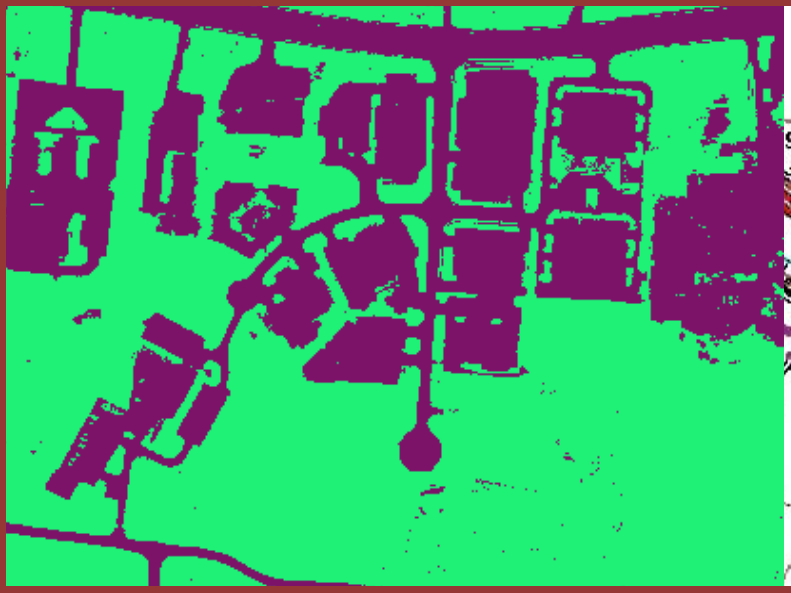
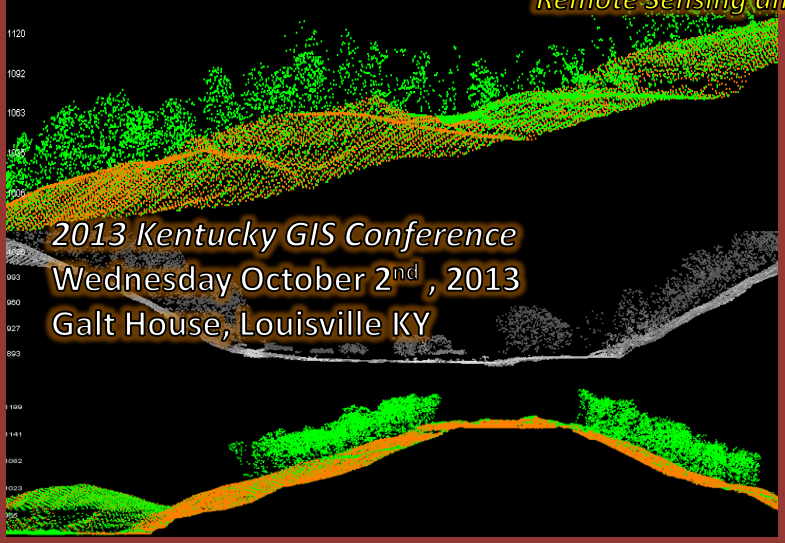


Remote Sensing in a GIS Environment

Demetrio P. Zourarakis, PhD, GISP, CMS-RS, CMS-GIS/LIS

Remote Sensing and GIS Analyst, Kentucky Division of Geographic Information



2013 Kentucky GIS Conference

Wednesday October 2nd , 2013

Galt House, Louisville KY

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Outline

- Sensor data
- Image enhancement methods
- Image classification schemes
- Toolsets (ArcGIS 10.1 SP1)
- Further resources

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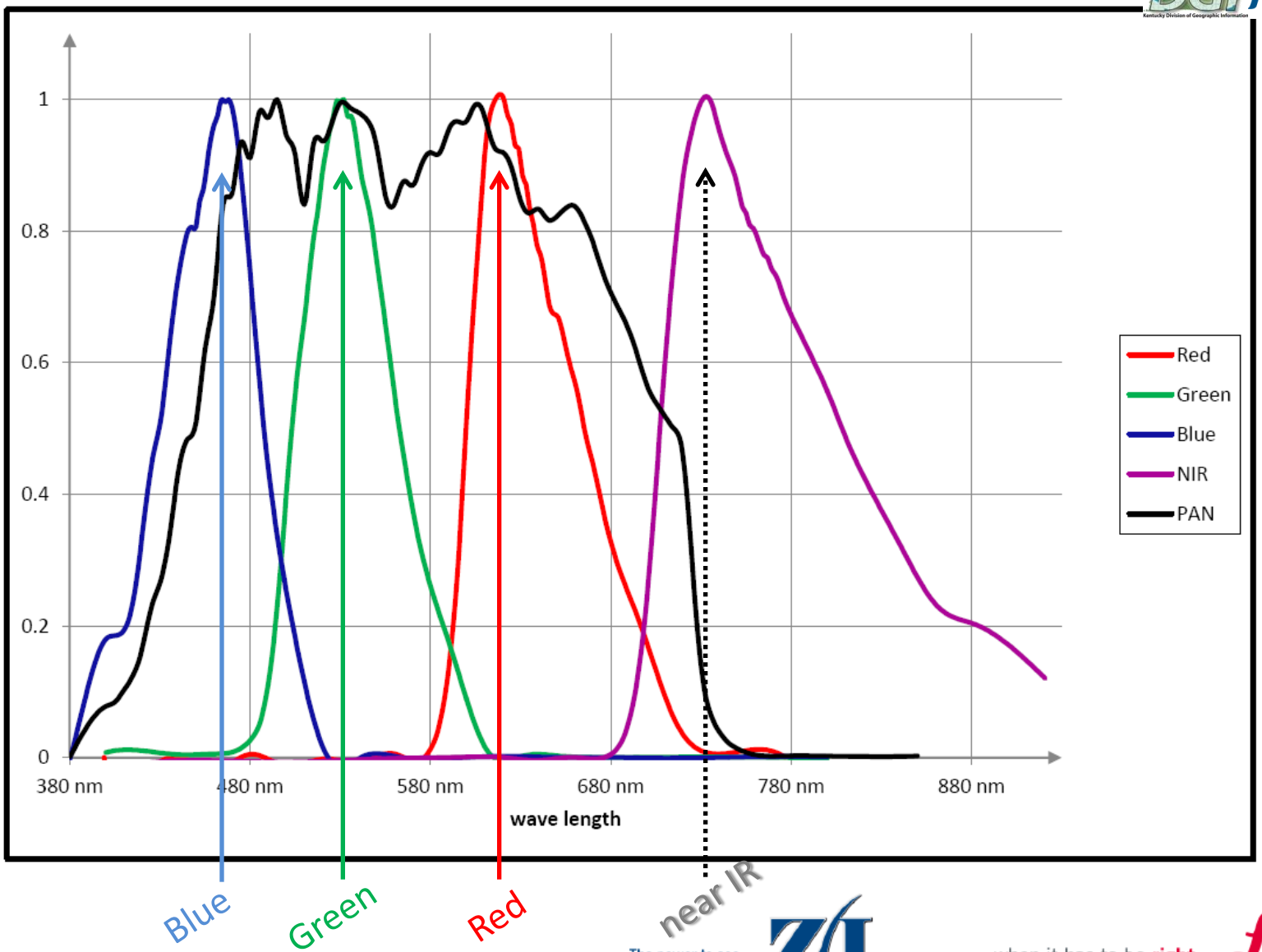
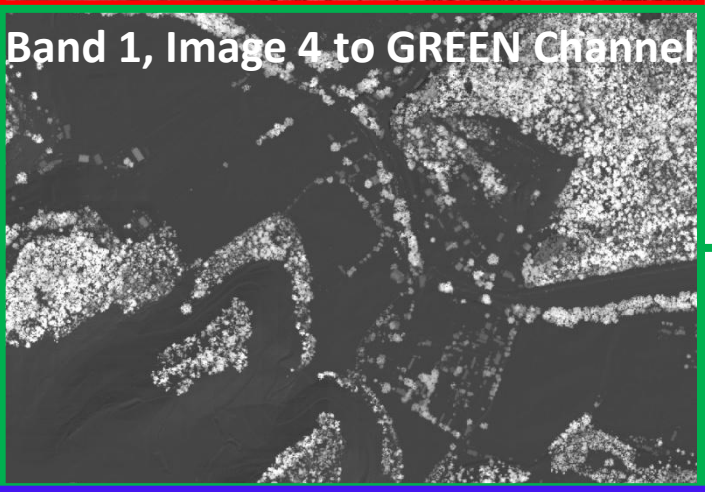
DMC II Sensor Design



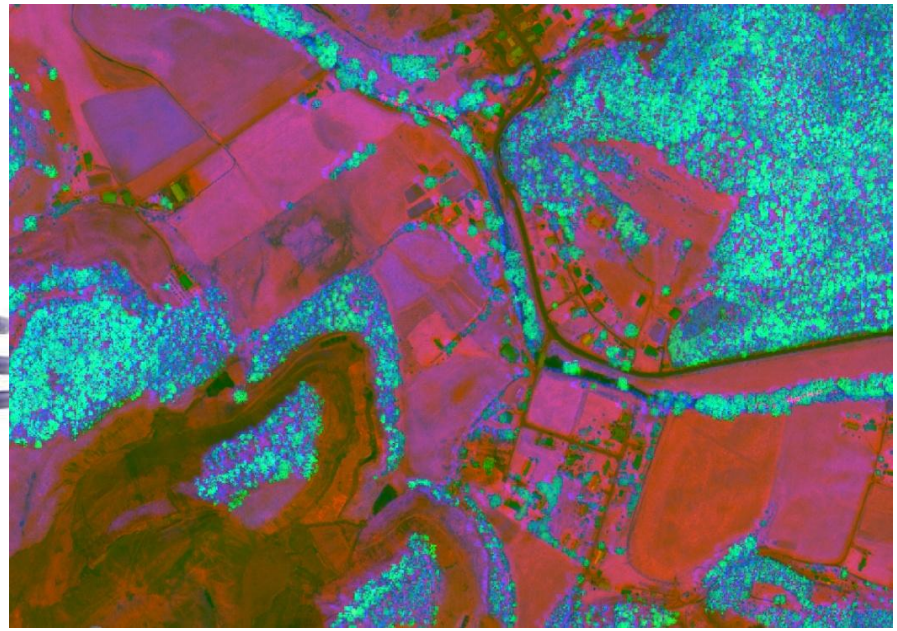
The power to see - when it has to be right

http://www.ifp.uni-stuttgart.de/phowo/2011/presentations/100Neumann.pdf

From “single band” to “composite image”



Display Device



Band 4, Image 1= near infrared, NAIP
Band 1, Image 4= normalized LiDAR DSM
Band 2, Image 5= fourth component, PCA - KYAPED

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Image Enhancements
(1)

Contrast Stretching

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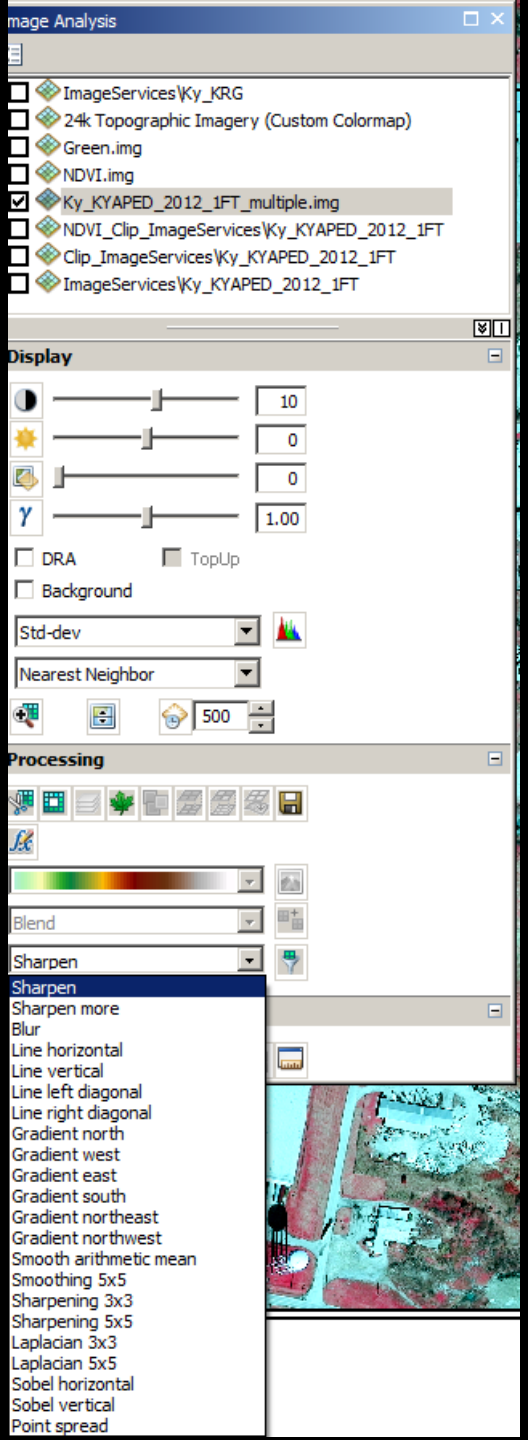

Spatial filters – convolution!
(e.g. sharpening, smoothing, edge detection)

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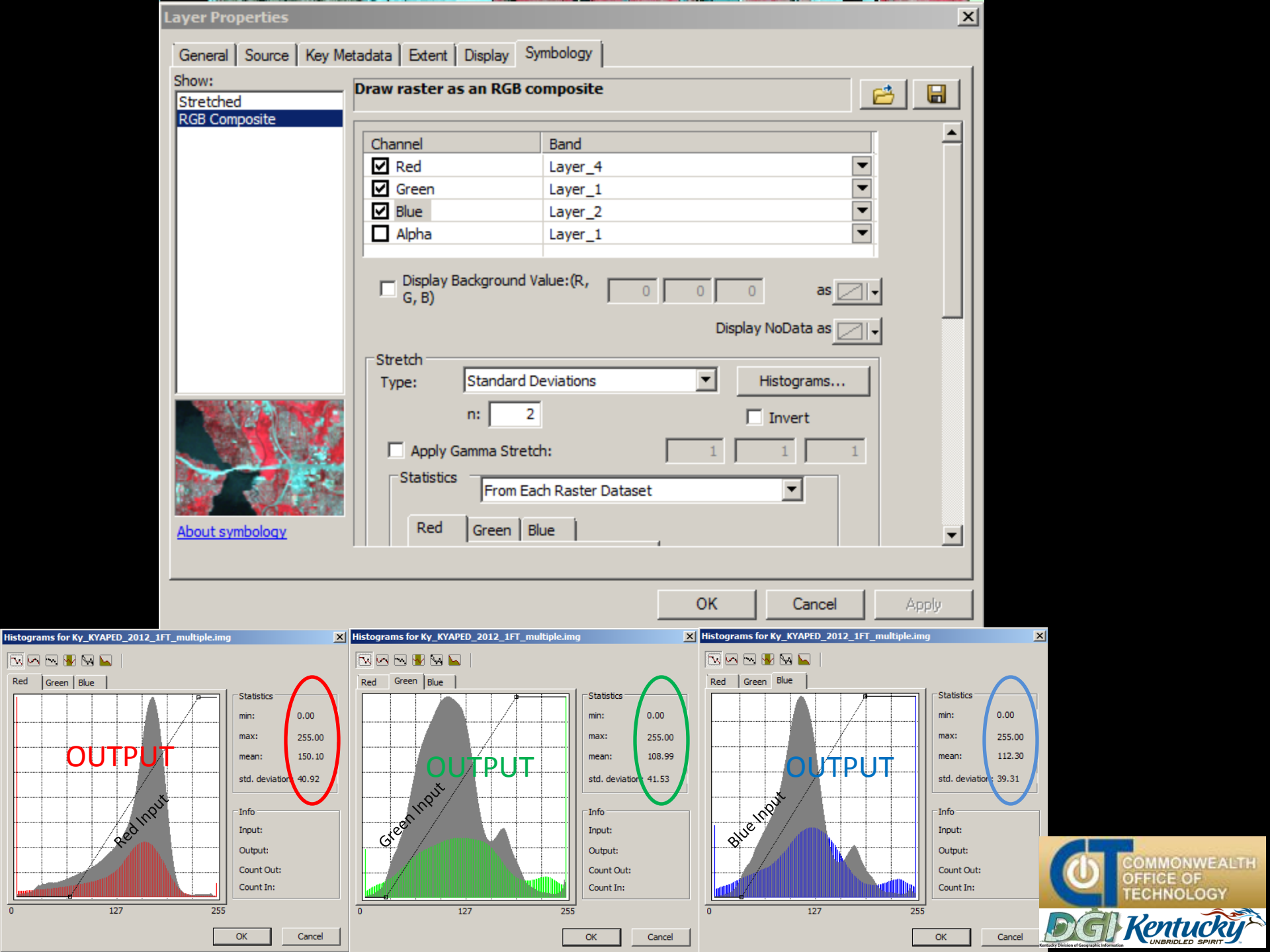
Layer Properties
General
Source
Key Metadata
Extent
Display
Symbology
Show:
Stretched
RGB Composite
Draw raster as an RGB composite
Channel
Band
Red
Layer_4
Green
Layer_1
Blue
Layer_2
Alpha
Layer_1
Display Background Value:(R, G, B)
0
0
0
as
Display NoData as
Stretch
Type:
Standard Deviations
Histograms...
n:
2
Invert
Apply Gamma Stretch:
1
1
1
Statistics
From Each Raster Dataset
Red
Green
Blue
About symbology
OK
Cancel
Apply
Histograms for Ky_KYAPED_2012_1FT_multiple.img
Red
Green
Blue
OUTPUT
Red Input
Statistics
min: 0.00
max: 255.00
mean: 150.10
std. deviation: 40.92
Info
Input:
Output:
Count Out:
Count In:
0
127
255
OK
Cancel
Histograms for Ky_KYAPED_2012_1FT_multiple.img
Red
Green
Blue
OUTPUT
Green Input
Statistics
min: 0.00
max: 255.00
mean: 108.99
std. deviation: 41.53
Info
Input:
Output:
Count Out:
Count In:
0
127
255
OK
Cancel
Histograms for Ky_KYAPED_2012_1FT_multiple.img
Red
Green
Blue
OUTPUT
Blue Input
Statistics
min: 0.00
max: 255.00
mean: 112.30
std. deviation: 39.31
Info
Input:
Output:
Count Out:
Count In:
0
127
255
OK
Cancel
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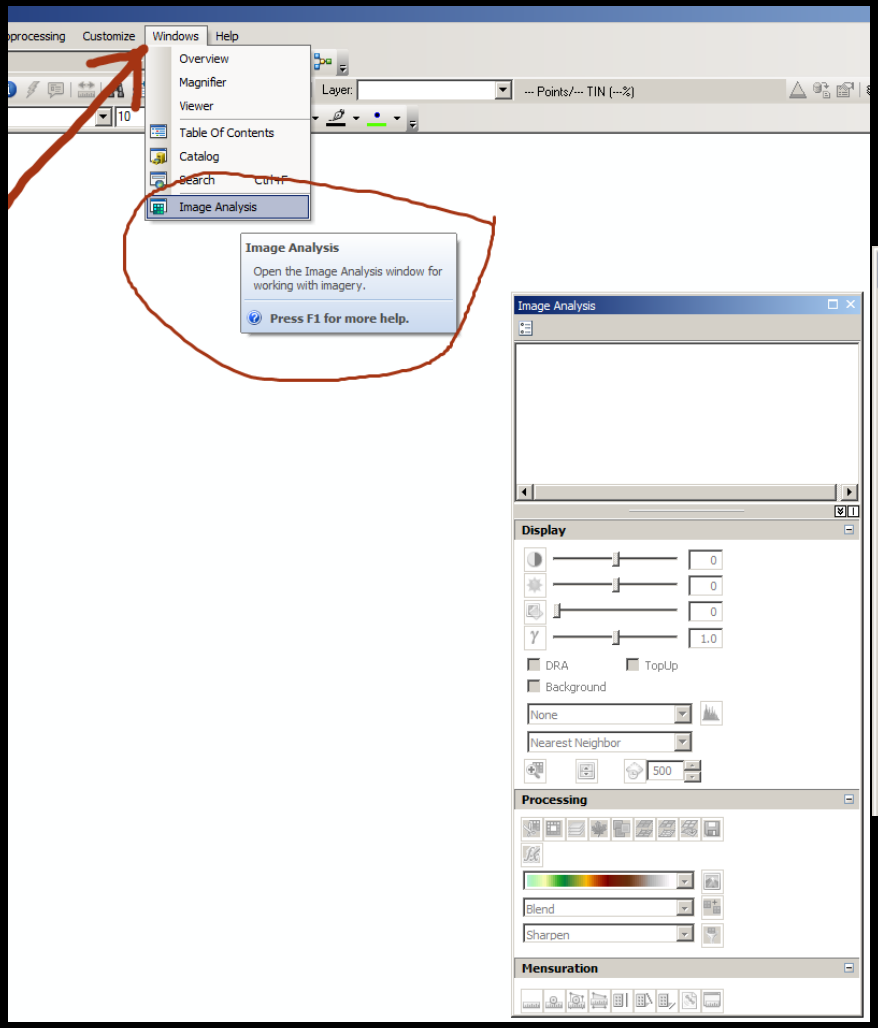
UNBRIDLED SPIRIT

N
0 125 250 500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
DGI Kentucky
UNBRIDLED SPIRIT
Kentucky Division of Geographic Information

N
0 125 250 500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
DGI Kentucky
UNBRIDLED SPIRIT
Kentucky Division of Geographic Information



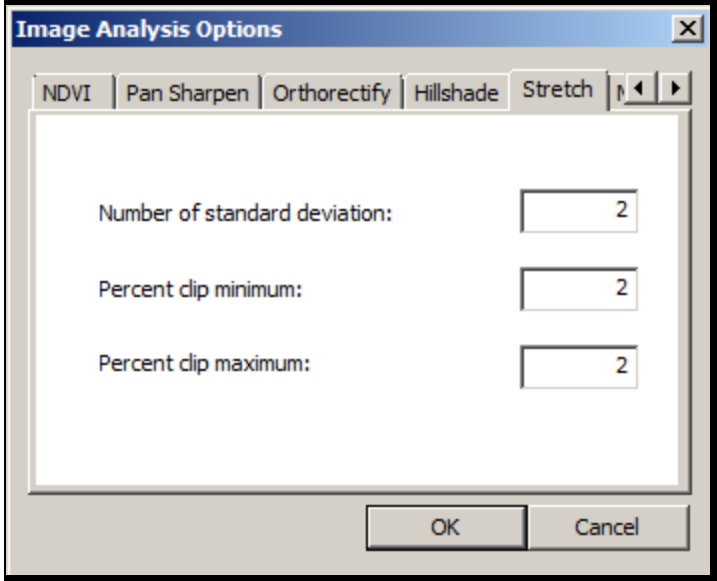


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Image Enhancements
(2)

Multi-band manipulation

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Normalized Difference Vegetation Index

… just one index of MANY.

"Band algebra" or "band math" used to combine information from "red band" ("band 1" in 4-band image) and "near infrared band" ("band 4" in 4-band image) **to map type and status of vegetative cover in *a given image*** *(or … changes in an image pair)*:

$$NDVI = \frac{(DN\text{"Infrared Band"} - DN\text{"Red Band"})}{(DN\text{"Infrared Band"} + DN\text{"Red Band"})}$$

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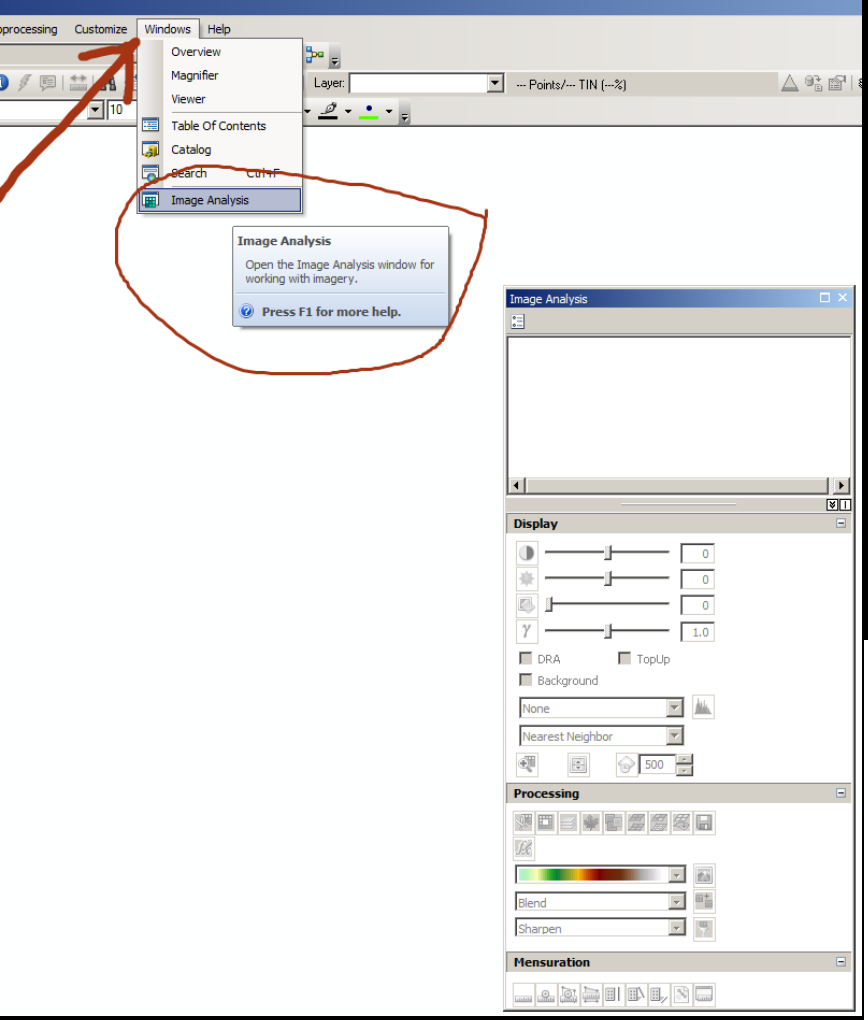

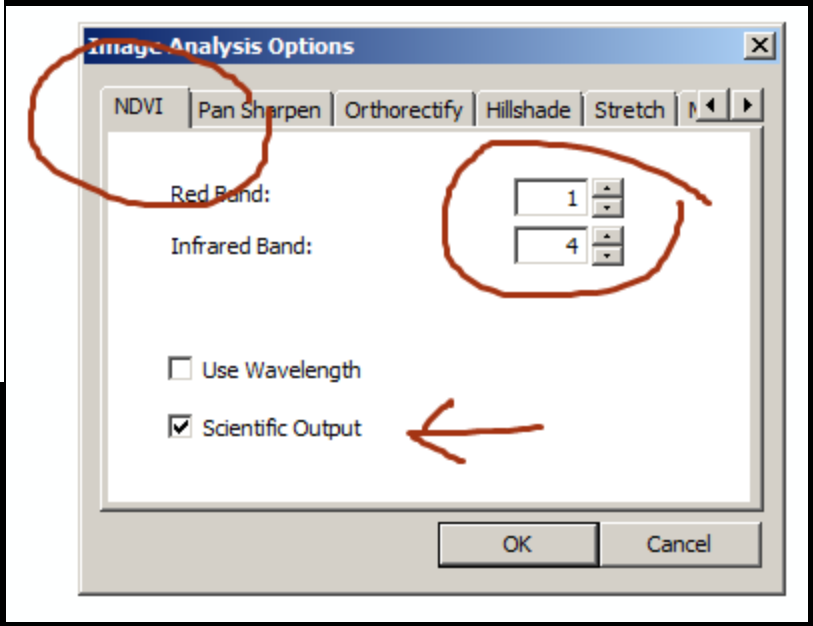

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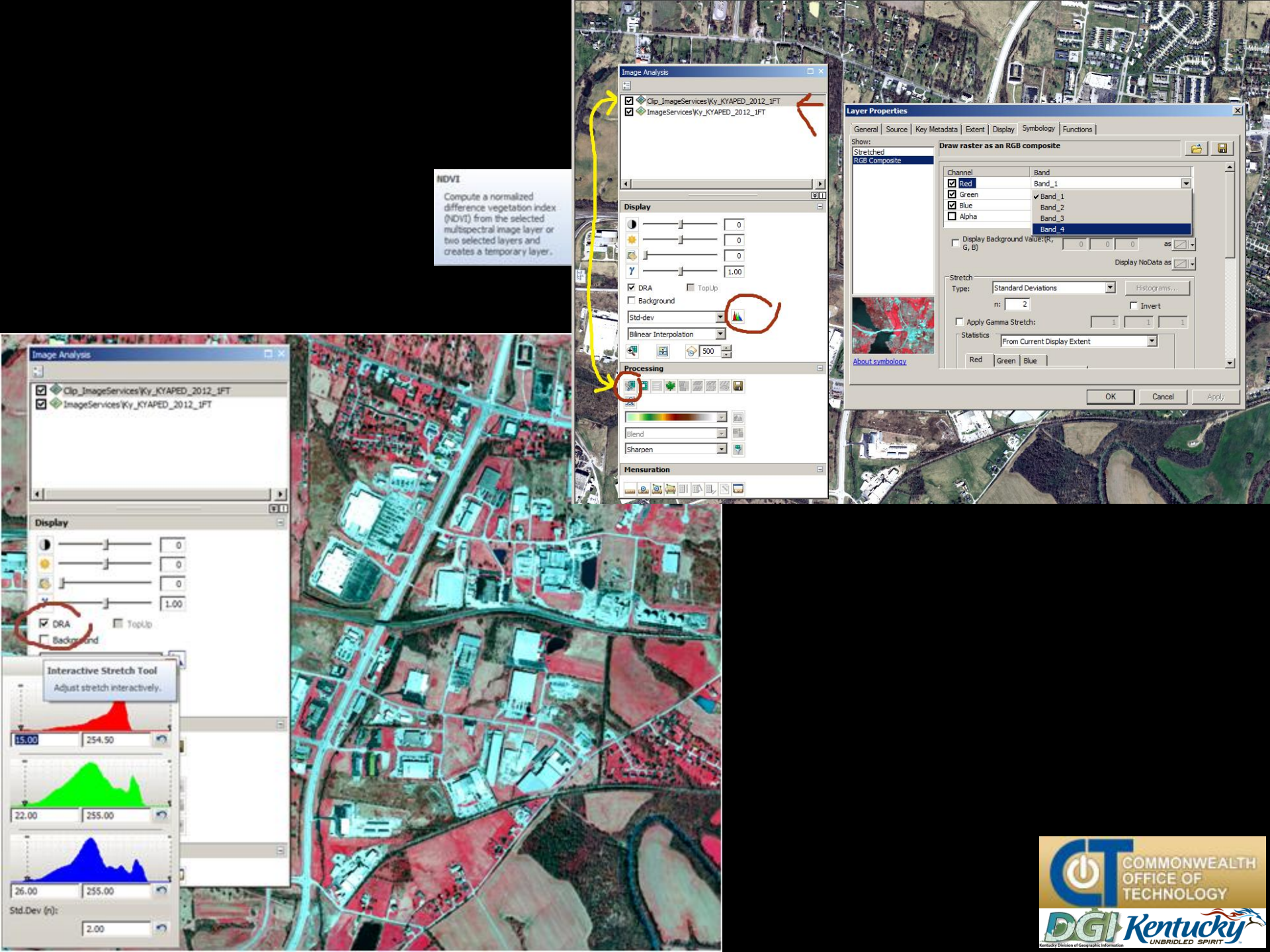
DGI Kentucky UNBRIDLED SPIRIT


NDVI
Compute a normalized difference vegetation index (NDVI) from the selected multispectral image layer or two selected layers and creates a temporary layer.
Image Analysis
Clip_ImageServices\Ky_KYAPED_2012_1FT
ImageServices\Ky_KYAPED_2012_1FT
Display
DRA
TopUp
Background
Std-dev
Bilinear Interpolation
Processing
Blend
Sharpen
Mensuration
Layer Properties
General
Source
Key Metadata
Extent
Display
Symbology
Functions
Show:
Stretched
RGB Composite
Draw raster as an RGB composite
Channel
Band
Red
Green
Blue
Alpha
Band_1
Band_2
Band_3
Band_4
Display Background Value: (R, G, B)
Display NoData as
Stretch
Type:
Standard Deviations
Histograms...
n:
Invert
Apply Gamma Stretch:
Statistics
From Current Display Extent
About symbology
OK
Cancel
Apply
Interactive Stretch Tool
Adjust stretch interactively.
15.00
254.50
22.00
255.00
26.00
255.00
Std.Dev (n):
2.00
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Mapping “Green” Land Cover

Mixed Use Watersheds

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N
0 125 250 500 Feet
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N
0 125 250 500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
DGI Kentucky
UNBRIDLED SPIRIT
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N
0 125 250 500 Feet
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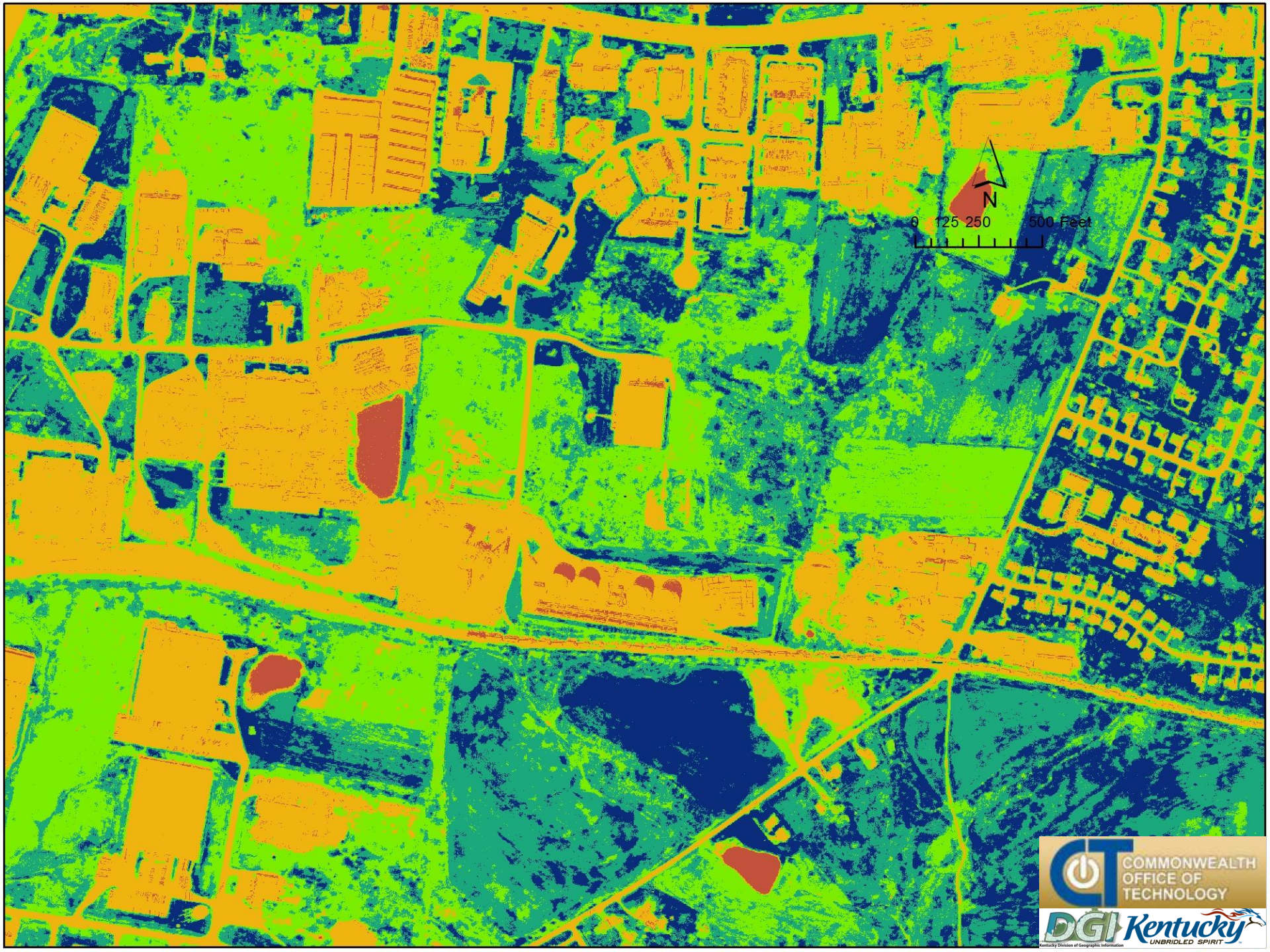
N
0 125 250 500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
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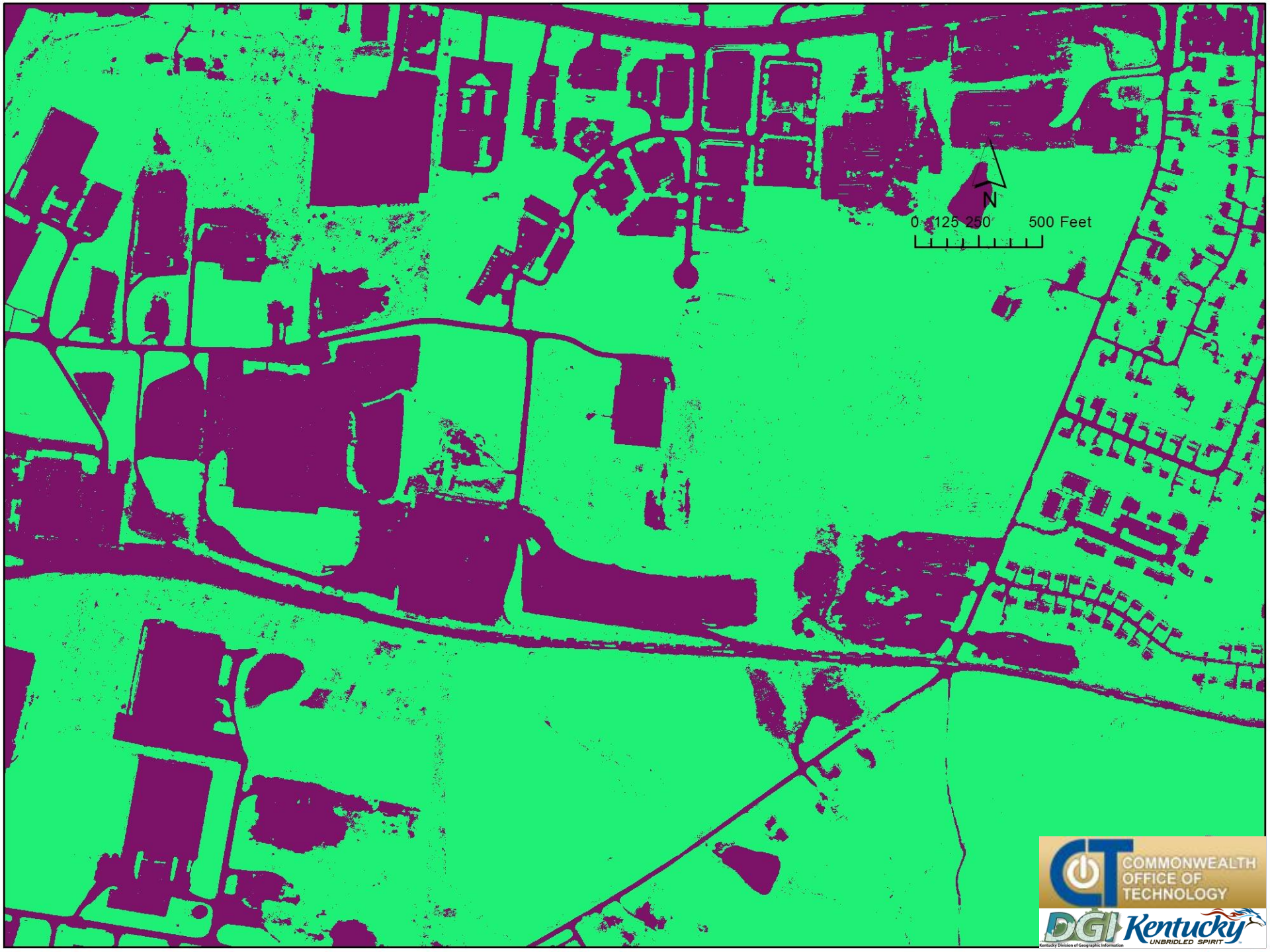
N
0 125 250 500 Feet
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Mapping Imperviousness

Louisville (SoBro)

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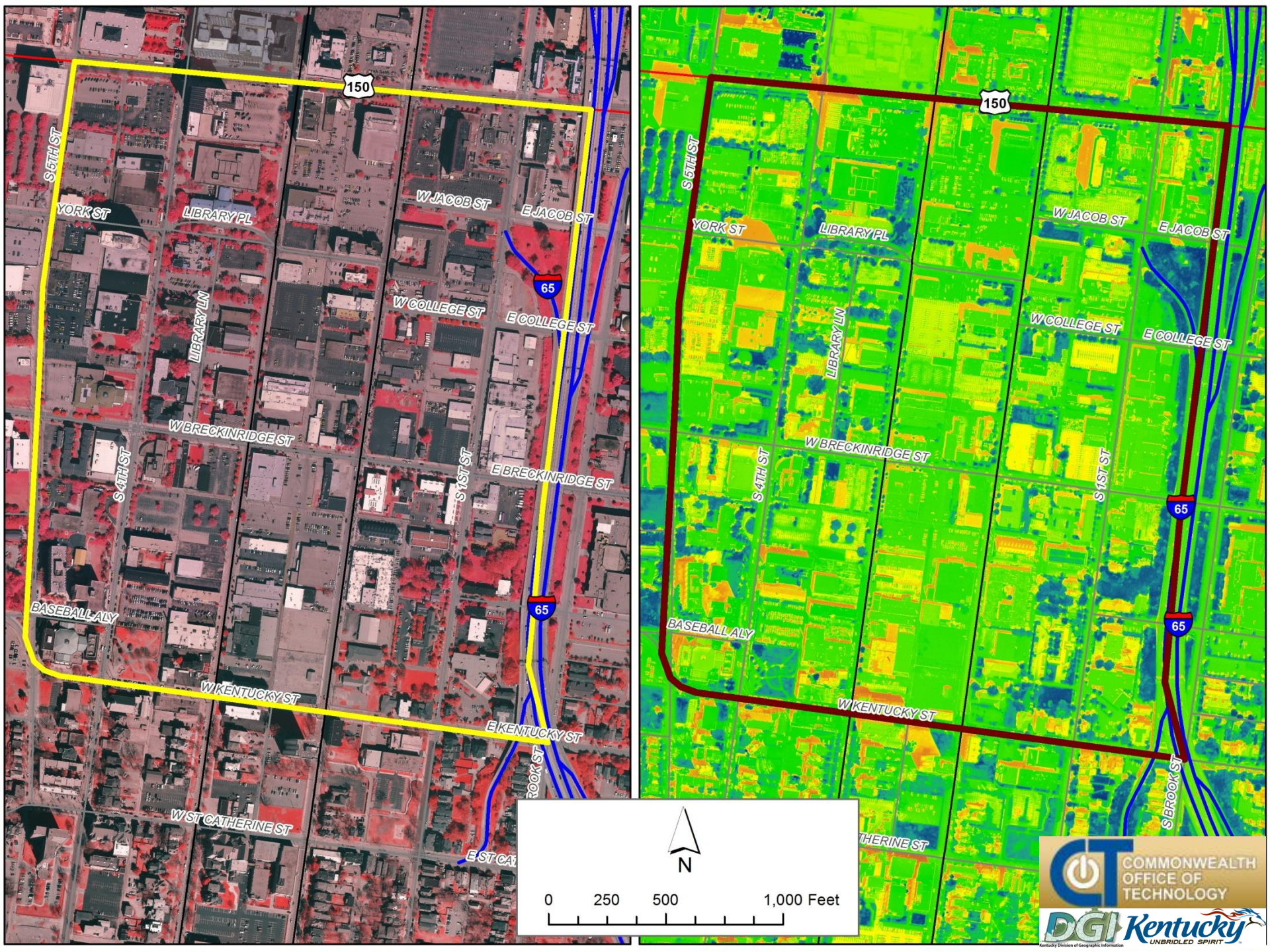
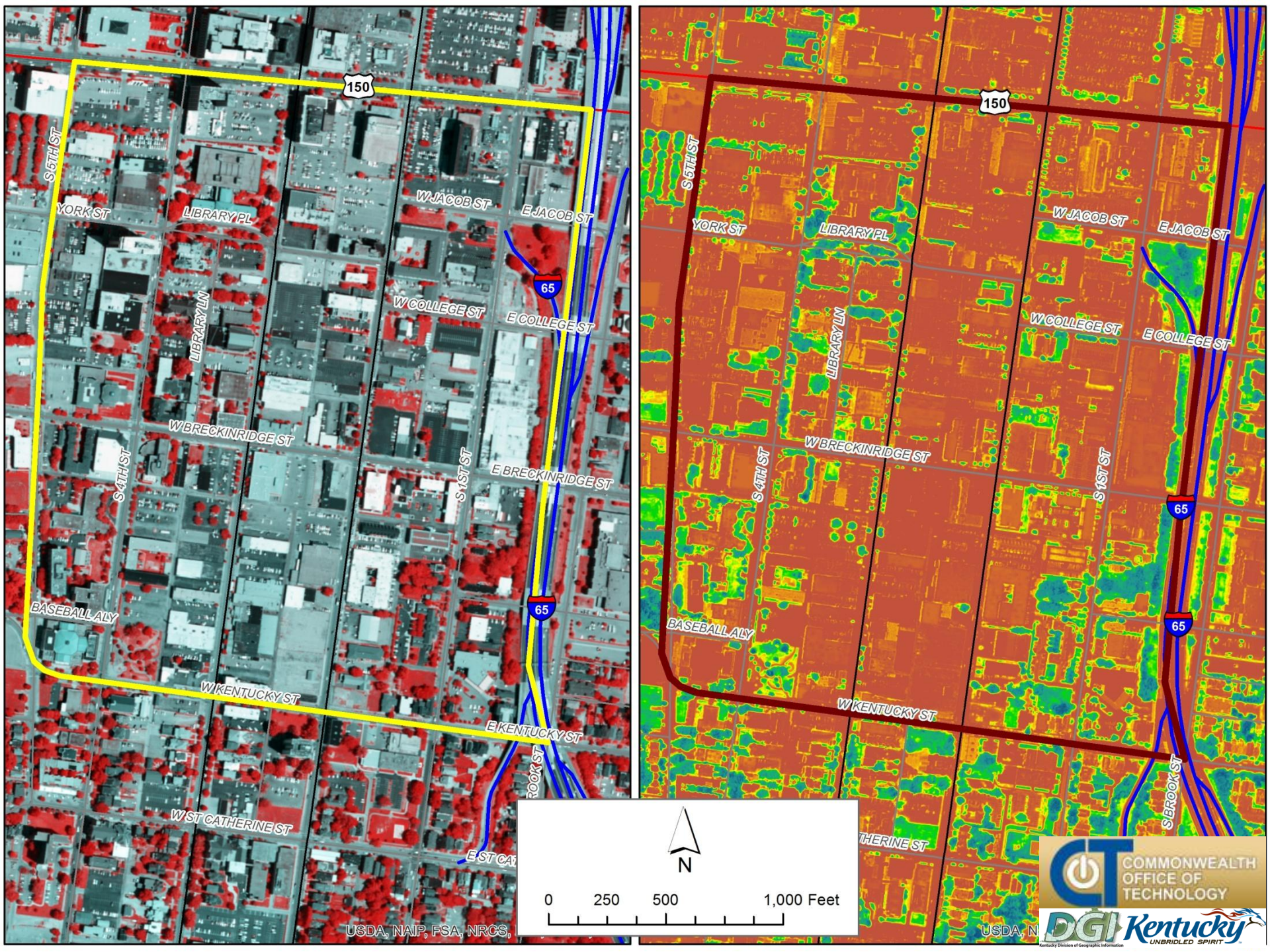

150
S 5TH ST
YORK ST
LIBRARY PL
W JACOB ST
E JACOB ST
65
W COLLEGE ST
E COLLEGE ST
LIBRARY LN
W BRECKINRIDGE ST
S 4TH ST
S 1ST ST
E BRECKINRIDGE ST
BASEBALL ALY
W KENTUCKY ST
E KENTUCKY ST
S BROOK ST
W ST CATHERINE ST
N
0 250 500 1,000 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
DGI Kentucky
UNBRIDLED SPIRIT


150
S 5TH ST
YORK ST
LIBRARY PL
W JACOB ST
E JACOB ST
65
W COLLEGE ST
E COLLEGE ST
LIBRARY LN
W BRECKINRIDGE ST
S 4TH ST
S 1ST ST
E BRECKINRIDGE ST
BASEBALL ALY
W KENTUCKY ST
E KENTUCKY ST
S BROOK ST
W ST CATHERINE ST
N
0 250 500 1,000 Feet
USDA, NAIP, FSA, NRCS,
COMMONWEALTH OFFICE OF TECHNOLOGY
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Green + "Hard" Spaces - Data Workflow Summary…

1. KYAPED services:
   http://kyraster.ky.gov/arcgis/rest/services/ImageServices/Ky_KYAPED_2012_1FT/ImageServer
   http://kyraster.ky.gov/arcgis/rest/services/ImageServices/Ky_LOJIC_2012_6IN/ImageServer
2. Clip image or restrict analysis extent (Geoprocessing Environment)
3. Image Analysis Window
   - NDVI (settings: Red=band 1; Near IR= band 4)
   - Scientific
4. Save NDVI one-band image
5. Calculate statistics and build pyramids
6. Classify (Natural Breaks)
7. Create binary mask with Map Algebra

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Temporal land cover change detection

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N
0 375 750 1,500 Feet
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UNBRIDLED SPIRIT
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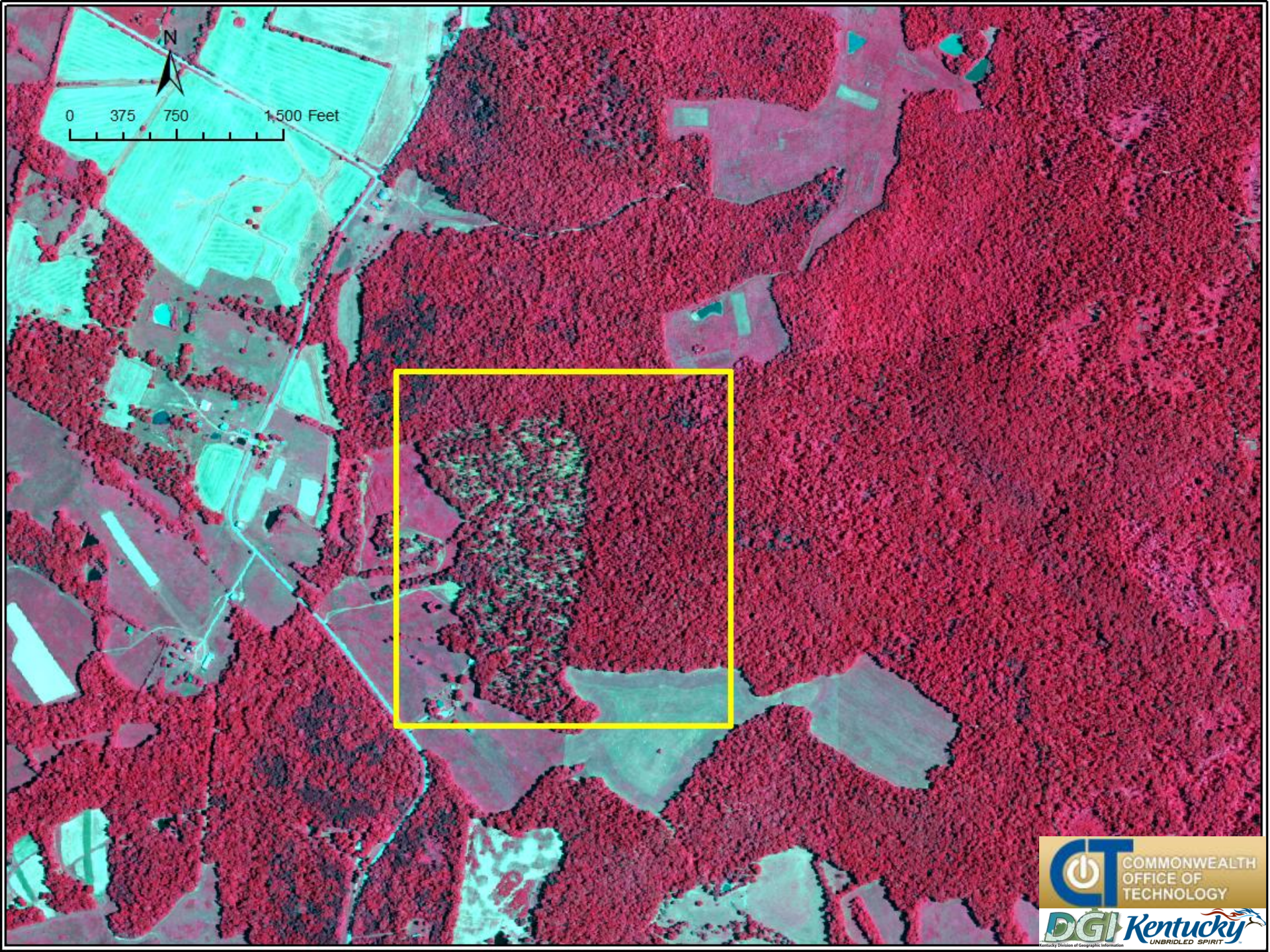
N
0 375 750 1,500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
DGI
Kentucky
UNBRIDLED SPIRIT


N
0 375 750 1,500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
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Kentucky
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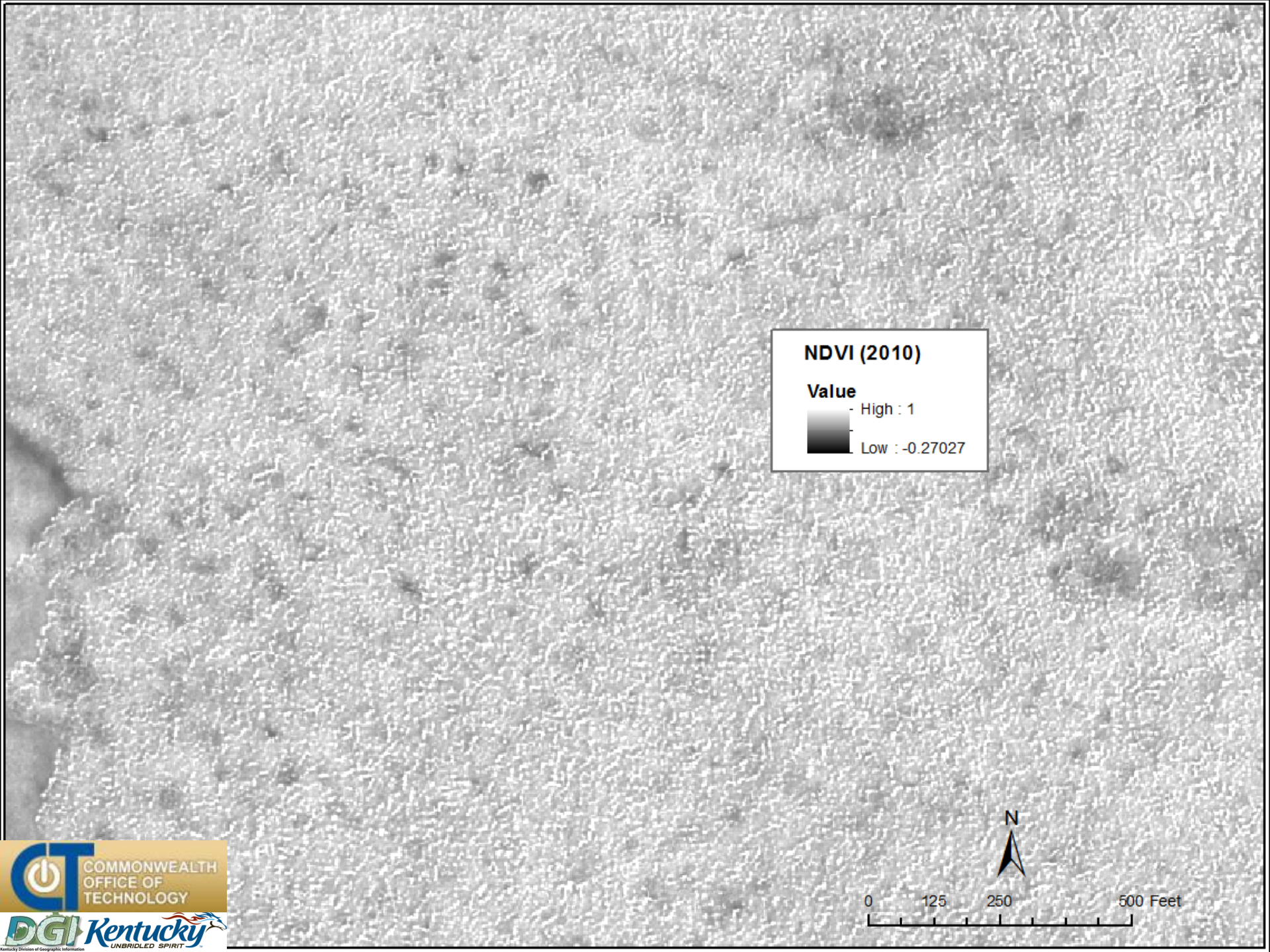
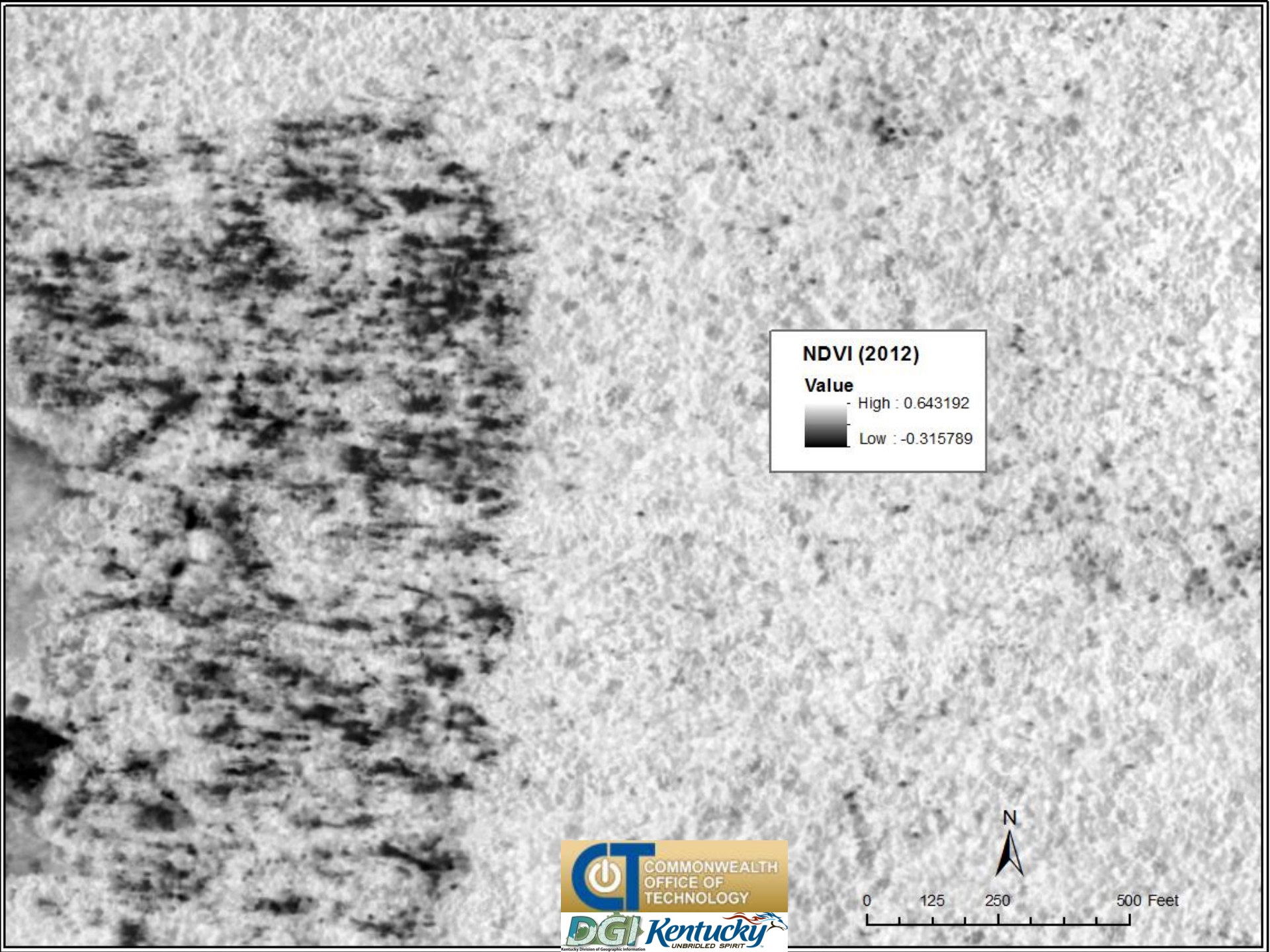

NDVI (2010)
Value
High : 1
Low : -0.27027
N
0
125
250
500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
DGI Kentucky
UNBRIDLED SPIRIT
Kentucky Division of Geographic Information


NDVI (2012)
Value
High : 0.643192
Low : -0.315789
N
0
125
250
500 Feet
COMMONWEALTH OFFICE OF TECHNOLOGY
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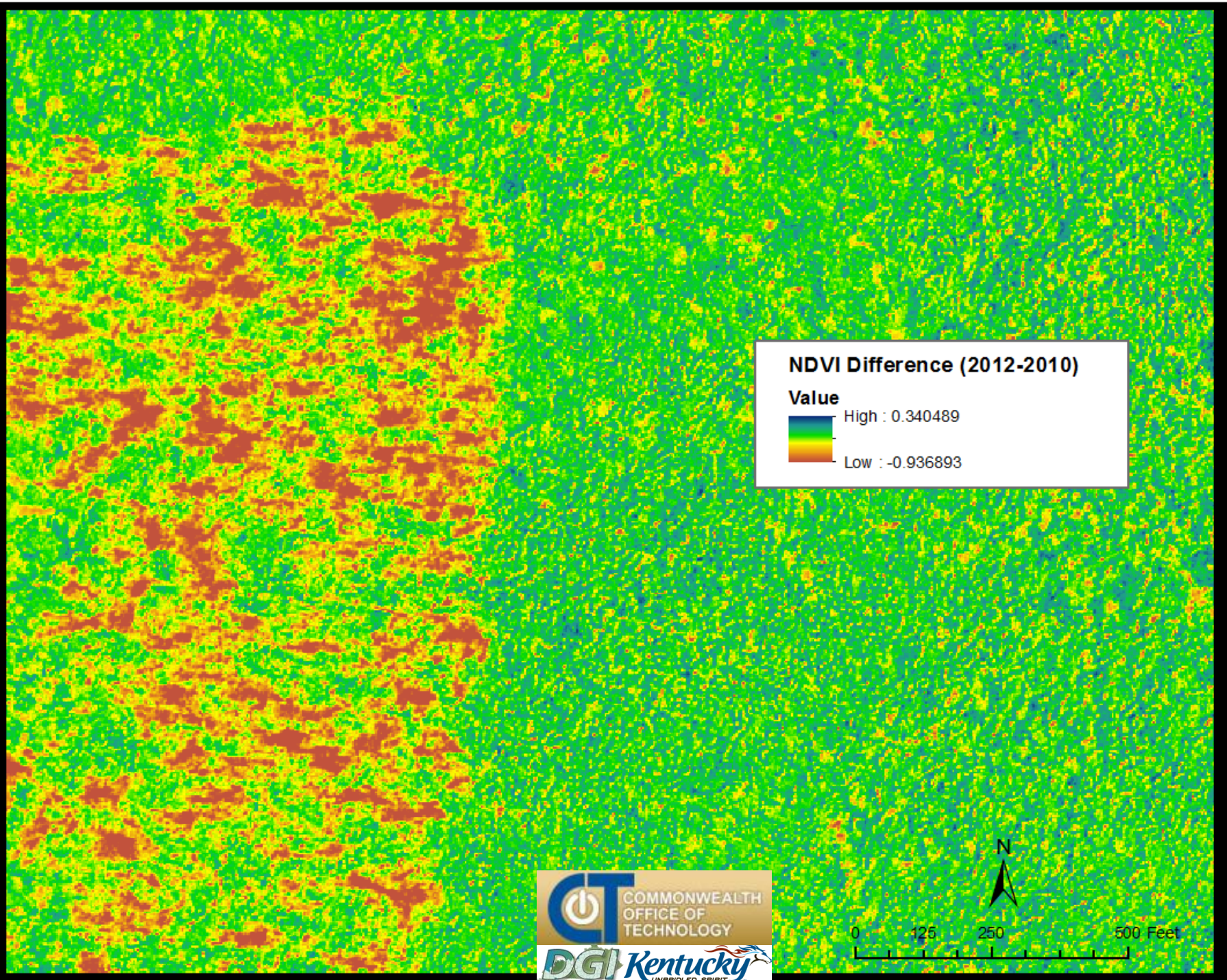
NDVI Difference (2012-2010)
Value
High : 0.340489
Low : -0.936893
N
0
125
250
500 Feet
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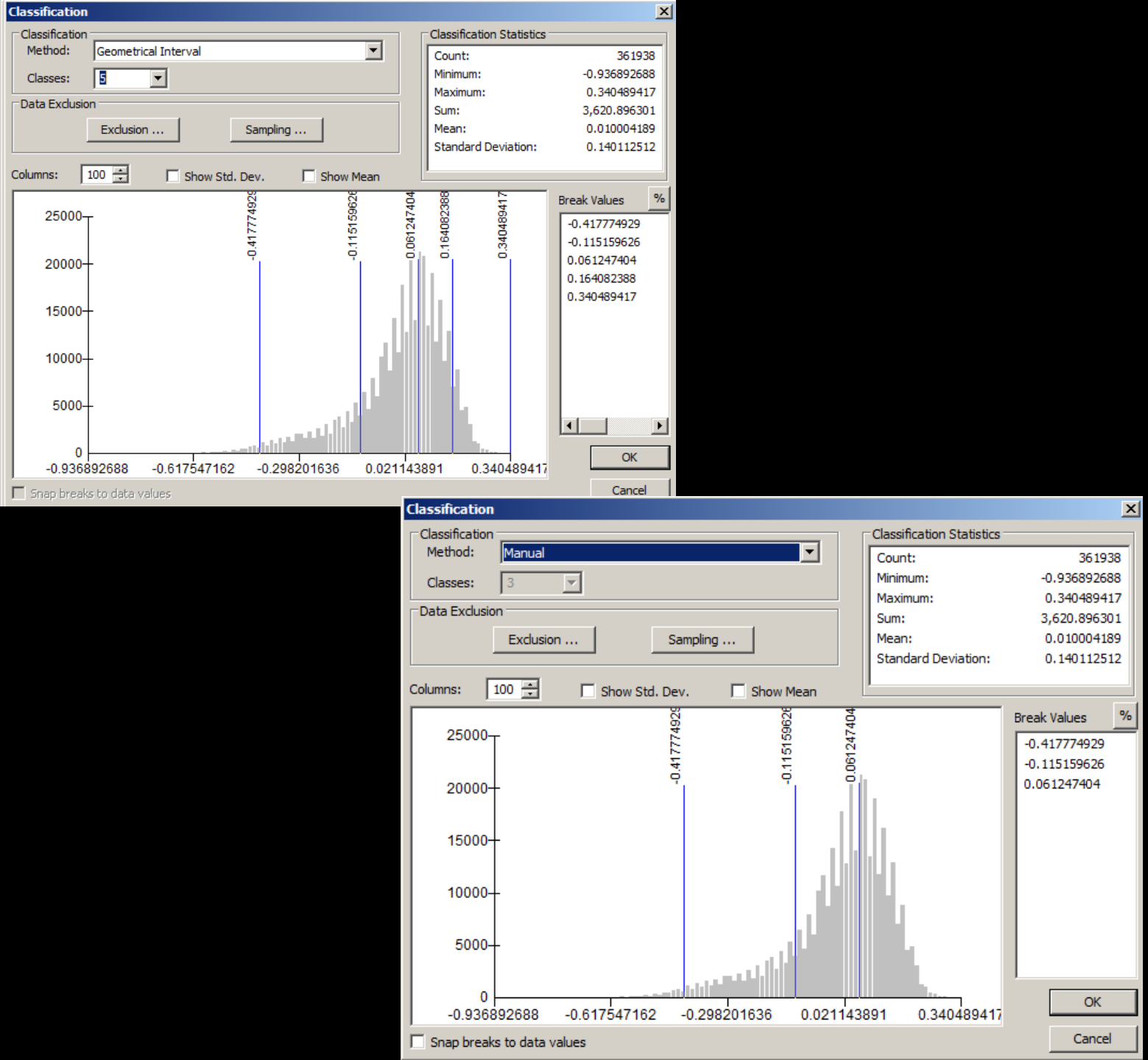
Classification
Classification
Method: Geometrical Interval
Classes: 5
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 361938
Minimum: -0.936892688
Maximum: 0.340489417
Sum: 3,620.896301
Mean: 0.010004189
Standard Deviation: 0.140112512
Columns: 100
Show Std. Dev.
Show Mean
25000
20000
15000
10000
5000
0
-0.936892688
-0.617547162
-0.298201636
0.021143891
0.340489417
-0.417774929
-0.115159626
0.061247404
0.164082388
0.340489417
Break Values
%
-0.417774929
-0.115159626
0.061247404
0.164082388
0.340489417
OK
Cancel
Snap breaks to data values
Classification
Classification
Method: Manual
Classes: 3
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 361938
Minimum: -0.936892688
Maximum: 0.340489417
Sum: 3,620.896301
Mean: 0.010004189
Standard Deviation: 0.140112512
Columns: 100
Show Std. Dev.
Show Mean
25000
20000
15000
10000
5000
0
-0.936892688
-0.617547162
-0.298201636
0.021143891
0.340489417
-0.417774929
-0.115159626
0.061247404
Break Values
%
-0.417774929
-0.115159626
0.061247404
OK
Cancel
Snap breaks to data values
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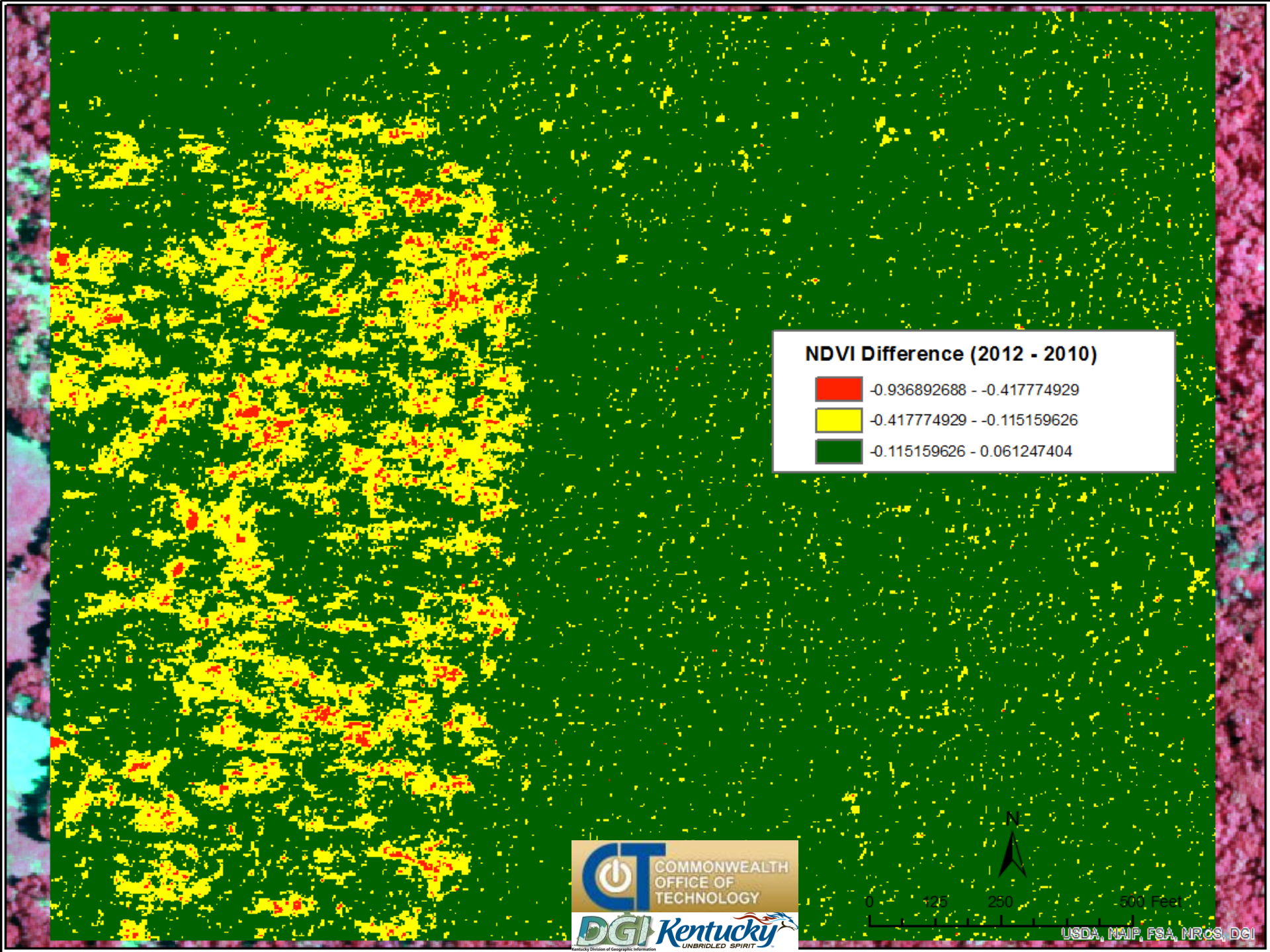
DGI Kentucky
UNBRIDLED SPIRIT


NDVI Difference (2012 - 2010)
-0.936892688 - -0.417774929
-0.417774929 - -0.115159626
-0.115159626 - 0.061247404
N
0
125
250
500 Feet
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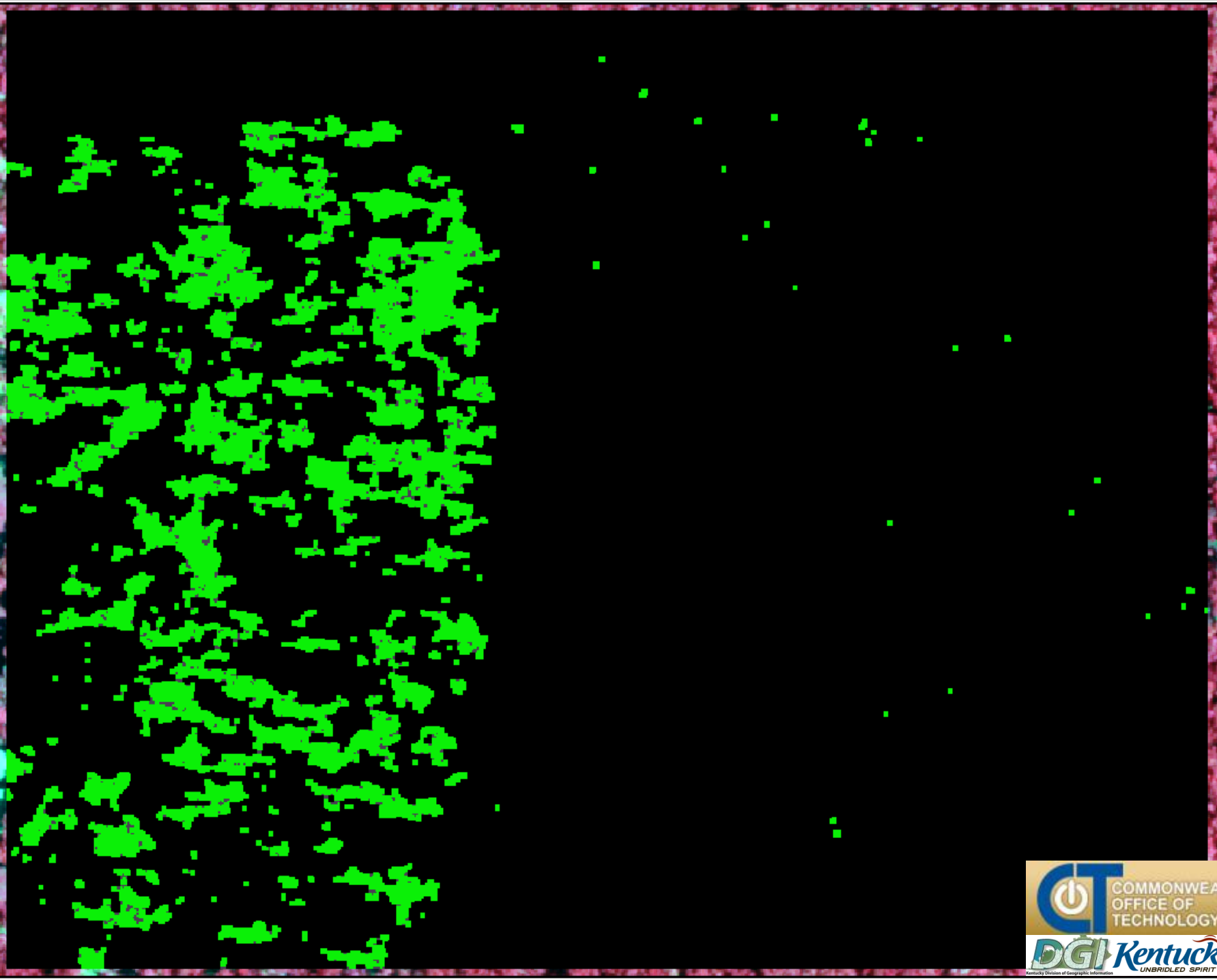
Kentucky
UNBRIDLED SPIRIT
Kentucky Division of Geographic Information
USDA, NAIP, FSA, NRCS, DGI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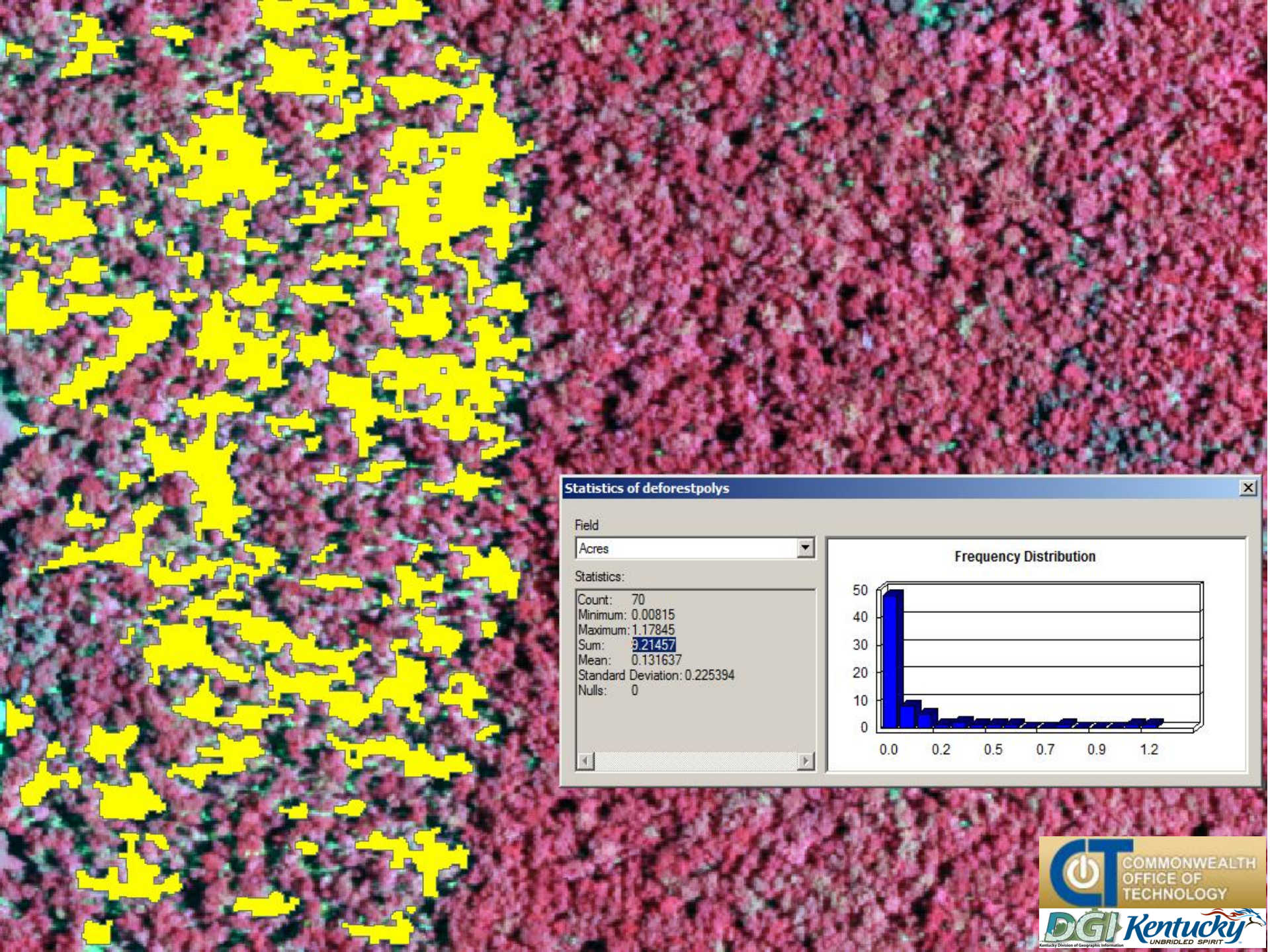
Statistics of deforestpolys
Field
Acres
Statistics:
Count: 70
Minimum: 0.00815
Maximum: 1.17845
Sum: 9.21457
Mean: 0.131637
Standard Deviation: 0.225394
Nulls: 0
Frequency Distribution
50
40
30
20
10
0
0.0
0.2
0.5
0.7
0.9
1.2
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Vegetation Change - Data Workflow Summary…

1. Image service:
   http://kyraster.ky.gov/arcgis/rest/services/ImageServices/Ky_NAIP_2012_1M/ImageServer
   http://kyraster.ky.gov/arcgis/rest/services/ImageServices/Ky_NAIP_2010_1M/ImageServer
2. Image Analysis Window
   - NDVI (settings: Red=band 1; Near IR= band 4)
   - Scientific
3. Map Algebra (raster calculator)
   - NDVI difference (time 2 – time 1)
4. Geometric interval classification
5. Binary mask (True= “significant “decrease)
6. Boundary clean (eliminate salt+pepper)
   - Descending order
   - Run twice
7. Region Group (contiguous change)
8. Filter by size (GT 31 sq. meters)
9. Convert to polygons
10. Calculate area

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Image Enhancements
(3)

Principal Components Analysis

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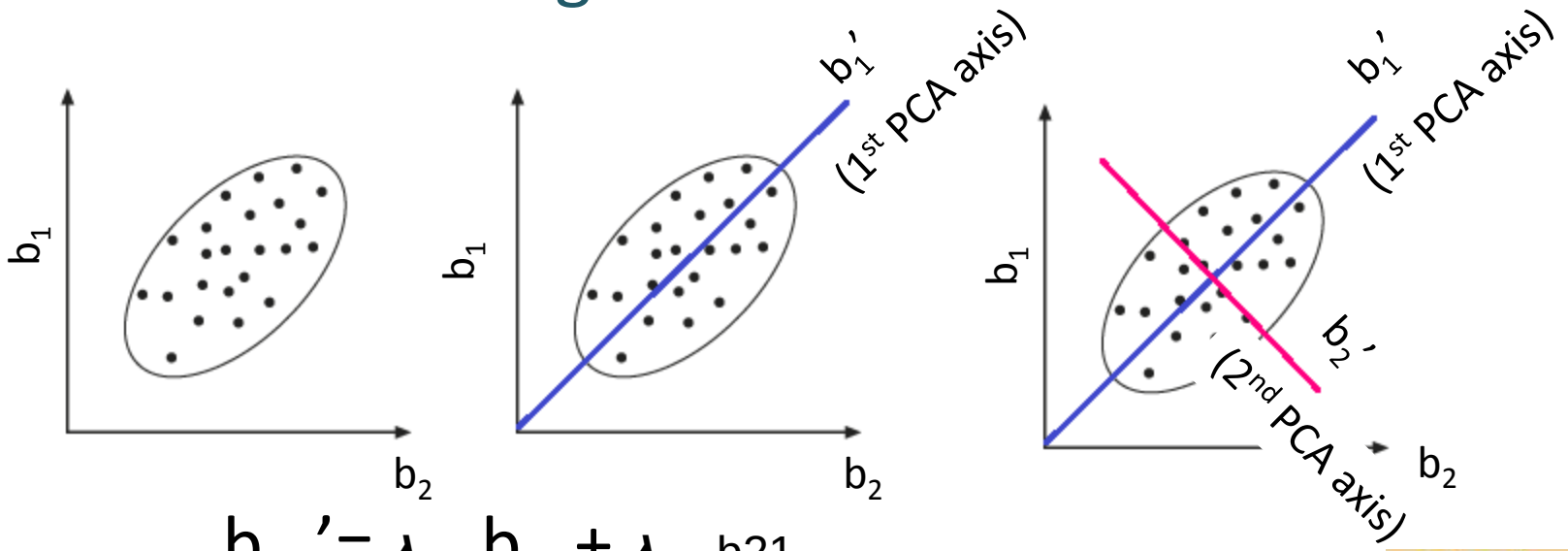
Principal Components Analysis (PCA)

A technique to reduce the dimensionality of data – retaining the most relevant portion of information in an image. Results in “false color” image.

Creates new synthetic, orthogonal bands, linear combination of original ones:



$$b_{11}' = \lambda_{11}.b_{11} + \lambda_{12}.b21$$

$$b_{21}' = \lambda_{21}.b_{11} + \lambda_{22}.b_{21}$$

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False Color Image
(First 3 of 4 PCs= RGB)
Image Classification
Classification
ImageServices\Ky_LOJIC_20
Interactive Supervised Classification
Maximum Likelihood Classification
Iso Cluster Unsupervised Classification
Class Probability
Principal Components
Principal Components
Perform principal components analysis on an input image.
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2nd PC= one band
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pca.TXT - Notepad

File Edit Format View Help

```
# Data file produced by Principal Components
#       Input raster(s):
#               C:\Users\DZOURA~1\AppData\Local\Temp\arc4F15\ImageServices/Ky_LOJIC_2012_6IN
#       The number of components = 4
#       Output raster(s):
#               C:\Users\dzourarakis\Desktop\2013_GIS_Conference\Unsup\pcasobro.img


#                   COVARIANCE MATRIX

#    Layer              1              2              3              4
#  ---------------------------------------------------------------------------
       1          1778.10982     1766.06148     1772.21461     2092.42442
       2          1766.06148     1787.59089     1784.08485     2196.58817
       3          1772.21461     1784.08485     1819.45573     2026.75937
       4          2092.42442     2196.58817     2026.75937     3904.32756
#  ===========================================================================


#                   CORRELATION MATRIX

#    Layer              1              2              3              4
#  ---------------------------------------------------------------------------
       1            1.00000        0.99059        0.98529        0.79414
       2            0.99059        1.00000        0.98926        0.83146
       3            0.98529        0.98926        1.00000        0.76043
       4            0.79414        0.83146        0.76043        1.00000
#  ===========================================================================


#                 EIGENVALUES AND EIGENVECTORS

# Number of Input Layers     Number of Principal Component Layers
             4                              4
# PC Layer              1              2              3              4
#  ---------------------------------------------------------------------------
# Eigenvalues
                   8341.09583      918.79753       24.32446        5.26620
# Eigenvectors
# Input Layer
       1            0.44354        0.36414       -0.78683       -0.22709
       2            0.45263        0.28484        0.14681        0.83213
       3            0.44171        0.44508        0.59878       -0.49826
       4            0.63505       -0.76692        0.02844       -0.08793
#  ===========================================================================

#                 PERCENT AND ACCUMULATIVE EIGENVALUES

# PC Layer    EigenValue    Percent of EigenValues    Accumulative of EigenValues
       1     8341.09583            89.7907                  89.7907
       2      918.79753             9.8907                  99.6815
       3       24.32446             0.2618                  99.9433
       4        5.26620             0.0567                 100.0000
#  ===========================================================================
```

Image Classification
(1)

Unsupervised Classification

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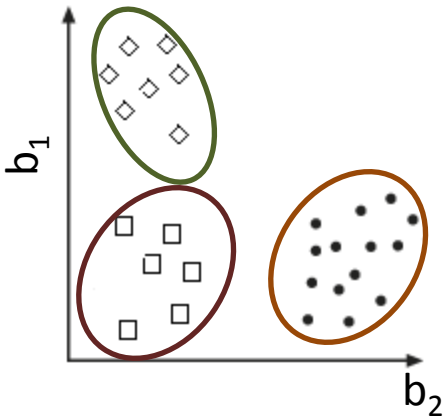
Unsupervised Classification

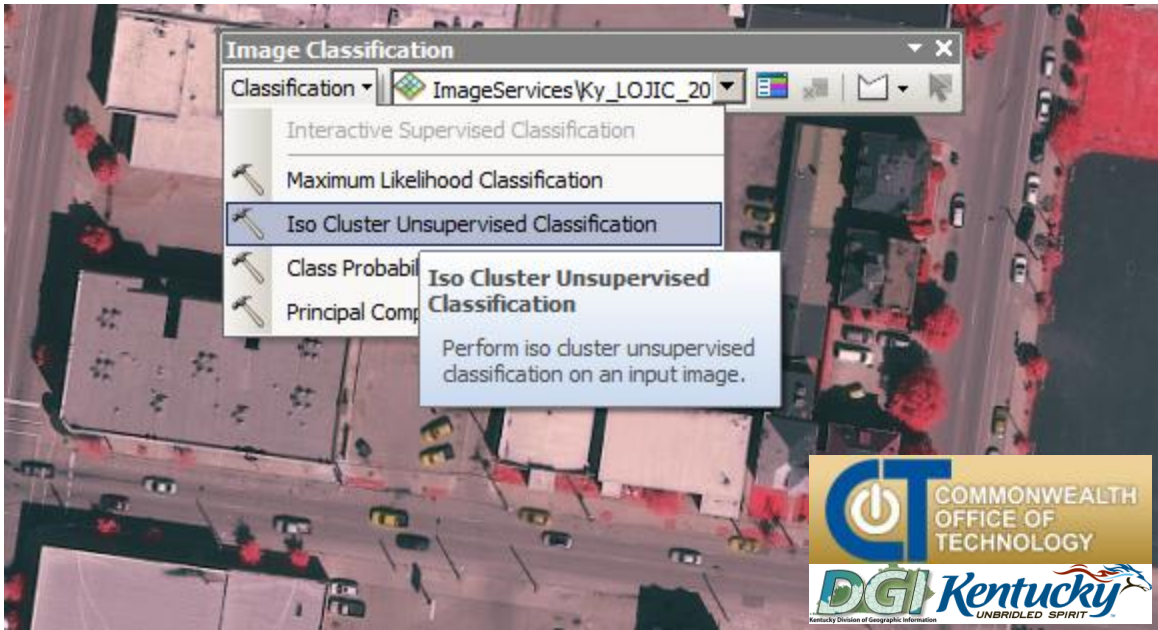
ISODATA

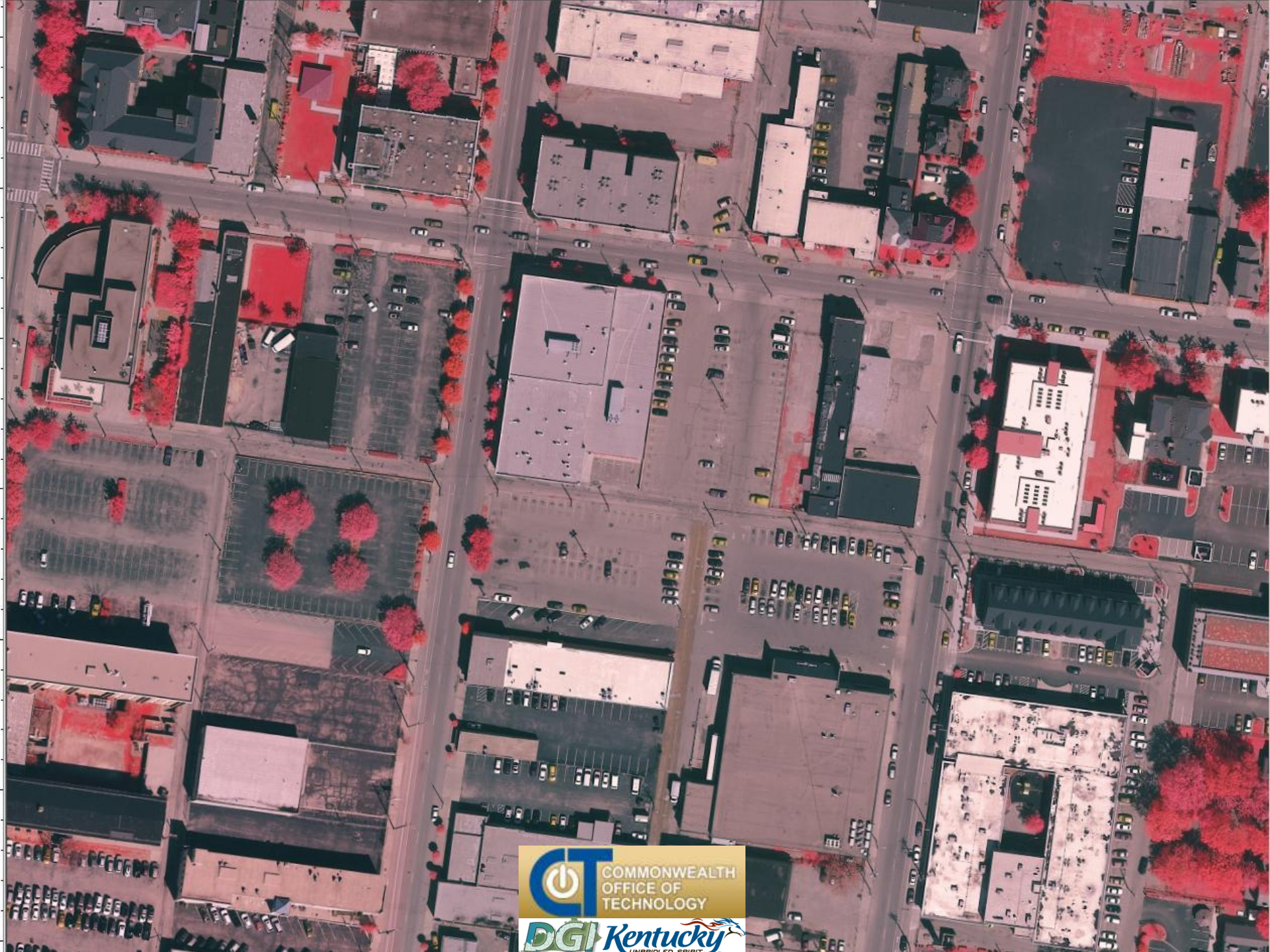
… just one method of MANY.

- "**Iterative** Self-Organizing Data analysis Techniques A"= ISODATA

- Clustering + cluster busting + cluster regrouping



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1
2
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10
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UNBRIDLED SPIRIT

sobro.gsg - Notepad

File Edit Format View Help

```
# Signatures Produced by Clustering of Raster
#               c:\users\dzoura~1\appdata\local\temp\arc4f15\imageservices/ky_lojic_2012_6in
#    number_of_classes=10  max_iterations=20  min_class_size=20
#    sampling interval=10

#    Number of selected grids
/*          4
#    Layer-Number    Band-name
/*          1       ImageServices/Ky_LOJIC_2012_6IN\Band_1
/*          2       ImageServices/Ky_LOJIC_2012_6IN\Band_2
/*          3       ImageServices/Ky_LOJIC_2012_6IN\Band_3
/*          4       ImageServices/Ky_LOJIC_2012_6IN\Band_4

#  Type   Number of Classes   Number of Layers    Number of Parametric Layers
    1            10                 4                      4
# ================================================================

#  Class ID     Number of Cells    Class Name
       1            38418
# Layers             1             2             3             4
# Means
                  41.62666      44.05776      43.42787      26.66891
# Covariance
    1             85.57769      86.83279      87.46175      59.77776
    2             86.83279      95.00468      98.50880      64.39974
    3             87.46175      98.50880     111.79656      59.12618
    4             59.77776      64.39974      59.12618     114.17863
# ----------------------------------------------------------------

#  Class ID     Number of Cells    Class Name
       2            24381
# Layers             1             2             3             4
# Means
                  62.93700      67.36955      66.10381      58.21008
# Covariance
    1             73.08906      70.70503      73.41807      -0.28266
    2             70.70503      80.52758      87.56188      -2.73252
    3             73.41807      87.56188     111.98820     -20.46233
    4             -0.28266      -2.73252     -20.46233     170.65529
# ----------------------------------------------------------------

#  Class ID     Number of Cells    Class Name
       3            23772
# Layers             1             2             3             4
# Means
                  82.29493      87.35782      85.79762      85.91397
# Covariance
    1             41.96573      36.99623      34.56707      37.59131
    2             36.99623      45.64976      49.04907      27.44528
    3             34.56707      49.04907      69.19479       6.32658
    4             37.59131      27.44528       6.32658     159.91953
# ----------------------------------------------------------------

#  Class ID     Number of Cells    Class Name
       4            30253
# Layers             1             2             3             4
# Means
                 101.01567     105.76095     101.96969     126.10290
```

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Image Classification
(2)

Supervised Classification

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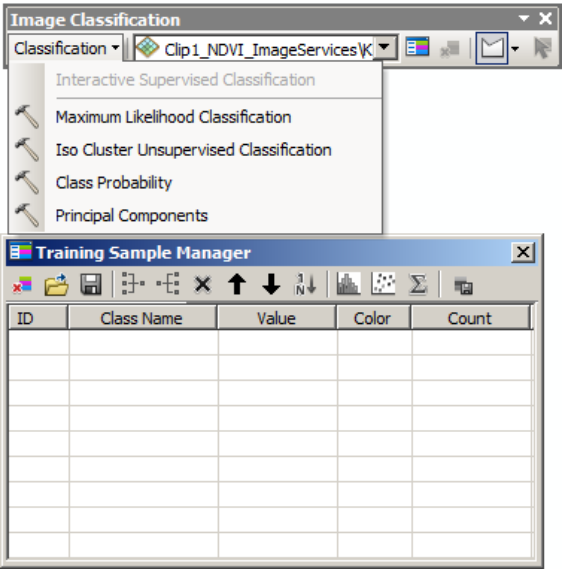
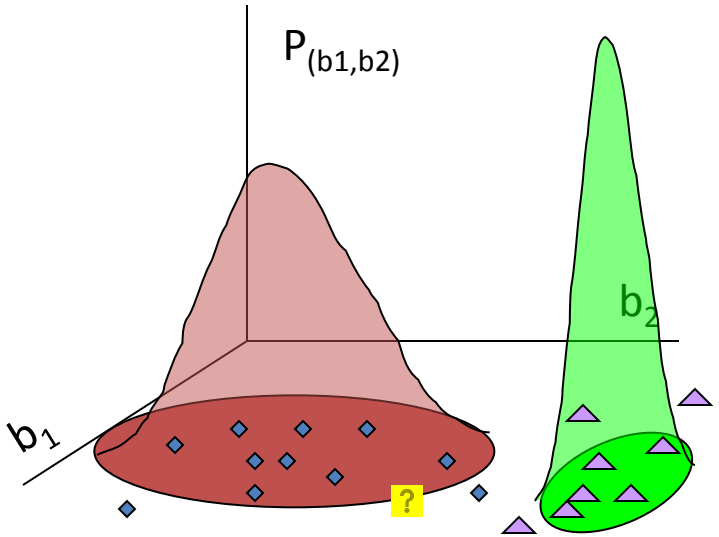
Supervised (Interactive) Classification

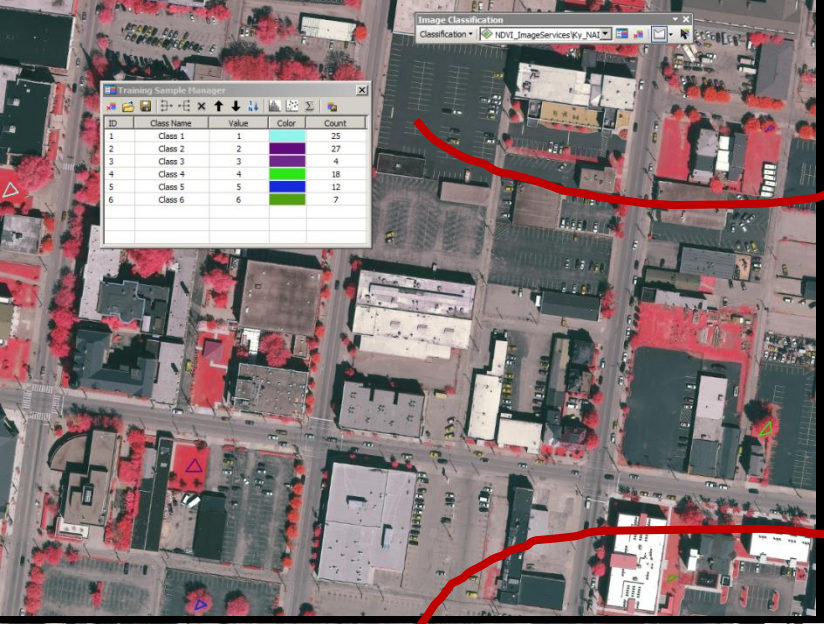
Maximum Likelihood Classifier

… just another classifier of MANY.

A parametric method – based on the assumption of normal distribution of the data, etc. Generates probability distributions for the populations as inferred from samples.

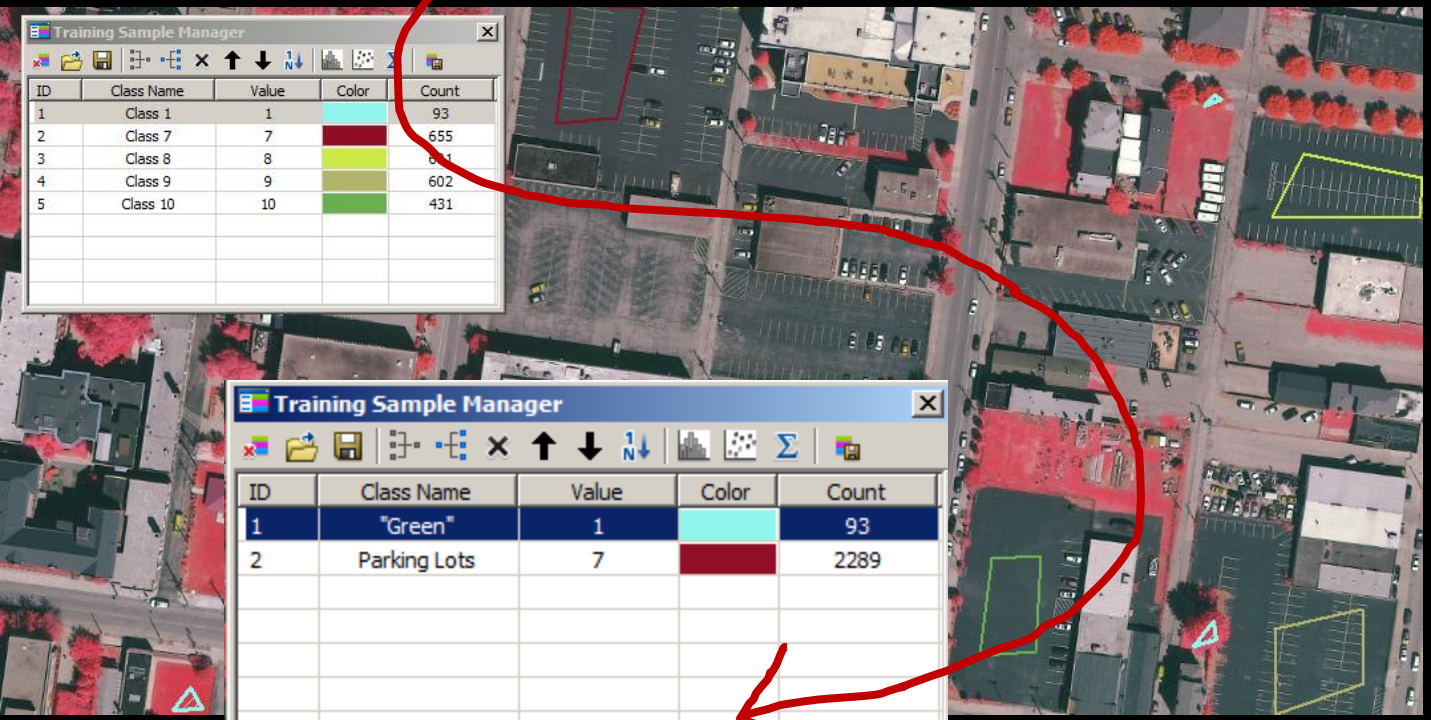






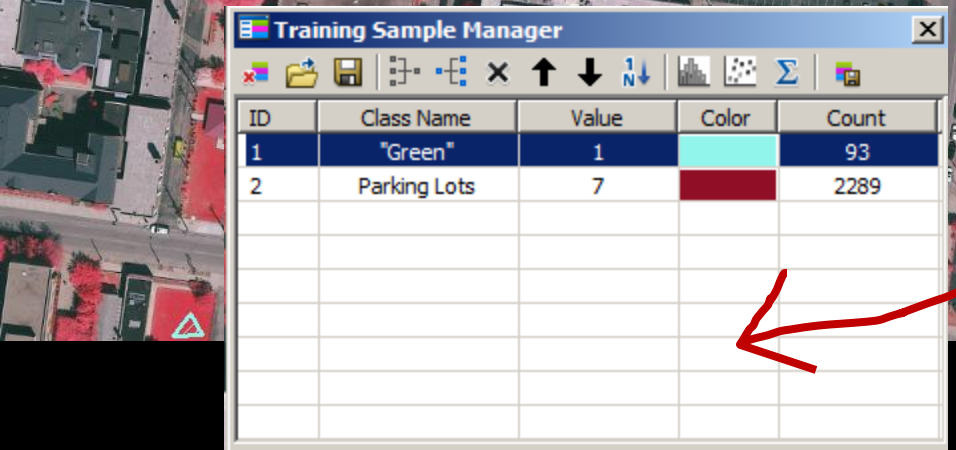
Training Sample Manager

ID	Class Name	Value	Color	Count
1	Class 1	1		25
2	Class 2	2		27
3	Class 3	3		4
4	Class 4	4		18
5	Class 5	5		12
6	Class 6	6		7



Training Sample Manager

ID	Class Name	Value	Color	Count
1	Class 1	1		93
2	Class 7	7		655
3	Class 8	8		6[illegible]
4	Class 9	9		602
5	Class 10	10		431



Training Sample Manager

ID	Class Name	Value	Color	Count
1	"Green"	1		93
2	Parking Lots	7		2289

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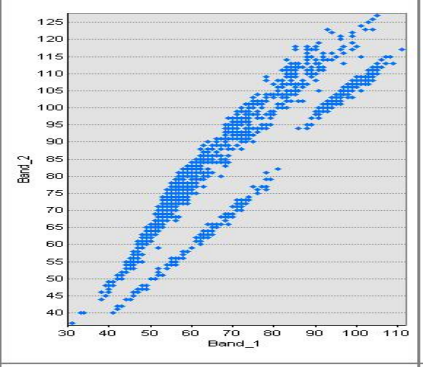
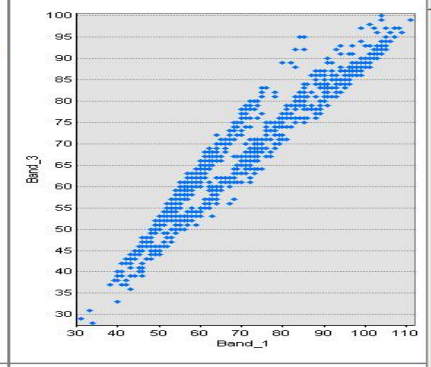
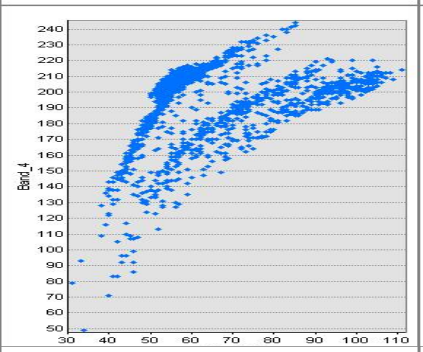
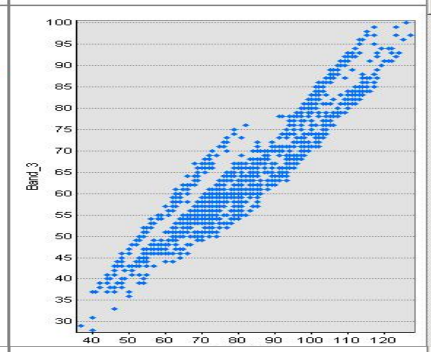
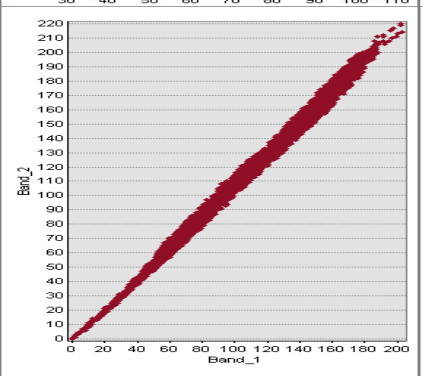
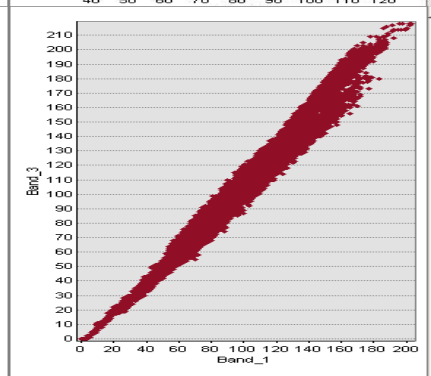


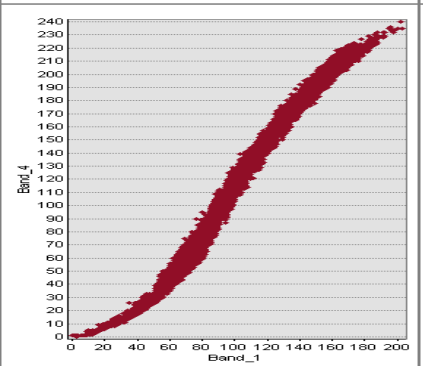


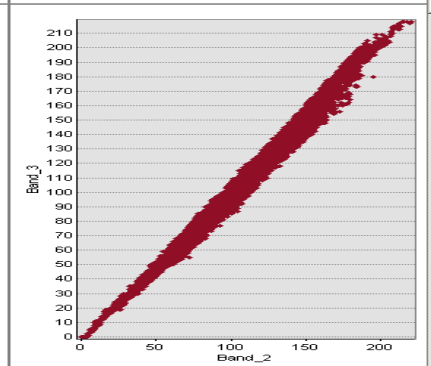










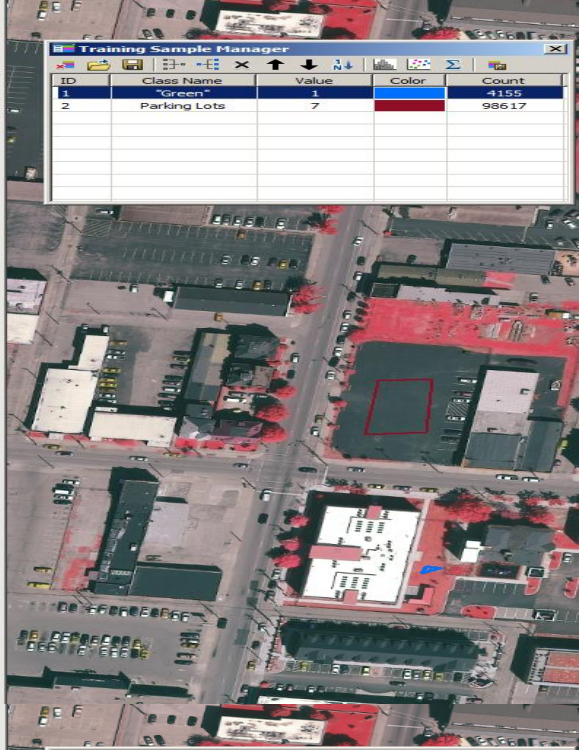


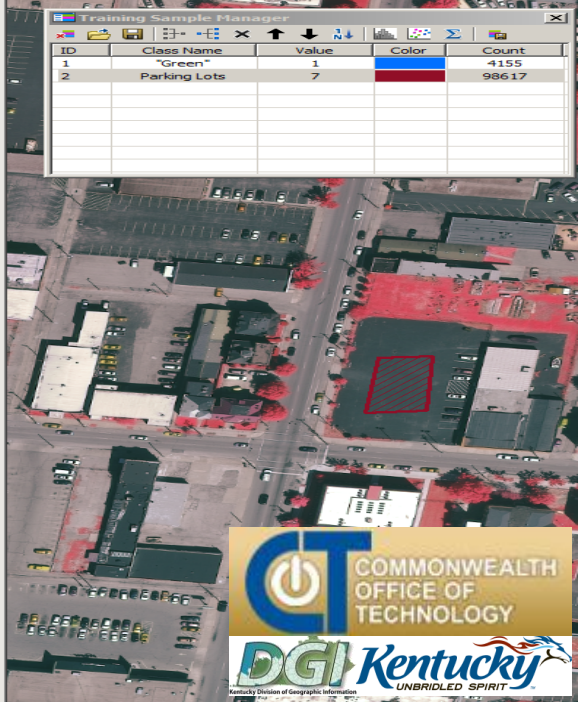
"Green"

Statistics	Band_1	Band_2	Band
Minimum	31.00	37.00	28.
Maximum	111.00	127.00	100.
Mean	61.32	76.59	61.
Std.dev	14.10	15.04	11.
Covariance			
Band_1	198.74	196.11	151.
Band_2	196.11	226.12	159.
Band_3	151.00	159.75	124.
Band_4	61.76	108.62	100.

Parking ...

Statistics	Band_1	Band_2	Band
Minimum	0.00	0.00	0.
Maximum	203.00	220.00	218.
Mean	74.00	79.53	79.
Std.dev	18.10	19.43	20.
Covariance			
Band_1	327.62	350.03	356.
Band_2	350.03	377.41	387.
Band_3	356.24	387.02	405.
Band_4	519.63	556.60	563.





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Training Sample Manager
ID
Class Name
Value
Color
Count
1
"Green"
1
4155
2
Parking Lots
7
98617
3
Rest
11
83425
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Automated Workflow

1. Model Builder (Tools)
2. Function Chains

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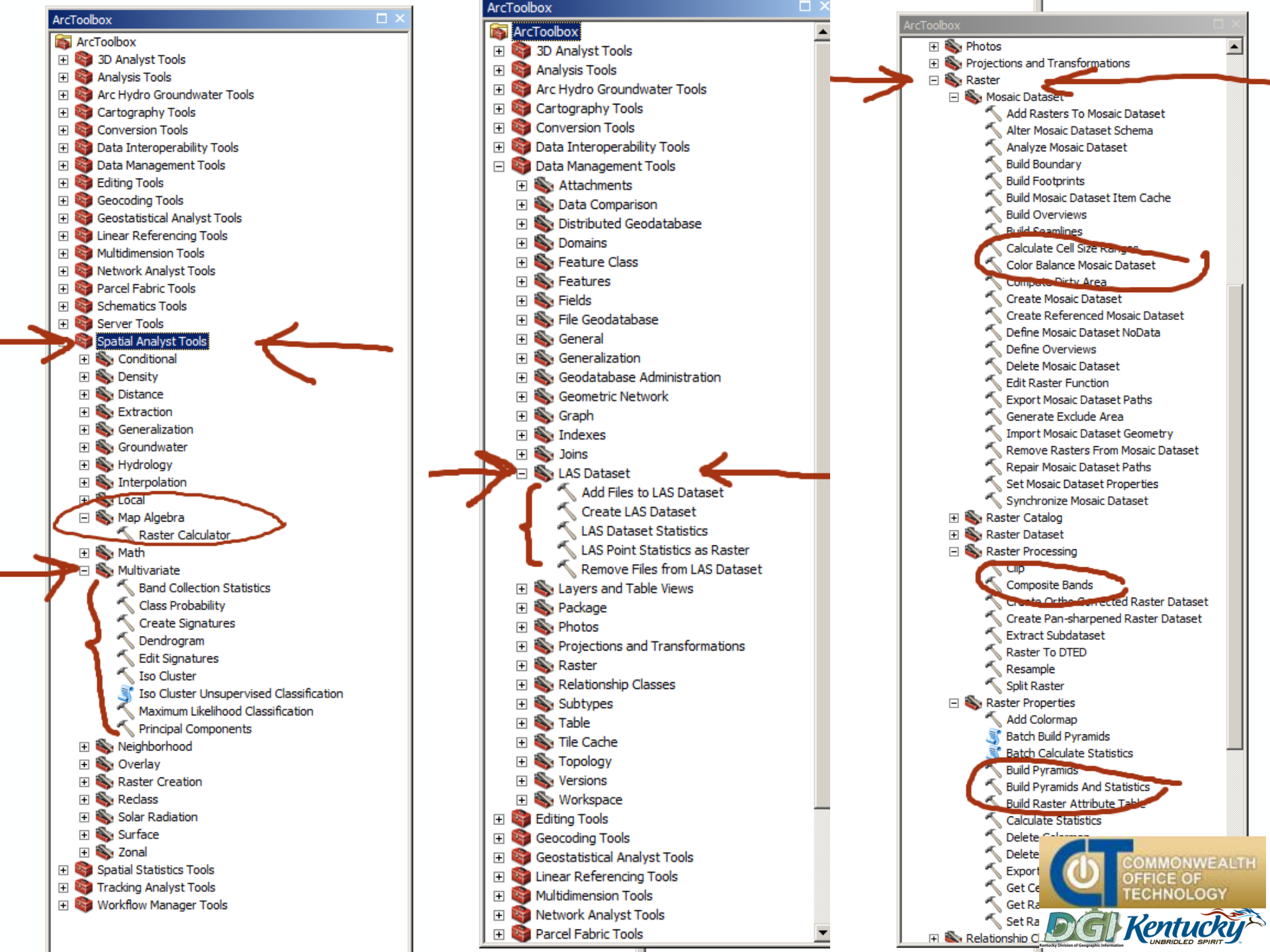
ArcToolbox
ArcToolbox
3D Analyst Tools
Analysis Tools
Arc Hydro Groundwater Tools
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Editing Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Parcel Fabric Tools
Schematics Tools
Server Tools
Spatial Analyst Tools
Conditional
Density
Distance
Extraction
Generalization
Groundwater
Hydrology
Interpolation
Local
Map Algebra
Raster Calculator
Math
Multivariate
Band Collection Statistics
Class Probability
Create Signatures
Dendrogram
Edit Signatures
Iso Cluster
Iso Cluster Unsupervised Classification
Maximum Likelihood Classification
Principal Components
Neighborhood
Overlay
Raster Creation
Reclass
Solar Radiation
Surface
Zonal
Spatial Statistics Tools
Tracking Analyst Tools
Workflow Manager Tools
ArcToolbox
ArcToolbox
3D Analyst Tools
Analysis Tools
Arc Hydro Groundwater Tools
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Attachments
Data Comparison
Distributed Geodatabase
Domains
Feature Class
Features
Fields
File Geodatabase
General
Generalization
Geodatabase Administration
Geometric Network
Graph
Indexes
Joins
LAS Dataset
Add Files to LAS Dataset
Create LAS Dataset
LAS Dataset Statistics
LAS Point Statistics as Raster
Remove Files from LAS Dataset
Layers and Table Views
Package
Photos
Projections and Transformations
Raster
Relationship Classes
Subtypes
Table
Tile Cache
Topology
Versions
Workspace
Editing Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Parcel Fabric Tools
ArcToolbox
Photos
Projections and Transformations
Raster
Mosaic Dataset
Add Rasters To Mosaic Dataset
Alter Mosaic Dataset Schema
Analyze Mosaic Dataset
Build Boundary
Build Footprints
Build Mosaic Dataset Item Cache
Build Overviews
Calculate Cell Size
Color Balance Mosaic Dataset
Create Mosaic Dataset
Create Referenced Mosaic Dataset
Define Mosaic Dataset NoData
Define Overviews
Delete Mosaic Dataset
Edit Raster Function
Export Mosaic Dataset Paths
Generate Exclude Area
Import Mosaic Dataset Geometry
Remove Rasters From Mosaic Dataset
Repair Mosaic Dataset Paths
Set Mosaic Dataset Properties
Synchronize Mosaic Dataset
Raster Catalog
Raster Dataset
Raster Processing
Clip
Composite Bands
Create Pan-sharpened Raster Dataset
Extract Subdataset
Raster To DTED
Resample
Split Raster
Raster Properties
Add Colormap
Batch Build Pyramids
Batch Calculate Statistics
Build Pyramids
Build Pyramids And Statistics
Calculate Statistics
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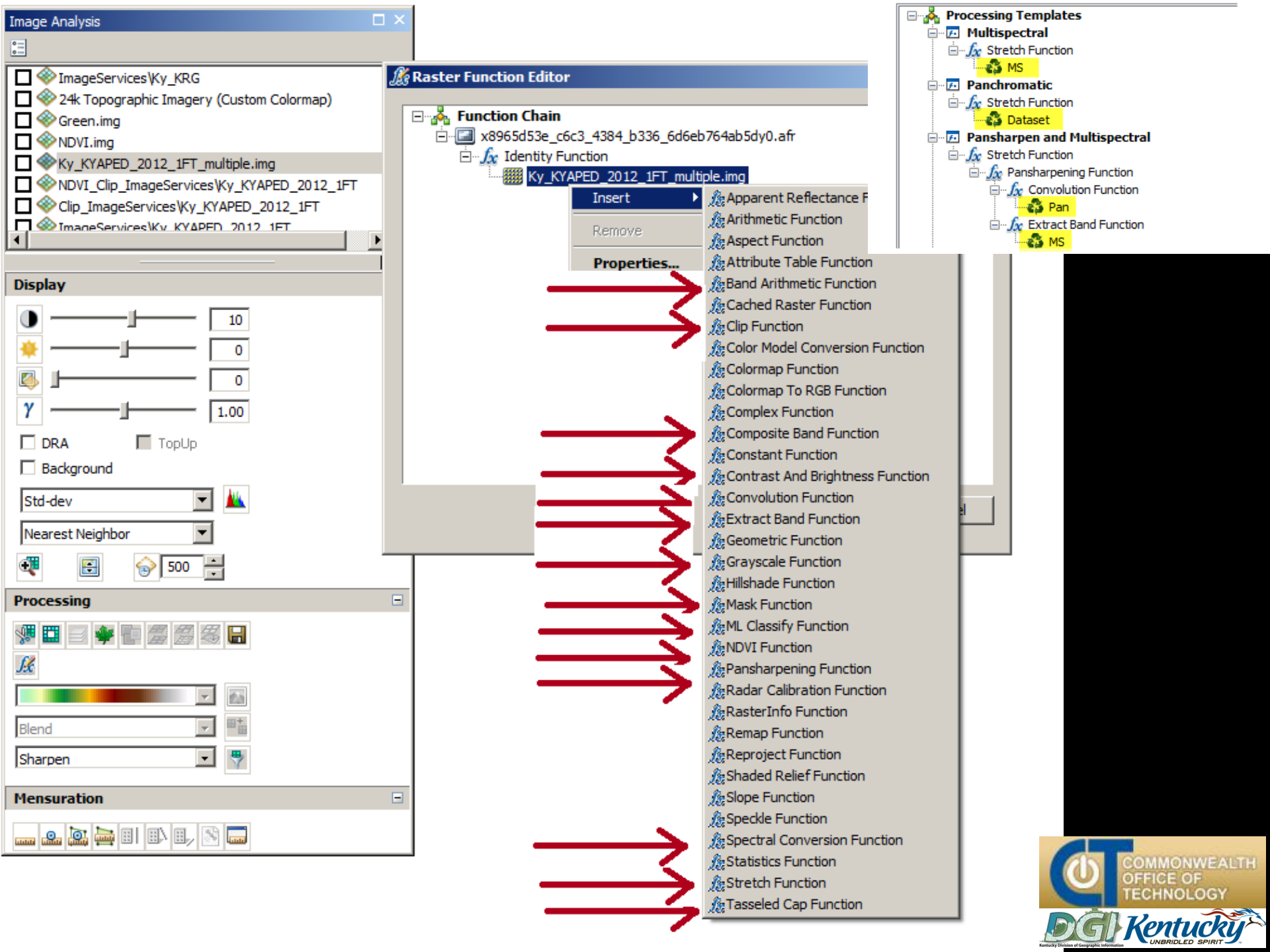
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24k Topographic Imagery (Custom Colormap)
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NDVI.img
Ky_KYAPED_2012_1FT_multiple.img
NDVI_Clip_ImageServices\Ky_KYAPED_2012_1FT
Clip_ImageServices\Ky_KYAPED_2012_1FT
Display
10
0
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DRA
TopUp
Background
Std-dev
Nearest Neighbor
500
Processing
Blend
Sharpen
Mensuration
Raster Function Editor
Function Chain
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Identity Function
Ky_KYAPED_2012_1FT_multiple.img
Insert
Remove
Properties...
Apparent Reflectance F
Arithmetic Function
Aspect Function
Attribute Table Function
Band Arithmetic Function
Cached Raster Function
Clip Function
Color Model Conversion Function
Colormap Function
Colormap To RGB Function
Complex Function
Composite Band Function
Constant Function
Contrast And Brightness Function
Convolution Function
Extract Band Function
Geometric Function
Grayscale Function
Hillshade Function
Mask Function
ML Classify Function
NDVI Function
Pansharpening Function
Radar Calibration Function
RasterInfo Function
Remap Function
Reproject Function
Shaded Relief Function
Slope Function
Speckle Function
Spectral Conversion Function
Statistics Function
Stretch Function
Tasseled Cap Function
Processing Templates
Multispectral
Stretch Function
MS
Panchromatic
Stretch Function
Dataset
Pansharpen and Multispectral
Stretch Function
Pansharpening Function
Convolution Function
Pan
Extract Band Function
MS
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Resources

- Kentucky Division of Geographic Information (http://gis.ky.gov)
- Kentucky Geography Network (KYGEONET) (http://kygeonet.ky.gov)
- Kentucky Geoportal (http://kygisserver.ky.gov/geoportal/catalog/main/home.page)
- Kentucky Aerial Photography and Elevation Data Program (http://kygeonet.ky.gov/kyfromabove/)

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Additional **Resources**

Imagery/LiDAR Provisioning Services

- USGS Earth Explorer: http://earthexplorer.usgs.gov/
- USGS Click site: http://lidar.cr.usgs.gov/
- GLOVIS: http://glovis.usgs.gov/
- NASA'sReverb|ECHO: http://reverb.echo.nasa.gov

Deprecated !

- Clark County GIS LiDAR:
- http://www.ccgisonline.com/clarkcountygisservices/lidar.html

New!

- Martin Isenberg LASZIP: http://www.laszip.org/

Contact Information

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demetrio.zourarakis@ky.gov

502-564-6246

http://gis.ky.gov

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