Image from NASA: https://commons.wikimedia.org/wiki/File:Earth_Western_Hemisphere_transparent_background.png#filelinks

Remote Sensing

Image Interpretation

WV VIEW

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In this module, we will explore image interpretation methods. Image interpretation is a very important component of the geospatial sciences, since digitizing features from aerial imagery is a primary means of creating new geospatial data or updating existing data. This is a skillset that is developed over time and relies on discipline-specific knowledge and expertise. Manual interpretation is still the primary use of most high spatial resolution aerial- and satellite-based image datasets.

Module Topics

1. Shape, size, shadow, tone, and associated features
2. Image interpretation examples
3. Geomorphic examples

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These are the topics covered in this module.

Photo Interpretation

Overview

- Identification process
  - Shape
  - Size
  - Shadow
  - Tone
  - Associated features
- Hints for identification

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When interpreting features from imagery, we commonly rely on our understanding of the scene in combination with the scene and feature characteristics, such as shape, size, shadow, tone, and associated features. In this module, we will discuss these components and also provide hints for interpreting common landscape features. Luckily, the human brain is the most accurate feature recognition system in existence.

Shape

- Likely human origin:
  - Geometrical shapes
    - Straight lines
    - Circles
    - Regular spacing

Example: Farming in Nebraska, USA (Google Earth)

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The shape of landscape features can be telling. For example, features are more likely to be anthropogenic in origin if they consist of regular geometric patterns, such as straight lines, circles, or other regular shapes. Examples include buildings, agricultural fields, and road networks. Some natural features can also be geometrically regular, such as geologic lineaments, rock fracture and jointing patterns, and patterned ground in periglacial landscapes. Again, regional, local, and/or expert knowledge is of great value in photo interpretation.

In the example image, man-made agricultural fields are evident due to their regular shapes (i.e., rectangular fields and circular central pivot irrigation). In contrast, natural features, such as stream channels, are more irregular.

Shape

Example: Schönbrunn Palace and Grounds Vienna, Austria (Google Earth)

Example: Geologic joints near Parsons, West Virginia

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In the example on the left, geometric shapes are evidence of a well-kept garden and grounds at the Schönbrunn Palace in Vienna, Austria.

In the example on the right, geologic joints could be mistaken for man-made features due to their regular geometric pattern. Again, content expertise and/or local knowledge is important in aerial image interpretation.

Size

Example: Pittsburgh International Airport (Google Earth)

- Measure
  - Can measure directly using orthorectified imagery
- Estimate
  - Comparison with another object

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Using modern, georeferenced, orthorectified imagery, it is possible to measure the size of features directly. It is also possible to compare the relative sizes of objects. For example, the relative size of vehicles and different aircraft can be discerned from this image of the Pittsburgh International Airport.

Shadow

Example: Wind Farm in Grant County, West Virginia (Google Earth)

Example: New River Gorge Bridge near Fayetteville, WV (Google Earth)

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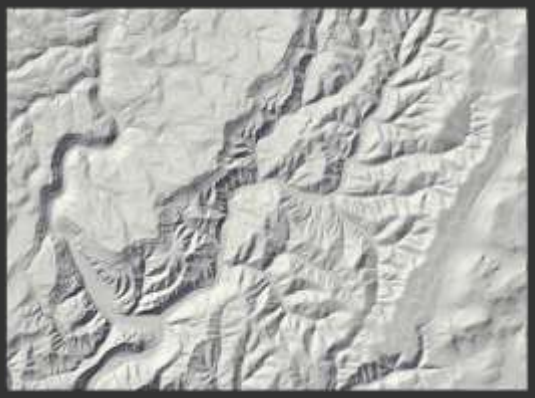
Shadow are useful for understanding the height of features and the shape of features. In the example on the left, the shape and relative height of the windmills are made obvious by their shadows. In the second example, the relative height of the bridge relative to the ground is made more obvious by its shadow, where the shadow is further from the bridge near the center of the gorge where the height from the ground is greater. It is also possible to see characteristics of the bridge in the shadow that would otherwise not be obvious, such as the bridge structure below the road surface.

Sun position matters



Azimuth = 315, Altitude = 45

Azimuth = 135, Altitude = 45

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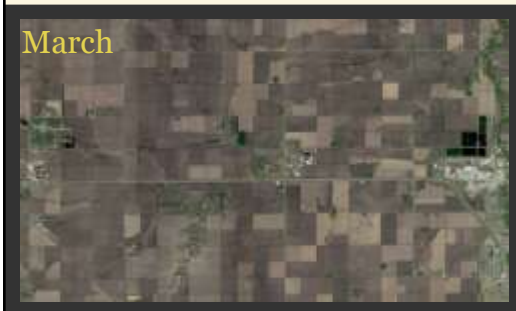
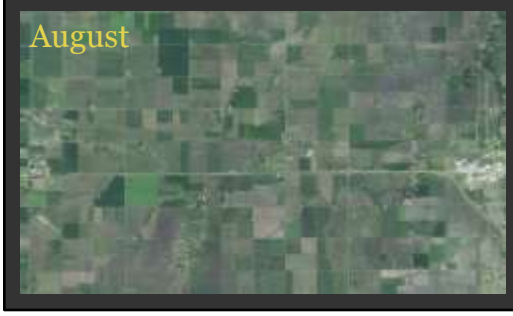
When using shadows to assess topography, the image should be viewed such that shadows are directed downward. This is because we see objects as illuminated from above. So, viewing an image with shadows cast upward can result in an odd optical illusion that causes topography to appear inverted. The provided hillshades highlight this issue. When the illuminating source is placed in a southeastern position, the topography looks inverted. In contrast, the topography looks correct when illuminated from a northwestern position and the shadows are cast downward or toward the bottom of the scene.

The interpretation of shadows is also impacted by the time of day and the illuminating geometry. For example, longer shadows will be cast earlier or later in the day due to the angle of illumination.

Tone





Factors affecting tone:

- Weather
- Time of day
- Season
- Sun-object-view geometry

❖Key issue:
- Contrast between object and background

Example: Farmland near Fargo, North Dakota

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The tone of an image and of individual landscape features is impacted by several factors including weather, time of day, season, and viewing geometry. For example, the farmland in the provided images look very different when the vegetation is dormant vs. active.

Generally, wetter conditions will tend to darken the tone of features.

Tone can be especially useful for interpreting features if the objects of interest contrast well with the background.

Tone

Factors affecting tone:

- Weather
- Time of day
- Season
- Sun-object-view geometry

❖Key issue:
- Contrast between object and background

Example: Norwegian Spruce Stand near Parsons, WV (Google Earth)

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In this example, a stand of Norway Spruce trees within a deciduous forest is very obvious in the leaf-off image. The stand is somewhat obvious in the leaf-on image due to a different texture and a slightly different tone.

Associated Features

Feature	Associated features
Church	Cemetery
Airfield	Hangar
Railway station	Footbridge
Fire station	Hose tower
Power station	Cooling tower
Water treatment facility	Filter beds
Bus stop	Shelter
Entrance gate	Security/access control point

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Associated features can also be of use. This again highlights the value of local and/or expert knowledge. The provided table lists some example features and associated features, which are key for interpreting the objects.

Associated Features

Example: Mount Storm Power Plant near Mount Storm, West Virginia (Google Earth)

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As an example of the value of associated features, this complex can be identified as a coal-fired power plant based on (1) the smoke towers, (2) the nearby substation, (3) the adjacent piles of coal, and (4) its proximity to a lake, which is used for cooling.

Associated Features

Example: Golf course near Aberdeen, Scotland (Google Earth)

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This feature could be identified as a golf course due to the associated greens and sand traps.

Associated Features

Example: Ruby Memorial Hospital in Morgantown, West Virginia (Google Earth)

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The medical helicopter pad is useful for identifying this feature as a hospital.

Examples

Hints for Identification

1. Roads and Railroads
2. Bridges
3. Quarries and Surface Mines
4. Water
5. Forests
6. Agriculture and Farmland
7. Urban features

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In the remainder of this module, we will provide some specific examples for identifying key landscape features.

Roads vs. Railroads

Example: Roads and Railroads in Cumberland, Maryland (Google Earth)

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Roads and railroads can be differentiated by (1) assessing the types of intersections present, (2) the identification of trains or cars, (3) the identification of road dividing markers, and (4) the occurrence of train yards.

Roads vs. Railroads

Example: Roads and Metro tracks near Reston, Virginia (Google Earth)

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This image contains a divided highway with a metro track running between the east- and west-bound lanes. The identification of the Metro platform aids in differentiating these features.

Highway Cut-and-Fill

Example: Corridor H in West Virginia (Google Earth)

Example: Sideling Hill Interstate 68 (Google Earth)

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Highway cut-and-fill are generally distinguished based on (1) shadows and (2) location along roads. Sometimes exposed rock surface may be present and/or a terracing pattern to encourage stability.

Bridges

Example: Bridge in Moundsville, West Virginia (Google Earth)

Example: New River Gorge bridge near Fayetteville, West Virginia (Google Earth)

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Shadows can be useful for determining the structure and type of bridges.

Cliffs, Quarries, and Steep Slopes

Example: Limestone quarry near Martinsburg, West Virginia (Google Earth)

Example: Large surface mine near Charleston, West Virginia (Google Earth)

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Surface mines and quarries have several key characteristics including (1) bare ground and/or evidence of reclamation, (2) equipment and trucks, (3) settling or retention ponds, (4) access roads, (5) adjacent plants and processing facilities, and (6) tailings and piles of earth materials. The signature of mining and quarrying will vary based on (1) the materials being extracted (e.g., coal, peat, limestone, stone, etc.), (2) the mining practices, and (3) environmental regulations.

Cliffs, Quarries, and Steep Slopes

Example: Surface coal mine in Powder River Basin near Gillette, Wyoming (Google Earth)

Example: Mountaintop removal mine in southern West Virginia (Google Earth)

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This slide highlights some different surface coal mining practices. The image on the right is an open-pit in the Powder River Basin of Wyoming where the coal seams are thick and the topography is relatively flat. Here, mines are characteristically large, open pits with adjacent access roads and excavated slopes. In contrast, mountaintop mining in southern West Virginia has a very different signature/pattern due to the mining of thinner coal seams and steeper topography.

Water

Example: Large mountain Lakes in Austrian Alps (Google Earth)

Example: Sun glint on Cheat River near Morgantown, West Virginia

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Water tends to have a dark tone in true color images. However, sun glint can result in a very bright tone. For river systems, evidence of turbulence or white water can also be diagnostic. The color of water can vary greatly based on chemical properties, such as the amount of mud, sediment, or total dissolved solids being transported.

Water

Example: Allegheny and Monongahela river confluence at Pittsburgh, Pennsylvania

https://commons.wikimedia.org/wiki/File:Pittsburgh-Point.jpg

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This image highlights the impact of sediment load. The Monongahela River in the lower section of the image is carrying more sediment at the time the image was taken in comparison to the Allegheny River in the upper portion of the frame. This results in a clear distinction between the waterbodies at this moment in time.

Docks and Boat Launches

Example: Cheat Lake Monongalia County, West Virginia (Google Earth)

Example: Deep Creek Lake Garrett County, Maryland (Google Earth)

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Docks are generally easy to locate; however, they can vary by size. Boat launches may be less obvious. Some are paved while others may just be dirt or gravel.

Dams and Locks

Example: Tygart Dam in Grafton, West Virginia (Google Earth)

Example: Lock and Dam on Monongahela River in Morgantown, WV (Google Earth)

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Dams are generally easy to distinguish since they occur along rivers and will have a lake behind them. Lock systems may be less obvious; however, they should have a lock mechanism to allow boats to pass alongside the accompanying dam. Water turbulence is also common as a result of the dam.

Forests

Example: Norway Spruce Stand near Parsons, WV (Google Earth)

Example: Conifer stand in Preston County, West Virginia

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Forests and woodlands are generally differentiated from other vegetation types based on texture. Also, leaf-off imagery can be useful for differentiating conifer and deciduous stands.

Forests

Example: Fall colors in Fredrick County, Virginia

Example: Fall colors in Bavarian Alps

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Fall colors and correctly timed imagery can be useful for differentiating trees or forest types. However, this is generally a difficult task that requires specialized training and adequate data.

Forests

Example: Timber harvesting in Nicholas and Greenbrier counties, West Virginia (Google Earth)

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Timber harvesting is characterized by clearings within forest extents and associated haul roads. Clear-cutting is not always easily differentiated from other features, such as development or the early stages of surface mining.

Oil and Gas Infrastructure

Example: Hydrologic Fracturing Well Sites in Greene County, Pennsylvania (Google Earth)

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Oil and gas well pads, such as Marcellus well pads in the Appalachian Basin, are characterized by well pads, access roads, and retention ponds. These sites are generally more obvious as they are being installed. After installation, the ponds and equipment are removed leaving behind a pad and access road.

Tree Farms

Example: Tree farms in Preston County, West Virginia (Google Earth)

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Tree farms can sometimes be distinguished from forests based on the orderly planting pattern.

Electric Utility Transmission Lines

Example: Electrical transmission line in Tucker County, West Virginia (Google Earth)

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Electrical transmission lines are generally identifiable as long, linear clearings. Sometimes, the towers or tower shadows can also be observed. Smaller lines are generally harder to distinguish.

Electric Utility Substations

Example: Electric Utility Substation in Preston County, West Virginia (Google Earth)

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Electrical utility substations can generally be identified based on many intersecting power lines and the occurrence of transformers and other electrical utility infrastructure. Electrical substations are also common near large industrial complexes and power plants.

Wetlands

Example: Wetland complex in Canaan Valley, West Virginia (Google Earth)

Example: Coastal wetland complex in eastern Maryland (Google Earth)

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Wetlands are generally difficult to delineate using aerial imagery alone. Detailed and accurate wetland delineation generally requires specialized training and field surveys. However, imagery can be useful for general mapping and site assessment.

Agriculture

Example: Farmland in Indiana (Google Earth)

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Agricultural fields and pastureland can generally be differentiated from forests and woodlands based on image texture. Tone can be useful for assessing moisture content. It is generally difficult to differentiate between crop types from aerial images alone without some local knowledge or an assessment of temporal patterns using multiple images. Bare and vegetated fields can generally be easily differentiated. It is generally not easy to differentiate pastureland from other grasslands or areas dominated by low vegetation. Associated features can help, including farmhouses, silos, and barns.

Agriculture

Example: Central-Pivot Irrigation in Idaho (Google Earth)

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Circular patterns resulting from central pivot irrigation are diagnostic of agriculture.

Agriculture

https://commons.wikimedia.org/wiki/File:Rice_fields_Chiang_Mai.jpg

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Farming practices vary by scale, crop type, topography, and region. For example, terraced rice cultivation in Asia looks very different from grain cultivation in the American Midwest.

Agriculture

Example: Large tomato greenhouses on Spain's Mediterranean Coast (Google Earth)

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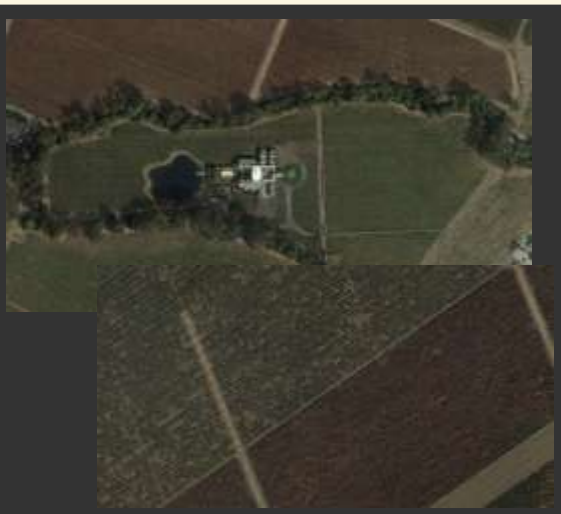
Agriculture is not always obvious. For example, this image from the Mediterranean coast of Spain consists of large greenhouse enclosures used for tomato farming.

Vineyards



Example: Vineyards near Napa, California (Google Earth)

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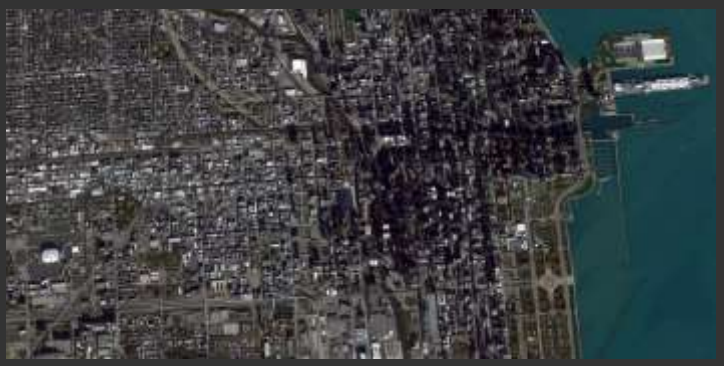
Vineyards may be differentiated from other vegetation based on the linear planting pattern and evidence of height from associated shadows.

Urban Features

- Buildings
- Industrial facilities
- Residential areas
- Shopping centers
- Roads, metro lines, railroads
- Parks
- Harbors
- Airports
- Train Stations
- Etc.



Example: Downtown Chicago, Illinois (Google Earth)

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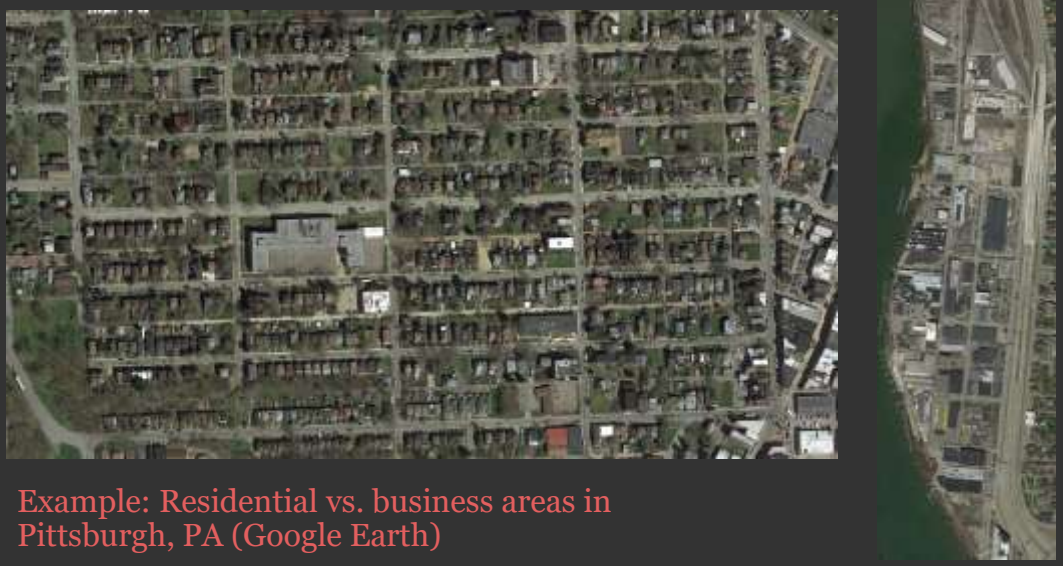
A wide variety of features are associated with urban development. Interpretation of urban environments rely heavily on context, shape, associated features, and local/expert knowledge. We provide some examples in the following slides.

Residential vs. Business



Example: Residential vs. business areas in Pittsburgh, PA (Google Earth)

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Residential vs. business areas in urban environments can partially be differentiated based on the size of buildings, the nature of the road network, and evidence of single-family homes and yards.

Shopping Centers

- Malls
- Strip Malls
- Grocery Stores

Example: Morgantown Mall Morgantown, West Virginia (Google Earth)

Example: Grocery Store Morgantown, West Virginia (Google Earth)

Example: EuroPark Mall Salzburg, Austria (Google Earth)

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Shopping center may have characteristics such as shopping cart returns, parking lots, and/or parking garages. These characteristics will vary by region. For example, the Morgantown Mall looks a bit different from the EuroPark Mall in Salzburg, Austria.

Factories and Industrial Features

Example: Industrial complexes near Charleston, West Virginia (Google Earth)

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Industrial features and areas are generally differentiated based on (1) occurrence of large buildings, (2) associated train yards, (3) storage tanks, (4) smokestacks, and (5) electrical infrastructure.

Schools and Universities

Example: Morgantown High School in Morgantown, West Virginia (Google Earth)

Example: Alderson Broaddus University in Philippi, West Virginia (Google Earth)

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Schools and universities often have sports fields and quadrangles that differentiate them from other complexes.

Places of Worship

Example: Camp Chapel Church near Kingwood, West Virginia (Google Earth)

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Places of worship can have very distinct architecture. However, this can vary based on religious affiliation, denomination, age, and size. Associated features can be helpful for identifying places of worship. For example, the identification of the church in the aerial photograph on the left is aided by the proximity to a cemetery. Again, local knowledge and an understanding of architectural practices in different regions can be useful for delineating landscape features.

Train Terminals

Example: Train station east of Salzburg, Austria (Google Earth)

Example: Train Terminal in Edinburgh, Scotland (Google Earth)

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Train terminals generally have associated rail lines and platforms. However, characteristics often vary by size and region.

Airports and Airfields

Example: Pittsburgh International Airport (Google Earth)

Example: Morgantown Municipal Airport (Google Earth)

Example: Private airstrip (Google Earth)

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Large airports are generally easy to identify due to the characteristic runway infrastructure, terminals, and hangars. However, there are many small private airstrips that may be difficult to locate. Sometimes these are simply grass-covered strips in fields.

Geomorphic Features

Geomorphic Features

Example: Folded mountain belt in central Pennsylvania (Google Earth)

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Imagery can also be of great value for interpreting geomorphic features. The last set of slides provide some examples. This first example shows a characteristic folded mountain belt made up of plunging anticlines and synclines in central Pennsylvania, USA.

Note that many geomorphic features can be more easily interpreted from digital terrain data, which is not being discussed here.

Geomorphic Features

Example: Abandoned river meander near Parsons, West Virginia (Google Earth)

Example: Water gaps in Grant County, West Virginia (Google Earth)

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This slide provides examples of an abandoned river meander and water gaps in West Virginia.

Geomorphic Features

Example: Ancient basalt flows in Idaho (Google Earth)

Example: Drumlins in Ireland (Google Earth)

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This slide shows examples of basalt flows in Idaho and drumlines in Ireland.

Geomorphic Features

Example: Alluvial fan in Nevada (Google Earth)

Example: Barchan dunes in Peru (Google Earth)

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This slide shows an alluvial fan in Nevada and a series of barchan dunes in Peru.

Geomorphic Features

Example: Barrier islands including Cape Hatteras, North Carolina (Google Earth)

Example: Abandoned oxbows near Elkins, West Virginia (Google Earth)

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Lastly, this slide shows a barrier island complex in North Carolina, USA and some abandoned oxbows near Elkins, West Virginia, USA.

This is the end of this lecture module.

Please return to the West Virginia View Webpage for additional content.

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Thanks! Hope you found this useful.