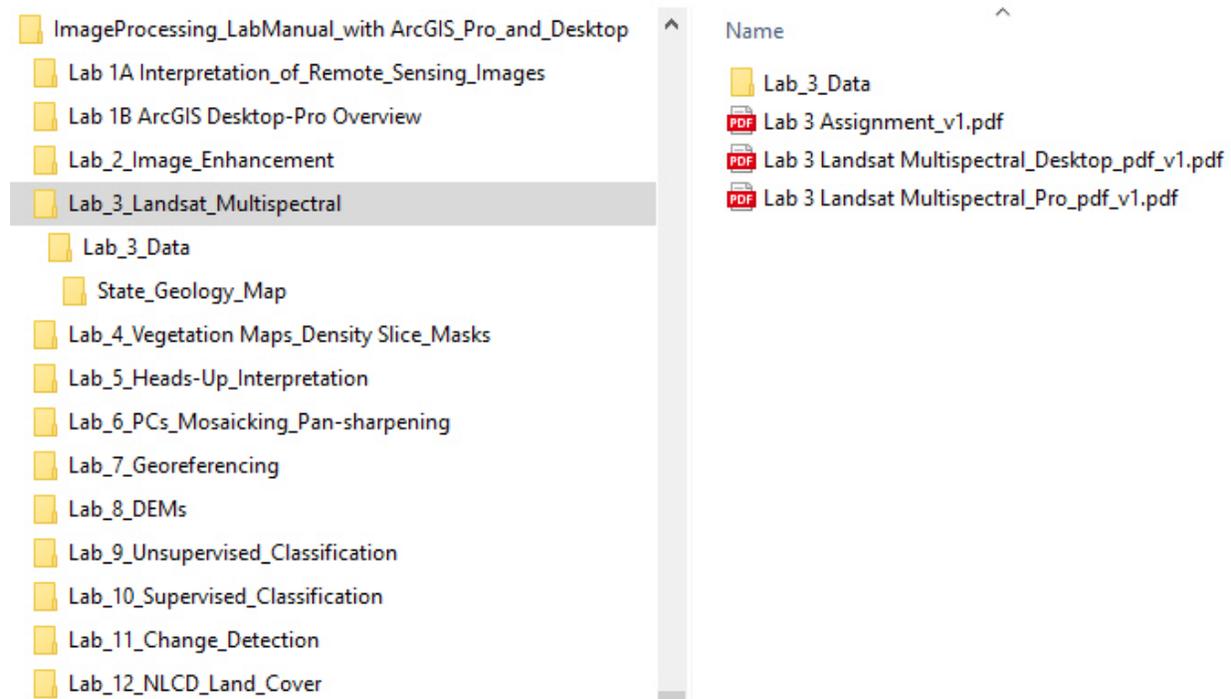


Image Processing for ArcGIS Pro and Desktop Labs 1 – 12

Student Material Overview

The directory structure for the student's Image Processing with ArcGIS Pro and Desktop folder is shown below. Each lab folder contains the Pro and Desktop handout as a pdf, the assignment sheet as a pdf, and the lab data.

The student chooses the Pro or Desktop version of the lab exercise depending on the software they are using. The labs average 18 pages each.



The lab data folders often contain metadata in .pdf, .txt, and .xml formats for imagery and maps used in the labs. The metadata is easily accessed and displayed with Windows and Mac directory software.

Questions and uploads are shown in context (with the topic of interest in the lab exercise), as a list at the end of the lab handout, and as a separate “Lab X Assignment_v1.pdf” (see above).

The introduction page of each lab specifies specific chapters, discussions, figures and plates in the textbook that are relevant to understanding the principles and image processing techniques involved in the lab exercise. In addition, the introduction page contains a list of image processing and GIS tasks included in the lab and some background material. The instructor can decide what tasks are to be included in a lab to fit course objectives and time limitations. The introduction page of each lab follows:

Lab 1A. Interpretation of Remote Sensing Images

This lab utilizes select Textbook's Plates and Figures with additional data in the Remote Sensing Digital Database: *Chapters 2, 3, and 4 data*.

The objective of this lab is to learn what properties or elements seen on images enable you to interpret features, and how important your experience is for interpreting.

Twenty-five (25) examples have questions on the Assignment handout. You are to write your answer on the sheet that is at the end of this handout. Several of the questions are only on the Assignment sheets or only on this handout under the image. *Add your name to the top of the Assignment handout.*

Properties or elements of image interpretation (see Jensen, 2007, Figure 1-15) include the following:

- Grayscale tone (black to white)
- Color
- Height and Depth
- Size (length, area, perimeter, volume)
- Shape
- Texture
- Pattern
- Shadow
- Site
- Association
- Arrangement

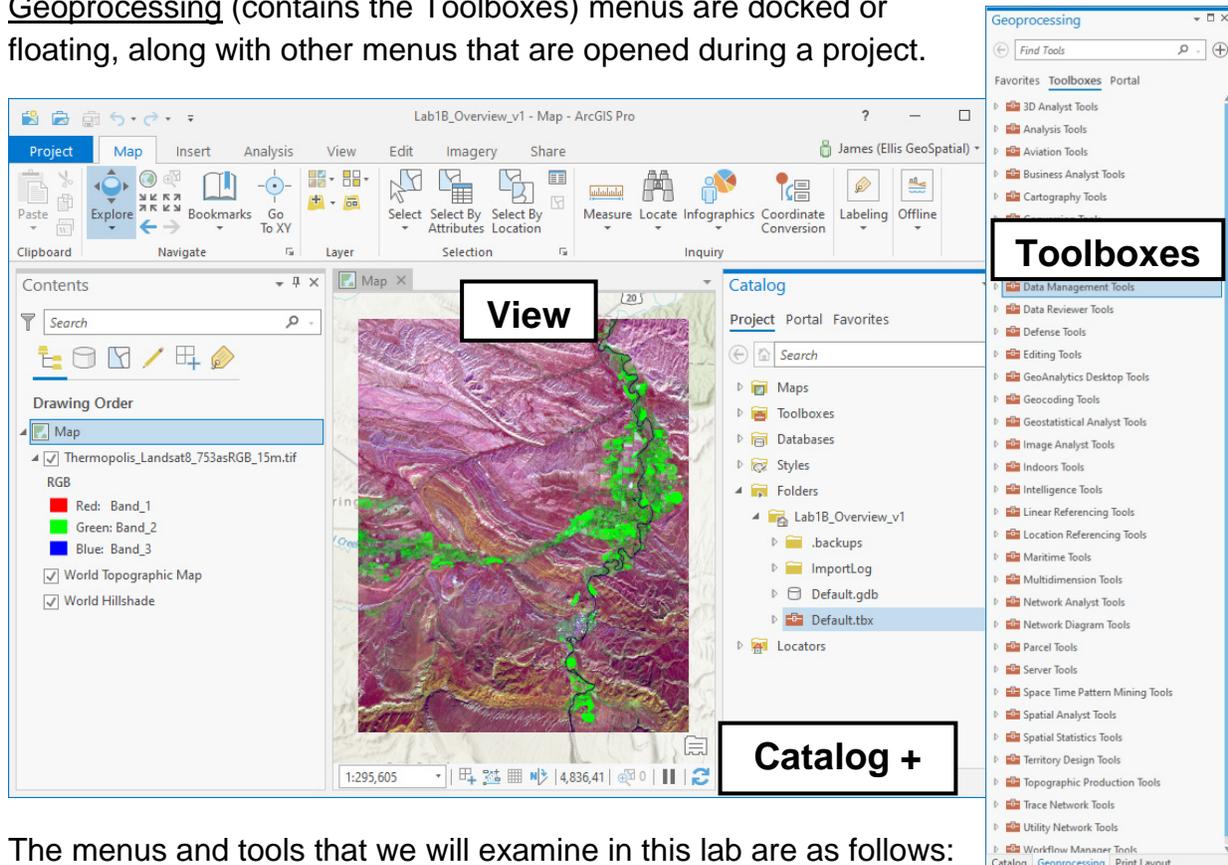
The interpreter's experience, previous observation(s) and ability to infer the identity of features based on deductive reasoning (*apiori* knowledge) are essential for enabling correct interpretations. For example, interpreters who grew up in the suburbs of the USA know that large elliptical features in backyards that have a white border and light blue interior on color aerial images are probably built-in pools. Interpreters who grew up in the sub Sahara Africa would not readily identify these features.

The following are aerial and satellite images. Discuss with the instructor which of the elements listed above were key for you interpreting the feature of interest. Think about how important the extent of your experience is with the feature being interpreted. Several examples will prove difficult to interpret – and that is OK!!

North is toward the top of the page.

Lab 1B Overview of ArcGIS Pro Software

The objective of this lab is to understand the structure and locations of basic image processing tools within ArcGIS Pro. A ribbon across the top has tabs that open numerous menus and tools depending on the type of layer selected in the Contents pane. The View is centered, with the Contents docked on the left. The Catalog and Geoprocessing (contains the Toolboxes) menus are docked or floating, along with other menus that are opened during a project.

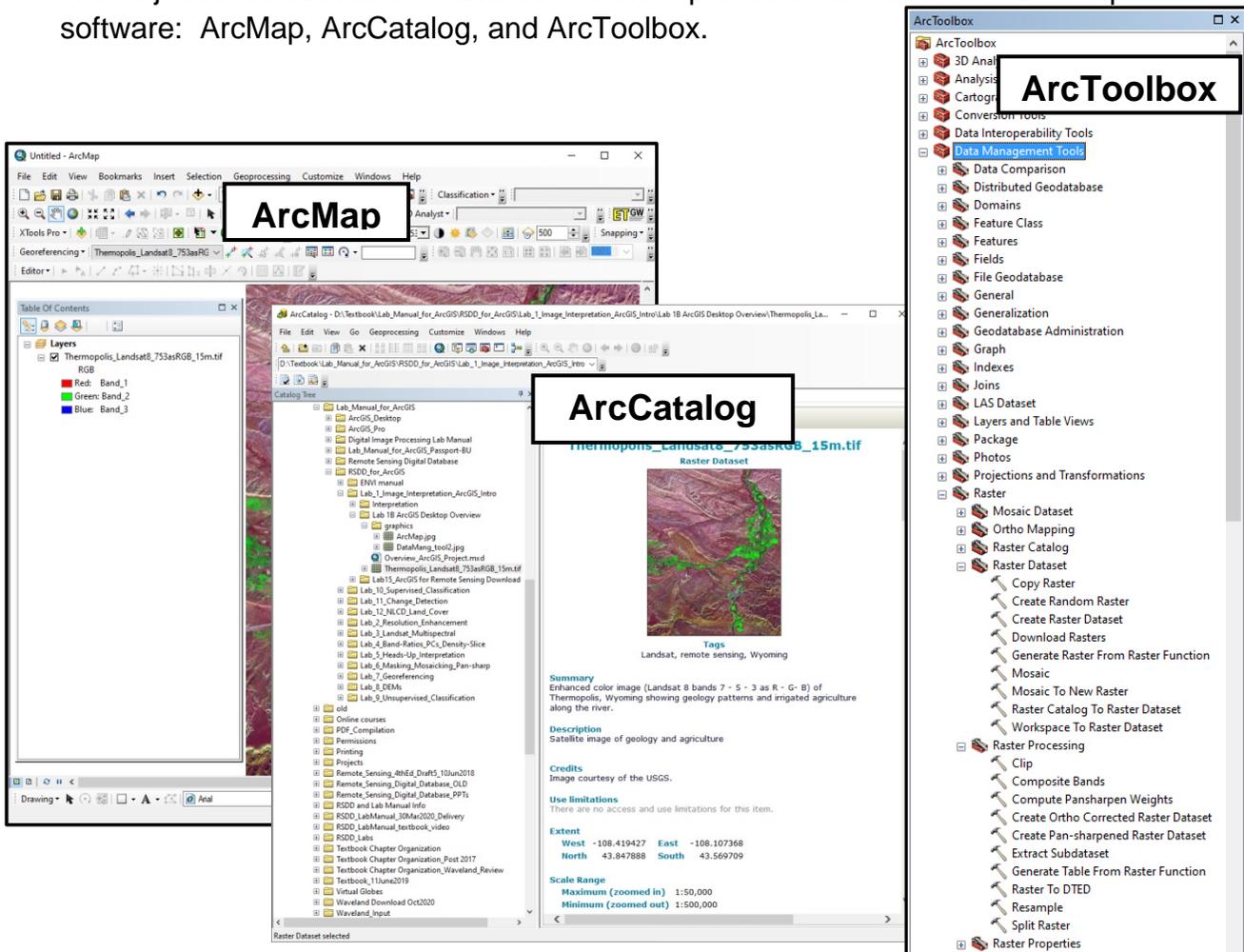


The menus and tools that we will examine in this lab are as follows:

- 1) Raster Layer Properties Menus
- 2) ArcGIS Pro Options
- 3) Exploring the ArcGIS Pro Ribbon (Menus and Tools)
- 4) Toolboxes > Conversion Tools > From Raster
- 5) Toolboxes > Data Management Tools > Projections and Transformations > Raster
- 6) Toolboxes > Data Management Tools > Raster
- 7) Toolboxes > Spatial Analyst (Required for this lab manual)
- 8) Toolboxes > 3D Analyst (Optional for Lab 8 DEMs)

Lab 1B. Overview of ArcGIS Desktop Software

The objective of this lab is to understand the 3-part structure of ArcGIS Desktop software: ArcMap, ArcCatalog, and ArcToolbox.



ArcMap displays the image, shows the Table of Contents, and provides a ribbon across the top and bottom for easy access to many tool bars.

ArcCatalog shows the directory and location of files in the database, displays metadata, and provides some basic tools (Export, Share as Image Service, Properties, etc.). The full ArcCatalog is accessed with a Desktop shortcut or program search and the less complete catalog is displayed with: *click-on* "Windows" tab > *click-on* "catalog"

ArcToolbox list the many GIS and several image-processing tools. The ArcToolbox is displayed as follows: *click-on* "Geoprocessing" tab > *click-on* "ArcToolbox"

We are interested in the types and location(s) of ArcGIS Desktop's image-processing tools. The tools are distributed and often duplicated with varying functionality across ArcMap, ArcCatalog, and ArcToolbox. Be patient while learning where tools are located and what each one does (capabilities and limitations).

Lab 2 Image Enhancement and Plotting

This lab utilizes images discussed and shown in the Textbook's Plate 5 and Figure 2-27. Larger files are available in the Textbook's Remote Sensing Digital Database's Chapter 2. Image bands and color composite images are discussed in the Textbook's Chapter 2 (pages 47 – 51) and contrast-stretching methods are discussed in Chapter 9 (pages 254 – 257).

The objectives of this lab are to evaluate image bands generated with reflected light at specific wavelengths, create enhanced color composites, and generate a GIS plot with scale bar and North arrow. Topics that will be covered include:

- 1) Loading an image into ArcMap
- 2) Metadata
- 3) Calculate image statistics
- 4) Evaluating individual bands and color composite images
- 5) Contrast stretching (enhancement)
- 6) Save your enhanced image as a GIS-ready file
- 7) Create a map with scale and north arrow

Five (5) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. One (1) image jpg is to be uploaded to the instructor.

Lab 3 Landsat Multispectral Imagery

Textbook Chapter 3 discusses the Landsat satellite system. Landsat is representative of multispectral sensors that collect multiple grayscale images (“bands”). Each band records a different wavelength range of reflected light. This lab utilizes images discussed and shown in the Textbook’s Plate 7 and Figures 3-2, 3-10, 3-11, and Tables 3-2 and 3-4. More files are available in the Textbook’s Remote Sensing Digital Database’s Chapter 3.

A discussion of the edge enhancement methods is available in Chapter 9 *Digital Image Processing* (pages 257 – 261).

The objective of this lab is to understand the remarkable multispectral Landsat data, create informative color composites, analyze the different color composites, and use some new tools. Topics that will be covered include:

- 1) Create a multispectral dataset from individual bands
- 2) Create different color composites
- 3) Measuring tools
- 4) Edge enhancement tool

Nine (9) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout.

There is one (1) exported jpg to upload to the instructor.

Lab 4 Vegetation Maps, Density Slice, and Masks

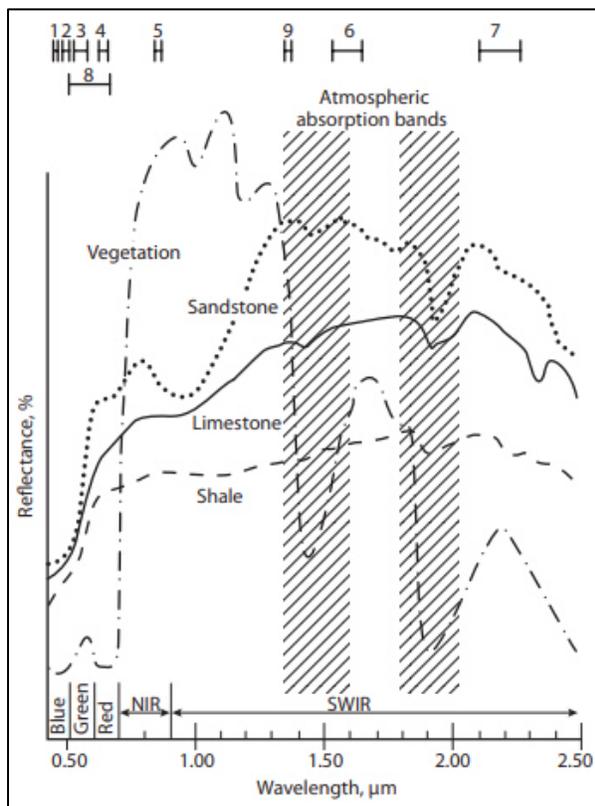
The textbook's Chapter 9 discusses these image processing tasks. This lab utilizes images described and shown in the Textbook's Plate 27A and B, and Figures 9-27 and 9-37. More files are available in the Textbook's Remote Sensing Digital Database's Chapter 3.

The objectives of this lab are to use ArcGIS's image enhancement tools to:

- 1) Divide two bands to create simple band ratios (S/R, iron oxide, clay minerals),
- 2) Generate the *Normalized Difference Vegetation Index* (NDVI) band ratio,
- 3) Generate and symbolize a density slice and mask,
- 4) Overlay a raster mask onto another GIS layer,
- 5) Generate a raster thematic map from a raster image,
- 6) Generate a vector polygon map from the thematic raster map

Six (6) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. There are two (2) exported files to upload to the instructor.

We will use the same Landsat 8 subscene from Thermopolis, Wyoming that was used in Lab 3, except this lab's version has been atmospherically corrected (minimizing the effects of haze, clouds, and changes in solar illumination due to time of year).



See Textbook Figure 3-2 for the Landsat 4, 5, and 7 TM bands.

The Landsat 8 Optical Line Imagery (OLI) sensor collects many bands (see band numbers across the top of the figure).

Each Landsat 8 band collects reflected light within a specific wavelength range:

- Band 2 blue
- Band 3 green
- Band 4 red
- Band 5 near IR
- Band 6 SWIR1
- Band 7 SWIR2

Lab 5 Heads-Up Interpretation

This lab utilizes a subscene from an aerial orthoimage image shown in the Textbook's Figure 7-15.

In addition, a discussion of heads-up digitizing is available in Chapter 10, page 296.

The objective of this lab is to interpret features on an image and to use ArcGIS's Editor toolbar, digitizing tools, and the shapefile's attribute table to build a new informative GIS vector map with points, lines, and polygons. The lab has five sections:

- 1) Build a new blank shapefile.
- 2) Choose Fields (categories) and Attributes for the shapefile's Attribute Table.
- 3) Add Fields (categories) and Attributes to the shapefile's Attribute Table.
- 4) Digitizing Lines (*shapefile created in steps 1 – 3*).
- 5) Digitizing Points and Polygons (*formatted shapefiles provided*).

Three (3) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. Two (2) file is to be uploaded to the instructor.

Lab 6 Principal Components (PCs), Mosaicking, and Pan-sharpening

The textbook's Chapter 9 discusses these image processing tasks. This lab utilizes images described and shown in the Textbook's Plates 27A and B and Figures 9-23A-F for Principal Components, and Figure 4-9 for pan-sharpening. More files are available in the Textbook's Remote Sensing Digital Database's Chapters 3, 4, and 9.

The objectives of this lab are to use ArcGIS's image enhancement tools for the following:

- 1) Generate PCs that often show subtle spectral patterns in features of interest,
- 2) mosaic two overlapping images,
- 3) sharpen a multispectral image with the panchromatic band.

Fourteen (14) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. There are two (2) files to upload to the instructor.

We will use the Landsat 8 scene of Wyoming (see Labs 2 and 3) for the Principal Components, two overlapping drone images from a mine in Missouri for the mosaicking, and a spatially high-resolution satellite image of Tokyo for the pan-sharpening exercise.

Lab 7 Georeferencing

The textbook's Chapter 9 discusses georeferencing. This lab utilizes portions of the images shown Plates 4 and 25 and Figures 1-5, 1-9, and 2-20.

The objectives of this lab are to use ArcGIS's image processing tools for the following:

- 1) Image-to-Image georeferencing
- 2) Image-to-Map georeferencing

There are two (2) files to upload to the instructor. Four (4) optional questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout.

We will use aerial photographs and maps of industrialized land with wetlands in central California. 1) The first exercise will use a 1959 scanned aerial photograph and a 2000 orthorectified aerial photograph. 2) The second exercise will use a scanned topographic map with embedded coordinate values. 3) An optional third exercise involves georeferencing an 1800 interpreted wetlands map so you can compare and better understand development and environmental changes over two centuries.

Lab 8 DEMs

Chapter 7 discusses the technology and processes in this lab. This lab utilizes images discussed and shown in the Textbook's Plate 21 and 22 and Figures 3-15 and 7-16 to 7-23. Larger files are available in the Textbook's Remote Sensing Digital Database's Chapters 3 and 7. A Space Shuttle DEM of a mountainous area in Afghanistan and a Lidar DEM of a suburban area in central California are analyzed in this Lab.

The objective of this lab is to use ArcGIS's image enhancement tools to derive more landform, environmental, and infrastructure information from DEM grids. The following enhancements will be included:

- 1) Color-code elevation
- 2) Hillshade
- 3) Contour
- 4) Visualization with the 3D Analyst extension (*Optional*)
 - 4a) DEM Topographic profile
 - 4b) Perspective View
 - 4c) Anaglyph View
- 5) DSM (digital surface model)
- 6) DTM (digital terrain model)

Seven (7) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. Two (2) files are to be uploaded to the instructor. There are two (2) more optional files to upload if you have the ArcGIS 3D Analyst extension.

Lab 9 Unsupervised Classification

This lab processes the image discussed and shown in the Textbook's Figure 3-15. More extensive files are available in the Textbook's Remote Sensing Digital Database's Chapter 3. Spectral classification of multispectral data is discussed in Chapter 9, pages 272 – 278.

This lab provides a basic understanding of unsupervised classification to generate a thematic raster map. But you will also learn processes that enable you to focus attention on features of interest in the map, increase information content, and more broadly distribute your map. The lab uses Landsat data from the mountainous, cirque-glaciated terrain of Afghanistan (see Lab 8). The tools that will be applied include:

- 1) Unsupervised classification
- 2) Select by attributes with SQL
- 3) Generalization (majority filter)
- 4) Conversion of the thematic raster map to a vector polygon shapefile
- 5) Adding attributes to the shapefile
- 6) Calculating area
- 7) Merging a shapefile onto a raster file
- 8) Optional: Display your integrated image in GoogleEarth
- 9) Optional: Convert your integrated image into a 3D virtual Earth .kmz file

Ten (10) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. One (1) table and one (1) optional jpg are to be uploaded to the instructor.

Lab 10 Supervised Classification

The classification exercise will be done with the Landsat 8 image used in the textbook (see Figures 9-28, 9-29, and 9-33 and Plates 29 and 30). The Landsat 8 image was acquired on September 23, 2014 of Martinez, California, an urbanized area with industry, commercial, suburbia, golf courses, and wetlands. The non-irrigated vegetation is dry.

We will be generating a **land use/land cover (LULC)** raster thematic map. The objectives of this lab are to learn how to evaluate multispectral bands used in a classification, build training sites, understand the parameters that impact the accuracy of supervised classifications, and convert your raster classification map into a GIS vector polygon file to support informative, value-added maps (see Chapter 9 Digital Image Processing for discussion).

Nine (9) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. Two (2) files are to be uploaded to the instructor.

Background

The analyst must have knowledge of the types of features that are being spectrally classified to successfully complete an accurate supervised classification map. The analyst decides on what classes to map (creates a legend) and then selects groups of pixels that are within each class to develop training sites. The spectral signatures obtained from training sites are used to classify an image.

Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless you select a probability threshold, all pixels are classified. Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood).

The ArcGIS steps to perform a supervised classification and deliver a useful map are listed below:

- 1) Identify and evaluate the input bands.
- 2) Decide on the classes (or classification categories)
- 3) Produce training samples to develop a signature file
- 4) Run the classification program.
- 5) Add the Class Names to the Attribute Table
- 6) Visually evaluate the accuracy of the LULC map
- 7) Fade the LULC shapefile map on a hillshade DEM
- 8) Create a Layout Map.
- 9) Use the Field Calculator to add Area (km²) to the Attribute Table

Lab 11 Change Detection

Change detection is discussed in the Textbook's Chapter 9 with the second example in this lab discussed on page 279 and shown in Figure 9-35 (the change detection image was generated with ENVI software, not ArcGIS Desktop). We will first analyze change at Mt. Diablo, California with Landsat images acquired sixteen (16) days apart, before and after a fire in 2013. Much of the Mt Diablo exercise is courtesy of M.B. Quinn, Geography Dept., Diablo Valley College, Pleasant Hill, California. The second example analyzes urban sprawl using Landsat images acquired ~25-years apart (1986 to 2010) in the Antioch and Brentwood area, California.

- 1) Fire on Mount Diablo, California
- 2) Urban Sprawl over 25 years, Antioch-Brentwood, California

Changes will be calculated based on the spectral characteristics and pixel brightness values of the same Landsat band acquired at different times.

Twenty-one (21) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout. There are no files to upload to the instructor.

Lab 12 NLCD Land Cover and Impervious Maps

This lab demonstrates the remarkable National Land Cover Database (NLCD) provided by a partnership of federal agencies led by the USGS. The NLCD is discussed in the Textbook's Chapter 14, pages 398 to 402 with Plate 49 and Figure 14-1 displaying the land cover example and Figure 14-2 displaying the impermeability example examined in this lab.

The objective of this lab is to become familiar with the NLCD landcover and impervious maps, and to understand how to query them and integrate them with other geospatial layers to improve your interpretations. The National datasets are huge so clipping out subareas over your areas of interest is important for computer performance. A simplistic approach to customizing the NLCD landcover legend for a clipped subarea is provided. Two pdfs describing the NLCD program are available for viewing in the "Lab_12_Data" folder (locate using your Windows or Mac directory structure).

Eight (8) questions are asked during this lab – you are to write your answer on the sheet that is at the end of this handout.