============================================================================


# Open the image and read into an array
im = spectral.envi.open(fname_im_hdr, fname_im)
im.wl = np.asarray(im.bands.centers)
im.Arr = im.load()

# plot the mean raw measured value
image_mean = np.mean(np.mean(im.Arr, axis=0), axis=0)
plt.figure(figsize=(10,4))
plt.plot(im.wl, image_mean)
plt.title('Mean Value, Raw Image')
plt.xlabel('Wavelength (nm)')
plt.ylabel('Raw Value')
plt.grid(True)
plt.show()


# Open the dark image and read into an array
im_dark = spectral.envi.open(fname_dark_hdr, fname_dark)
im_dark.wl = np.asarray(im_dark.bands.centers)
im_dark.Arr = im_dark.load()

# plot the mean raw measured dark value
image_dark_mean = np.mean(np.mean(im_dark.Arr, axis=0), axis=0)
plt.figure(figsize=(10,4))
plt.plot(im.wl, image_dark_mean)
plt.title('Mean Value, Dark Image')
plt.xlabel('Wavelength (nm)')
plt.ylabel('Raw Value')
plt.grid(True)
plt.show()


# crop the image
imArr_cropped = im.Arr[crop_rows[0]:crop_rows[1], crop_cols[0]:crop_cols[1], :]
im.nr, im.nc, im.nb =imArr_cropped.shape

# Create the RGB with blue lines bounding the white refernce area
im_RGB = msf.make_rgb(imArr_cropped, im.wl)
for r in white_ref_rows:
```

```
    im_RGB[r,:,0] = 0
    im_RGB[r,:,1] = 0
    im_RGB[r,:,2] = 1.0

plt.figure(figsize=(12, 12))
plt.imshow(im_RGB)
plt.show()

print(f'Origonial shape of im_igm.Arr = {im.Arr.shape}')
print(f'Shape of im_igm.Arr after croppping = {imArr_cropped.shape}')
```






0
500
1000
1500
2000
2500
0
200

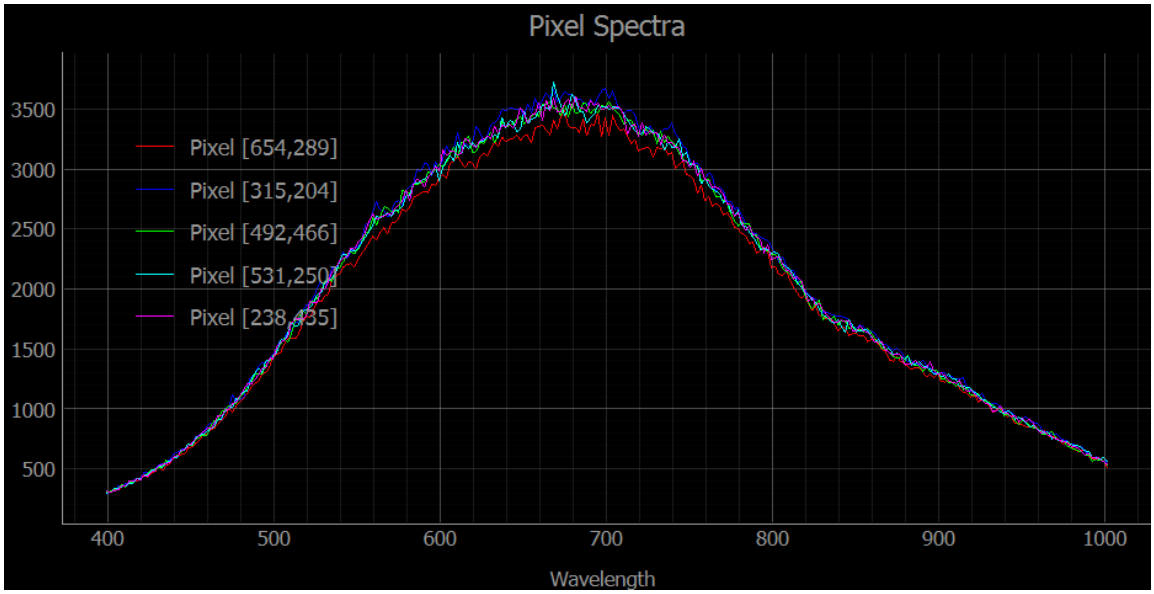
```
Origonial shape of im_igm.Arr = (3696, 640, 272)
Shape of im_igm.Arr after croppping = (2880, 400, 272)
```

In [89]:
```
importlib.reload(hva)
hva.viewer(im.Arr, im.wl)
```

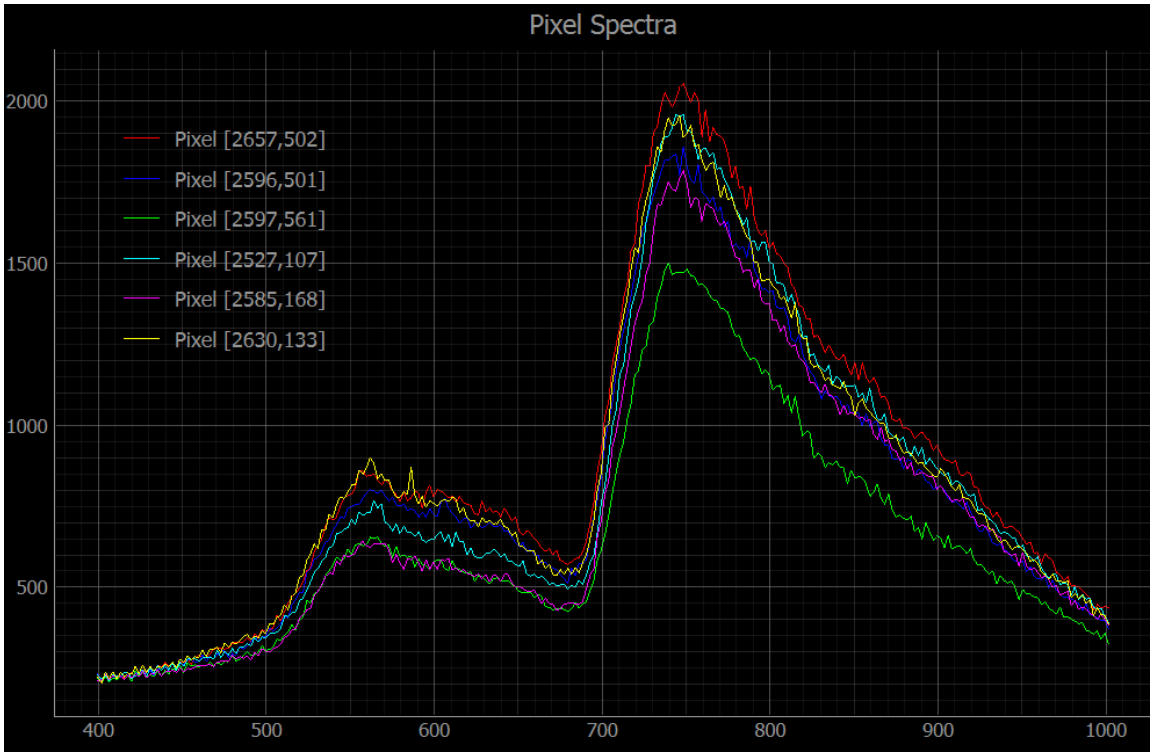
```
[654,289],
[315,204],
[492,466],
[531,250],
[238,435],
[2644,507],
[2657,502],
[2596,501],
[2597,561],
[2527,107],
[2585,168],
[2630,133],
```

Out[89]: <hsiViewer.hsi_viewer_array.viewer at 0x20516463010>

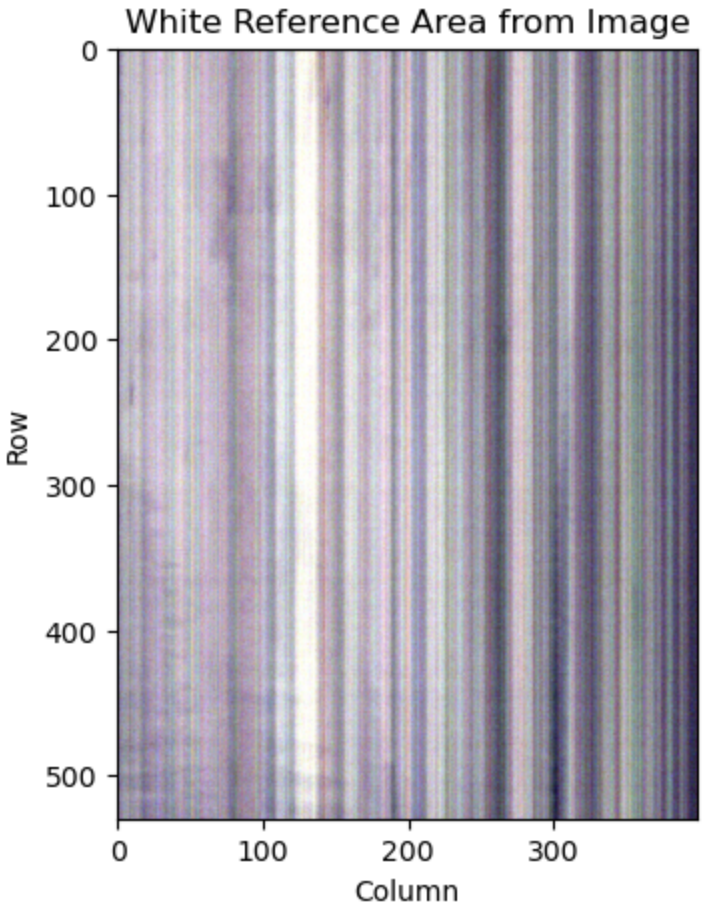
Spectra from White Reference, Raw Image



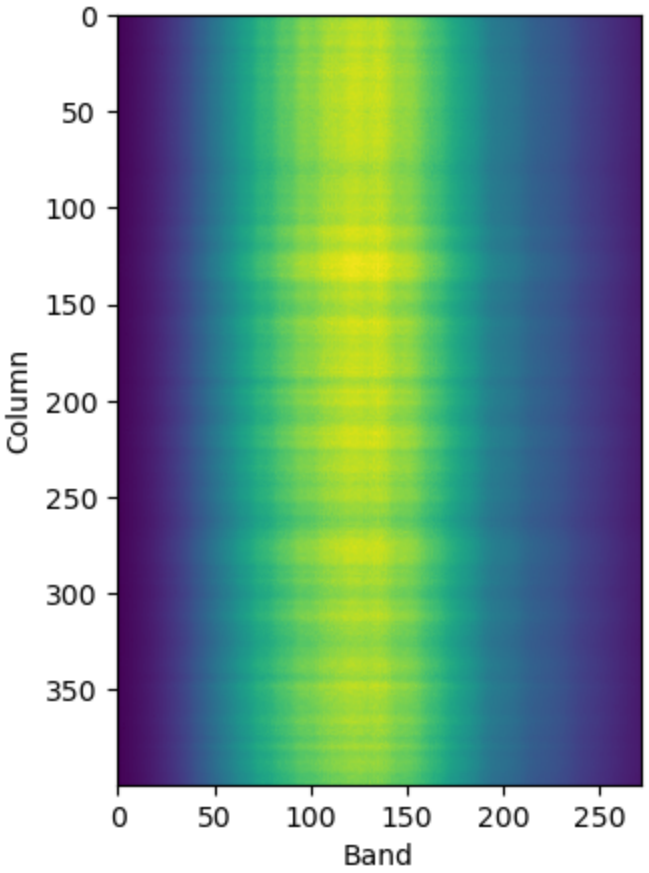
Spectral from healthy veg, raw image



In [84]:
```
# create the white reference region from the inage
im_wr = imArr_cropped[white_ref_rows[0]:white_ref_rows[1], :, :]
#im_wr[:,20,:] = 10000 # use these to check the arrangement of the columns and band
#im_wr[:,:,100] = 10000 # use these to check the arrangement of the columns and ban
im_wr_RGB = msf.make_rgb(im_wr, im.wl)
plt.figure(figsize=(5,5))
plt.imshow(im_wr_RGB)
plt.title('White Reference Area from Image')
plt.xlabel('Column')
plt.ylabel('Row')
plt.show()
```

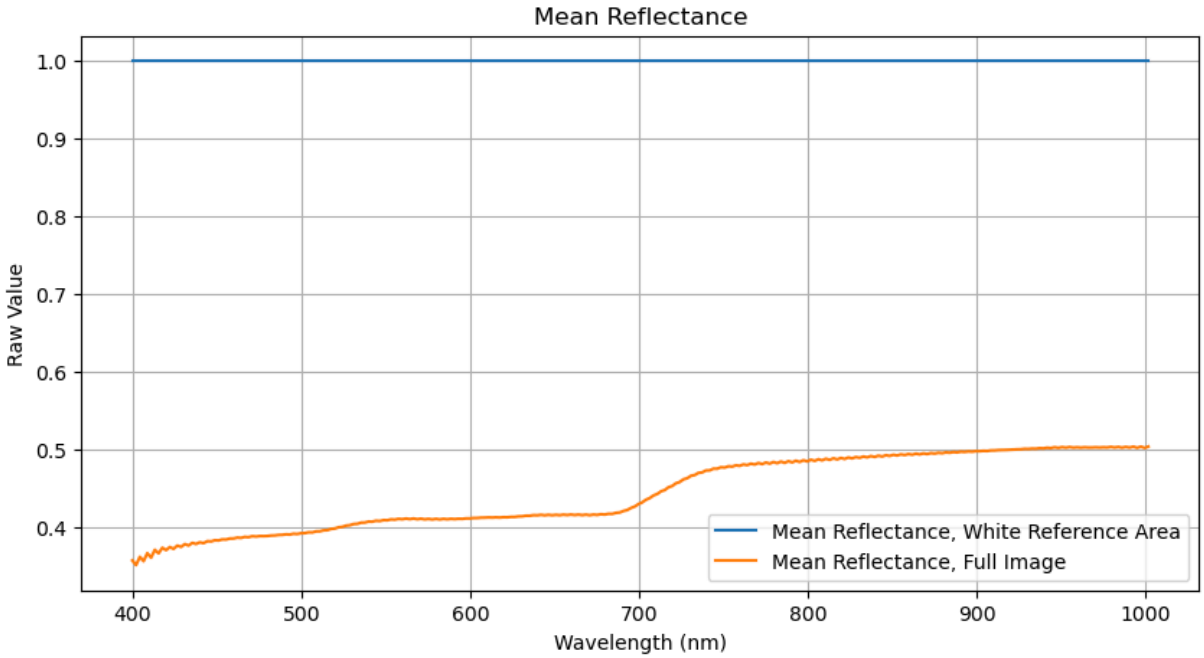


In [85]:
```
# image of Focal Plane Array
im_FPA = np.mean(im_wr, axis=0)
plt.figure(figsize=(5,5))
plt.imshow(im_FPA)
plt.xlabel('Band')
plt.ylabel('Column')
plt.show()
```



In [86]:
```
# convert to reflectance
im_ref = np.zeros((im.nr, im.nc, im.nb))
for c in range(im.nc):
    for b in range(im.nb):
        im_ref[:,c,b] = np.squeeze(    (imArr_cropped[:,c,b]-image_dark_mean[b])
```

In [87]:
```
# plot the mean reflectance
# compute mean refleactance of white reference area
im_ref_wr = im_ref[white_ref_rows[0]:white_ref_rows[1], :, :]
im_ref_wr_mean = np.mean(np.mean(im_ref_wr, axis=0), axis=0)

# compute mean reflectance of full image
im_ref_mean = np.mean(np.mean(im_ref, axis=0), axis=0)
plt.figure(figsize=(10,5))
plt.plot(im.wl, im_ref_wr_mean, label='Mean Reflectance, White Reference Area')
plt.plot(im.wl, im_ref_mean, label='Mean Reflectance, Full Image')
plt.title('Mean Reflectance')
plt.xlabel('Wavelength (nm)')
plt.ylabel('Raw Value')
plt.legend()
plt.grid(True)
plt.show()
```

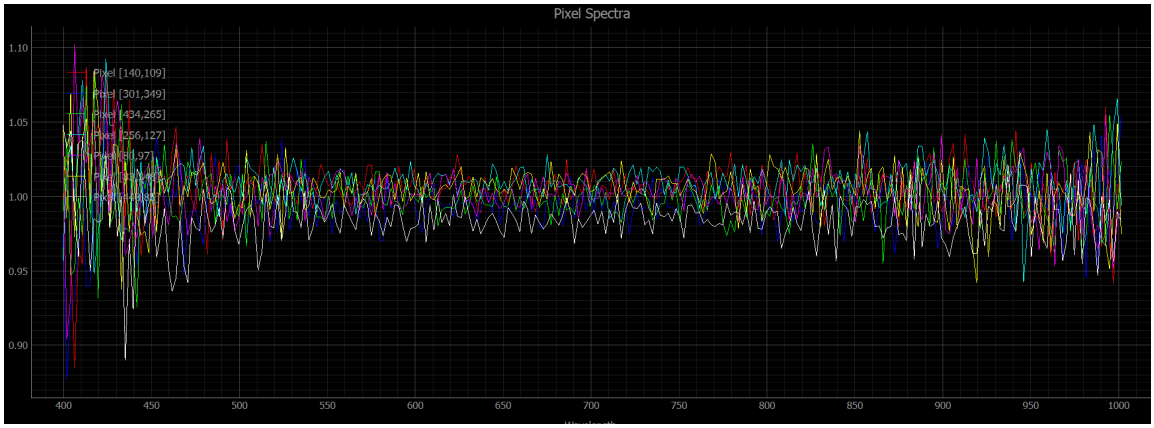


In [88]:
```
importlib.reload(hva)
hva.viewer(im_ref, im.wl)
```

```
[140,109],
[301,349],
[434,265],
[256,127],
[80,97],
[83,348],
[448,86],
[2117,330],
[2198,351],
[2228,359],
[2314,267],
[2328,278],
[2558,194],
[2511,35],
[2421,23],
[1734,276],
[1611,336],
[1614,337],
[2014,278],
[1550,35],
```

Out[88]: <hsiViewer.hsi_viewer_array.viewer at 0x205164bcd30>

Pixels on White Reference:



Pixels on healthy veg: