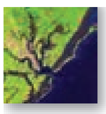
APPENDIX: SOURCES OF IMAGERY AND OTHER GEOSPATIAL INFORMATION

Source: NOAA

Obtaining timely, accurate, geospatial information is one of the most important and challenging activities of remote sensing and GIS investigations. Chapter 2 reviewed numerous types of remote sensing data acquired using airborne and satellite remote sensing systems. This Appendix provides more detailed information about how to access selected types of remote sensing and other types of geospatial data using the Internet. The datasets listed are not exhaustive, but will hopefully provide sufficient information to evaluate and obtain some of the most commonly used types of remote sensing and other types of geospatial data.

This Appendix begins by introducing four federal geospatial data search engines and image repositories. Next, three representative commercial geospatial data search engines and/or repositories are reviewed. The remainder of the Appendix is devoted to a discussion of selected: 1) thematic datasets (e.g., elevation, hydrology, land use/land cover), 2) sources of public remote sensor data, and 3) sources of commercial and international remote sensor data.



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- ASTER Global Digital Elevation Map (METI and NASA)
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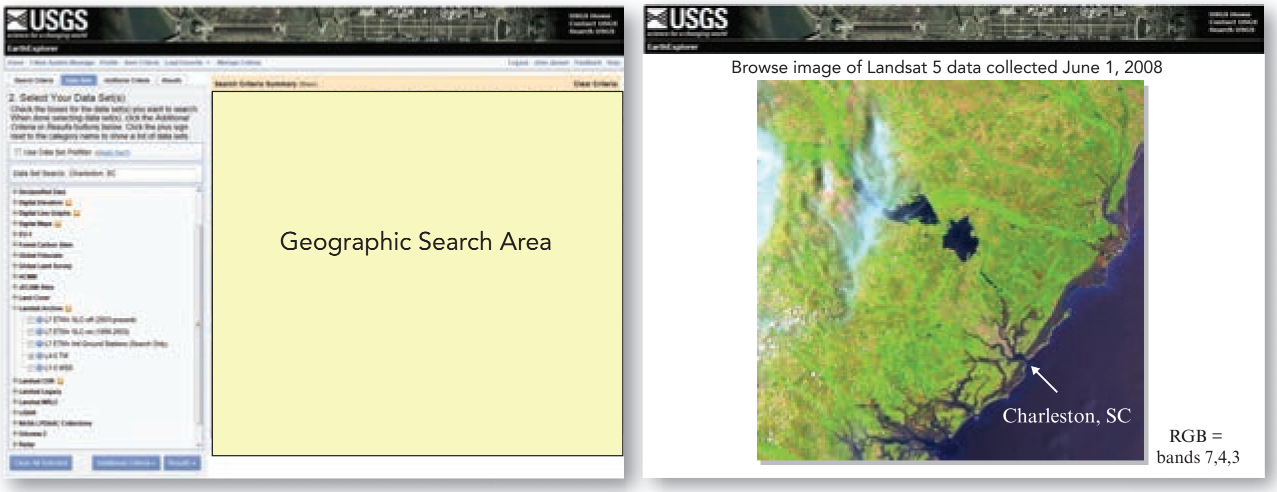
Hydrography Data

- NHD—National Hydrologic Database (USGS)
- EDNA—Elevation Derivatives for National Applications (USGS)

USGS *EarthExplorer* User Interface **Results of a Search for Landsat 5 Imagery**



a. b.

FIGURE A–1 a) The USGS *EarthExplorer* user interface (http://earthexplorer.usgs.gov/). The geographic search area is available online. A search for Landsat 4 and 5 imagery of Charleston, SC, from 2005 to 2010 in June was selected. b) This June 1, 2008, Landsat 5 image was one of several images that met the search criteria (imagery courtesy of NASA).

Land Use/Land Cover and Biodiversity/Habitat Data

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- NPN—U.S. National Phenology Network

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Remote Sensor Data—Public

- Selected publicly available sources of analog and digital remote sensor data.

Remote Sensor Data—Commercial and International

- Selected commercial and international sources of analog and digital remote sensor data.

Federal Geospatial Data Search Engines and Repositories

A powerful characteristic of federal geospatial data repositories is that the data are in the public domain and available to the general public at no expense. Only a select few of the many federal image and geospatial repositories are introduced here.

USGS *EarthExplorer*

One of the best places to look for remote sensing data and various remote sensing–derived products is at the U.S. Geological Survey's *EarthExplorer* website (http://earthexplorer.usgs.gov/). This site allows users to select a geographic place or region by typing in the name of a location, entering geographic coordinates, or drawing on a map (Figure A-1a). Once the geographic area has been identified, the user can identify specific types of data from the menu. This includes access to digitized aerial photography (discussed below), AVHRR, Calibration/Validation Reference Sites, Commercial (IKONOS-2), Declassified data, Digital Elevation (ASTER Global DEM, GMTED2010, GTOPO30, GTOPO30 HYDRO 1K, SRTM, SRTM Void Filled), Digital Line Graphs, EO-1 (ALI, Hyperion), Forest Carbon Sites, Landsat (Global Land Survey, Archive, CDR, Legacy, MRLC), LiDAR, NASA SPDAAC Collections, Orbview-3, RADAR (SIR-C), Vegetation monitoring, HCMM, and Land Cover (NLCD 1992, 2001, 2006). For example, the user interface in Figure A-1a was used to search for Landsat 5 Thematic Mapper imagery of

The National Map

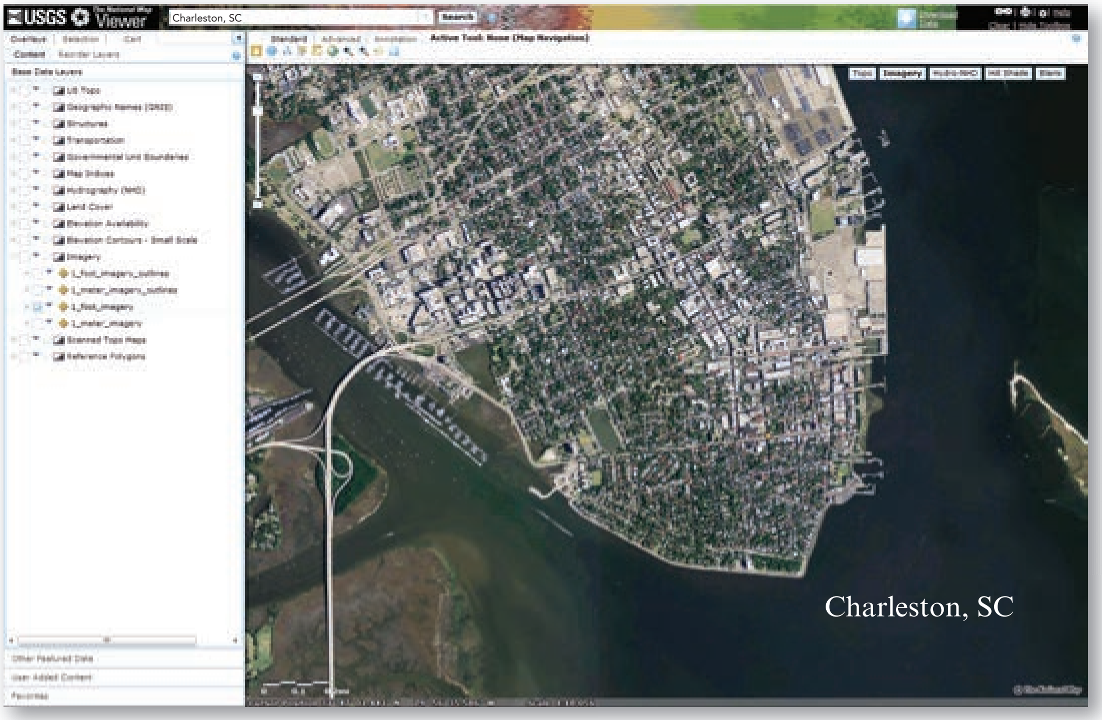


FIGURE A–2 *The National Map* user interface is especially useful for locating information about geographic boundaries, terrain elevation, geographic names, hydrography, land cover, orthoimagery, structures, and transportation (http://nationalmap.gov/viewer.html). This is a display of 1 × 1 ft. orthoimagery of Charleston, SC (aerial photography courtesy of the U.S. Geological Survey).

Charleston, SC, collected in June from 2005 to 2010. One of the results of the search is shown in Figure A-1b. The user may discard the search or order a digital copy of the June 2, 2008, Landsat image.

From 1972 to 2005, the USGS Earth Resources Observation and Science (EROS) Center provided remote sensing *film*-based products to the public. EROS is home to an archive of 12 million frames of analog photography ranging from 1937 to the present. The archive contains analog collections from both aerial and satellite platforms including programs such as the National High Altitude Program (NHAP), National Aerial Photography Program (NAPP), U.S. Antarctic Resource Center (USARC), Declassified 1 (CARONA, ARGON, and LANYARD), Declassified 2 (KH-7 and KH-9), and Landsat (1972 – 1992, Landsat 1-5). Since 2004, EROS has been digitally scanning the analog collection at resolutions ranging from 64 μm (400 dpi) to 25 μm (1,000 dpi) depending upon the severity of the *vinegar* syndrome (a slow form of chemical deterioration that causes the film to shrink, buckle, and become unusable). The digitized imagery is available at no cost through the *EarthExplorer* interface (Moe and Longhenry, 2013).

Users must register with *EarthExplorer* to save searches and order data. Some digital datasets can be downloaded immediately. Other datasets take a few hours or a couple of days for the data to be extracted and then made available to the user via FTP. Normally, users are not sent to additional sites to order data. This is an advanced search engine that is very useful for those who know the type and characteristics of the imagery and/or other geospatial data they are looking for.

USGS *The National Map*

Managed by the National Geospatial Program (NGP), *The National Map* viewer (Figure A-2) provides data visualization and download of all eight *National Map* datasets, including: geographic boundaries, elevation, geographic names, hydrography, land cover, orthoimagery, structures, transportation, and US Topo products (Carswell, 2011; USGS NGP, 2014). The majority of *The National Map* effort is devoted to acquiring and integrating medium-scale (nominally 1:24,000-scale) geospatial data for the eight base layers from a variety of sources and providing access to the resulting seamless coverages of geospatial data.

An orthoimage is remotely sensed image data in which displacement of features in the image caused by terrain

***Global Visualization Viewer* (*Glovis*) Interface**

FIGURE A–3 The *Global Visualization Viewer (Glovis)* user interface provides information about the availability of the following types of imagery: aerial (NHAP, NAPP), ASTER, EO-1 (Advanced Land Imager, Hyperion), Landsat archive, Landsat Global Land Survey, Landsat MRLC collections, Landsat Legacy Collections, MODIS (Aqua, Terra, combined), and Terra Outlook (http://glovis.usgs.gov/). This is a display of high spatial resolution NAPP aerial photography of Hilton Head, SC, collected on January 8, 2006. The image can be downloaded directly from the *Glovis* website (aerial photography courtesy of U.S. Geological Survey).

relief and sensor orientation have been mathematically removed. Orthoimagery combines the image characteristics of a photograph with the geometric spatial accuracy and reliability of a planimetric map. USGS digital orthoimage resolution may vary from 6 in. to 1 m. *The National Map* provides free downloads of public domain, 1 × 1 m orthoimagery for the conterminous U.S. with many urban areas and other locations at 2-ft. or finer resolution. For example, 1 × 1 ft. spatial resolution orthoimagery of Charleston, SC, in *The National Map* database is displayed in Figure A-2.

The National Map viewer also allows visualization and identification queries (but not downloads) of other data, including: Ecosystems, Protected Areas, Gap Analysis Program Land Cover, Hazards, Weather, Wetlands, Public Land Survey System, and National Park Service Boundaries. To research and download historical USGS data, such as Digital Orthophoto Quadrangles and Digital Line Graphs, or to access specific LiDAR point cloud data, use the USGS *EarthExplorer* website.

USGS *Global Visualization Viewer*

The USGS *Global Visualization Viewer* (*Glovis*) is a straightforward tool for searching and ordering specific types of satellite and aerial imagery. The types of data that can be searched include aerial (NHAP, NAPP), ASTER, EO-1 (Advanced Land Imager, Hyperion), Landsat archive, Landsat Global Land Survey, Landsat MRLC collections, Landsat Legacy Collections, MODIS (Aqua, Terra, combined), and Terra Outlook.

A search for National Aerial Photography Program (NAPP) imagery of Hilton Head, SC, is shown in Figure A-3. The color-infrared aerial photograph was obtained on January 8, 2006. If desired, this image can be downloaded directly from the Glovis interface.

***Data.gov* User Interface**

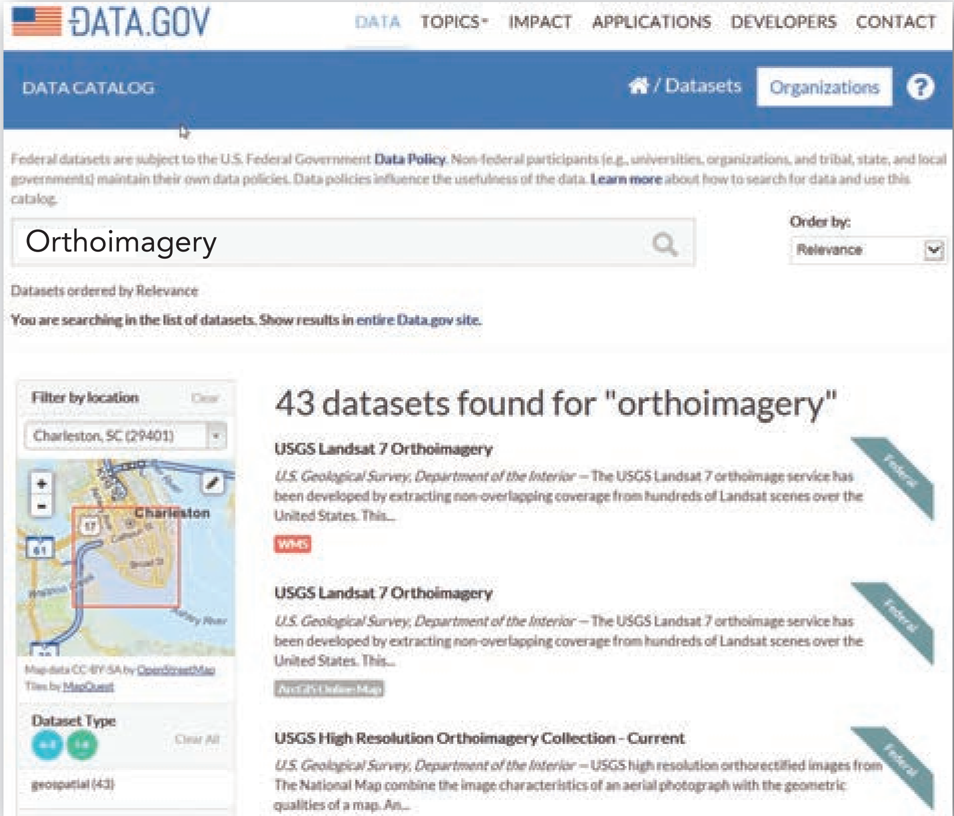


FIGURE A–4 The *Data.gov* user interface (http://catalog.data.gov/dataset) allows the user to filter by location and then search a list of datasets by type. In this example, the user specified the "geospatial dataset type" and requested information on all the "Orthoimagery" for Charleston, SC. The results of the search identified 43 orthoimagery datasets available for the study area. The user can evaluate the metadata associated with each file and/or download the data (courtesy of Data.gov).

Data.gov

On October 1, 2011, *Data.gov* was introduced as "the home of the U.S. government's open data." With this move, U.S. national geospatial assets were brought together in one place to theoretically make it easier for the public to browse and access over 400,000 maps, datasets, and geospatial services (Figure A-4). In addition, the services, mapping and visualization capabilities, and data standards behind these sites also became accessible. This work was done in coordination with a refresh of the Geospatial Platform, which remains the online home for the Federal Geographic Data Committee's guidance, policies, and standards.

Data.gov allows the user to search for geospatial information by searching for a particular type of dataset in a particular geographic location (Figure A-4). In this example, the location was specified as Charleston, SC, and the geospatial database was searched to find "Orthoimagery." The result was a list of 43 orthoimagery datasets. This website is ideal for less experienced users who are not absolutely sure what image or other geospatial data they are looking for.

Commercial Geospatial Data Search Engines and/or Repositories

There are numerous commercial image and geospatial search engines such as *Google* earth, bing, *ArcGIS Online*, and others. Selected characteristics of these three geospatial search engines are introduced for demonstration purposes.

Google, Inc., *Google* earth Search Engine

The *Google* earth website provides detailed image and other geospatial information about most locations in the world. The user can specify the latitude, longitude coordinates or interactively locate the area of interest on the synthetic *Google* earth three-dimensional globe.

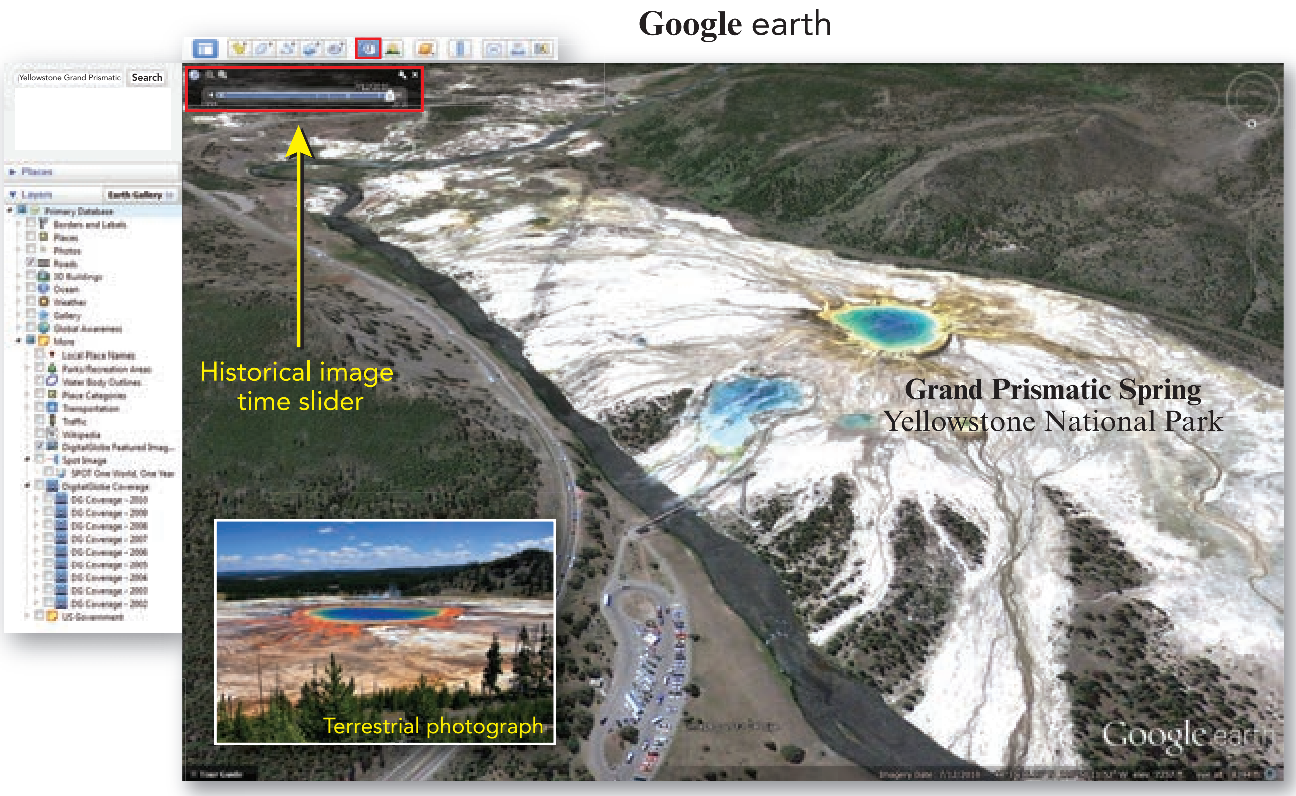


FIGURE A–5 *Google* earth can be used to look at imagery of almost anywhere on the Earth. In this example, the user requested geospatial information about the Grand Prismatic Spring in Yellowstone National Park in Wyoming. The historical image slider can be used to select for display any of the remote sensing imagery stored in the database. In this particular case, a DigitalGlobe GeoEye-1 natural-color image of the Grand Prismatic Spring obtained on July 12, 2010, is displayed (user interface courtesy of *Google* earth, Inc.; imagery courtesy of DigitalGlobe, Inc.; terrestrial photograph provided by the author).

Google earth relies heavily on imagery acquired by DigitalGlobe, Inc. (e.g., IKONOS, GeoEye, QuickBird, and WorldView-1 and -2). For example, Figure A-5 depicts one image derived for a search on the Grand Prismatic Spring in Yellowstone National Park in Wyoming. The July 12, 2010, GeoEye-1 natural color image is draped over U.S. national elevation data (NED) yielding a very informative three-dimensional display of the spring and surrounding roads and mountainous terrain. *Google* earth also uses public-domain imagery such as that provided by the U.S. Department of Agriculture Farm Service Agency.

The simple historical image slider user-interface in the upper left-hand corner of the interface can be used to interactively display each of the dates of imagery of the study area that reside in the database. In this particular case the following images are available:

- 8/24/1994 USGS Black and White
- 10/23/2003 DigitalGlobe
- 11/6/2004 DigitalGlobe
- 8/10/2006 DigitalGlobe
- 9/29/2006 USDA Farm Service Agency
- 8/27/2009 USDA Farm Service Agency
- 7/12/2010 GeoEye-1

In the Layer sidebar, *Google* earth provides information about all the DigitalGlobe and SPOT image data available for the study area as well as other thematic information such as roads that can be overlaid on the imagery. Users often extract screen captures of the imagery displayed using *Google* earth for a variety of non-scientific purposes. It is necessary to contact the original data provider such as DigitalGlobe, Inc. or SPOT Image, Inc. to obtain the original remote sensor data.

Microsoft, Inc., bing Search Engine

The Microsoft, Inc., bing search engine provides detailed image information about most locations in the world. The user can specify the latitude, longitude coordinates or interactively locate the area of interest using the bing interface. bing relies heavily on digital frame camera aerial photography (e.g., UltraCam) acquired by photogrammetric engineering firms such as

Microsoft, Inc. bing

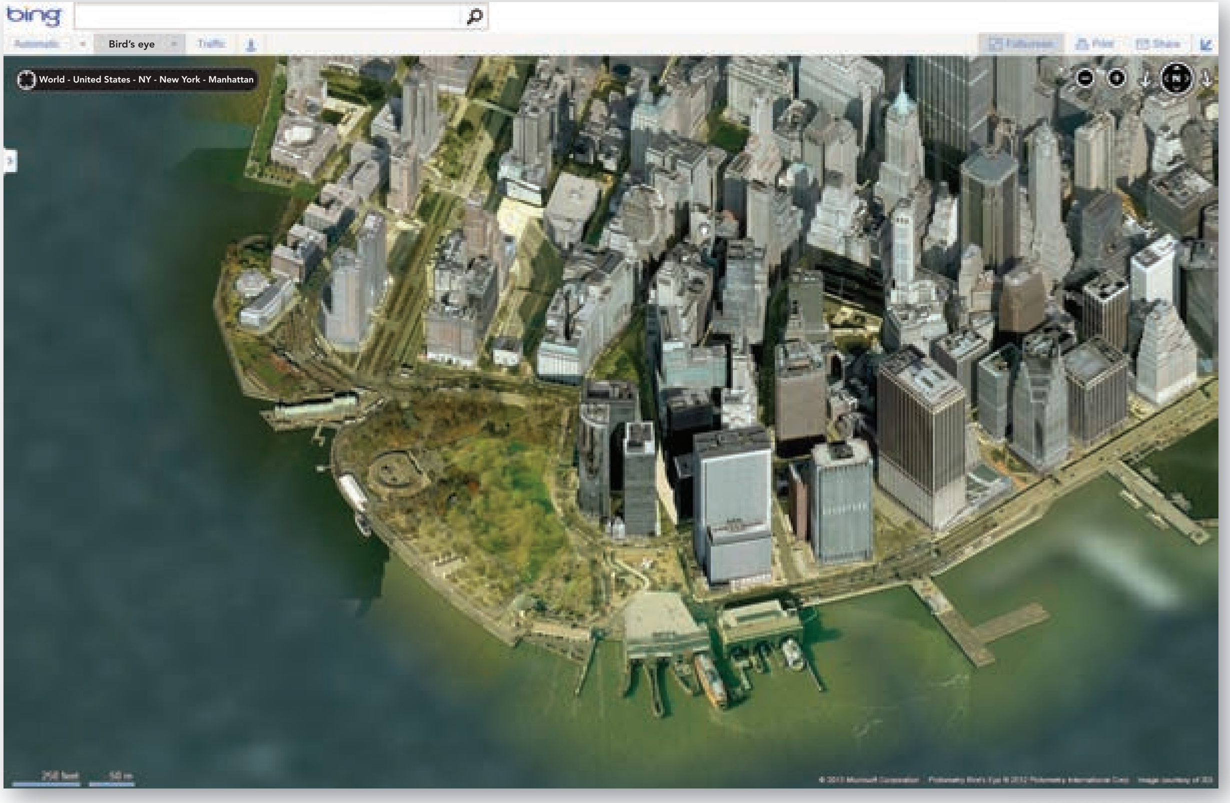


FIGURE A–6 The Microsoft Inc., bing interface was used to view imagery of downtown New York City, NY. High spatial resolution 3Di digital aerial photography is displayed. The user has also specified that Bird's Eye three-dimensional building information available from Pictometry International, Inc. be displayed on top of the remote sensor data (image courtesy of Pictometry International, Inc.; user interface courtesy of Bing, Microsoft, Inc.).

3Di, Sanborn Map Company, Pictometry International, Vexcel Imaging, and others. For example, Figure A-6 depicts high spatial resolution natural color digital aerial photography of a search centered on downtown New York City, NY. Three-dimensional building information provided by Pictometry International's Bird's Eye view is overlaid on top of the imagery. bing also uses public-domain and satellite imagery. Users often extract screen captures of bing imagery for a variety of non-scientific purposes. It is necessary to contact the original data providers to obtain the original remote sensor data.

Esri, Inc., *ArcGIS Online Map and Geoservices*

The Esri, Inc., *ArcGIS Online Map and Geoservices* website offers information associated with basemaps, demographic maps, reference maps, specialty maps, and imagery (Figure A-7) (http://www.esri.com/software/arcgis/arcgis-online-map-and-geoservices/data-doors).

Esri Map Services

Remote sensing investigations almost always require access to other types of geospatial information. Below is a list of numerous types of image and map databases available through *ArcGIS Online* Map Services (http://www.esri.com/software/arcgis/arcgisonline/maps/maps-and-map-layers).

World Imagery Basemap: World Imagery provides ≤ 1 × 1 m satellite or aerial imagery in many parts of the world and lower resolution satellite imagery worldwide. The map includes NASA Blue Marble: Next Generation 500 × 500 m resolution imagery at small scales (above 1:1,000,000), i-cubed 15 × 15 m eSAT imagery at medium-to-large scales (down to 1:70,000) for the world, and USGS 15 × 15 m Landsat imagery for Antarctica. The map features 0.3 × 0.3 m resolution imagery in the continental United States and 0.6 × 0.6 m resolution imagery in parts of Western Europe from DigitalGlobe. In other parts of the world, 1 × 1 m resolution imagery is available from IKONOS, i-cubed Nationwide Prime, Getmapping, AeroGRID, IGN Spain,

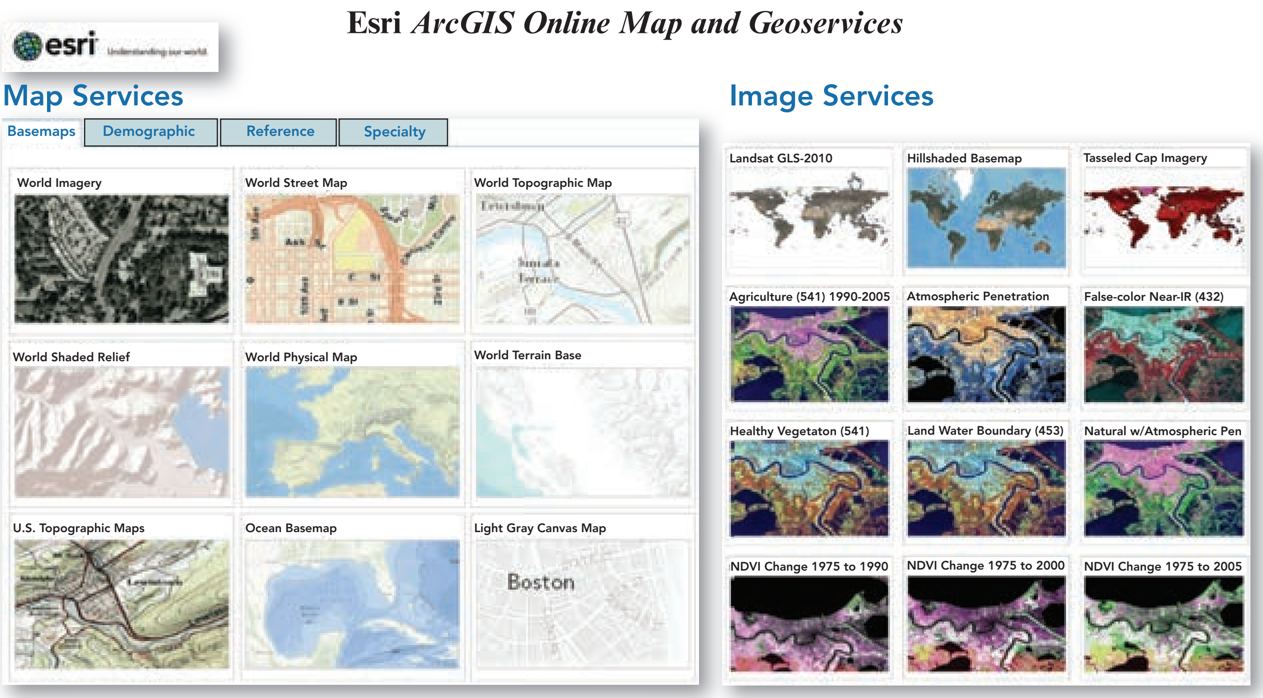


FIGURE A–7 The Esri *ArcGIS Online Map and Geoservices* interface provides access to Map Services (e.g., basemaps, demographic, reference maps, and specialty maps) and Image Services (e.g., Landsat GLS-2010, hillshaded basemap, tasseled cap imagery, and numerous Landsat band combination datasets). It also provides access to the Esri *ChangeMatters*fi program and to *MDA NaturalVue*fi satellite imagery (screenshots and images courtesy of Esri, Inc.).

and IGP Portugal. The dataset also contains data from the USDA Farm Services Agency National Agriculture Imagery Program (NAIP) imagery, USGS Digital Ortho Quarter Quad (DOQQ) imagery, and Aerials Express 0.3 to 0.6 m resolution imagery for several hundred metropolitan areas. Additionally, imagery at different resolutions has been contributed by the GIS User Community.

Other Basemaps: World Street Map, World Topographic Map, World Shaded Relief, World Physical Map, World Terrain Base, USA Topographic Maps, Ocean Basemap, Light Gray Canvas Map, National Geographic World Map, and Landsat Hill-shaded Basemap are available.

Demographic Maps: Details about the U.S. population are available, including: Average Household Size, Daytime Population, Diversity Index, Labor Force Participate Rate Median Age, Median Home Value, Median Household Income, Median Net Worth, Retail Spending Potential, Unemployment Rate, etc.

Reference Maps: World Boundaries and Places, World Boundaries and Places Alternate, World Reference Overlay, and World Transportation are available.

Specialty Maps: DeLorme World Basemap, World Navigation Charts, and Soil Survey Maps.

Esri Image Services

Esri, Inc., provides a very useful array of image services that can be of significant value to people looking for various types of remote sensor data. Below is a summary of several of the most important image services (http://www.esri.com/software/arcgis/arcgis-online-map-and-geoservices/image-services).

Landsat Global Land Survey 2010: The entire Landsat image services collection is available through *ArcGIS Online*. This service was compiled from the USGS/NASA Global Land Survey (GLS) 2010 orthorectified dataset. The dataset includes imagery from Landsat 5 TM and Landsat 7 ETM$^+$ at 30 × 30 m resolution, and includes all reflected energy bands, i.e., Landsat bands 1, 2, 3, 4, 5, and 7. The Landsat 7 data are corrected for Scan Line Corrector (SLC) errors. They were enhanced with radiometric correction and histogram stretching to make them more visually appealing. Landsat 8 data are now available online (http://www.esri.com/esri-news/arcnews/spring14articles/landsat-8-imagery-available-for-online-users).

Landsat Hill-shaded Basemap: Natural color, 15 × 15 m resolution, pan-sharpened Landsat imagery is orthorectified to 50 m RMSE. It is radiometric corrected and enhanced with topographic hill-shading and color balancing to produce a basemap that can be overlaid with other geospatial information using a GIS.

Landsat Color Composites 1975, 1990, 2000, 2005 and 2010: Esri provides Landsat imagery using the following band combinations (RGB = bands x, y, and z):

- False-color/Near-infrared (4,3,2),
- Agriculture (5,4,1),
- Atmospheric Penetration (7,5,4),
- Healthy Vegetation (4,5,1),
- Land/Water Boundary (4,5,3),
- Natural with Atmospheric Penetration (7,4,2),
- Shortwave Infrared (7,4,3),
- True Color/Natural Color (3,2,1), and
- Vegetation Analysis (4,5,3).

Tasselled Cap Service: This image service is based on USGS GLS 2010 orthorectified Landsat data and the tasseled cap transformation discussed in Chapter 7. Tasseled cap data are useful for monitoring vegetation development over a growing season for predicting crop maturity and yield. The Brightness image contains most of the variability in the image and is similar to panchromatic imagery. The Greenness image is useful for discriminating between plant species and quantifying plant vigor and biomass. The Wetness image is related to plant and soil moisture characteristics. The remaining bands contain noise such as haze, clouds and atmospheric affects. Brightness, Greenness and Wetness images are displayed as a color composite (RGB) where bright human-made and natural areas are red, vegetation is in shades of green, and wet or moist features are blue.

Landsat ChangeMatters®: This online service mosaics multiple-date Landsat images irrespective of the Landsat sensor that acquired them (Green, 2011). *ChangeMatters®* displays user-specified individual dates of imagery using standard band combinations, including: near-infrared color composites (e.g.,TM bands 4,3,2) useful for vegetation studies and urban analysis; natural color with atmospheric penetration (e.g., TM bands 7,4,2) best suited for analysis of vegetation and some urban studies; healthy vegetation; land/water boundary detection; and vegetation analysis providing information for agriculture and forest management. The NDVI of the two images is computed on the fly and used to document the change in NDVI between the two images (http://www.esri.com/software/landsat-imagery/viewer). Two examples of the *ChangeMatters®* user interface were presented in Chapter 12.

Esri also provides Landsat NDVI (Normalized Difference Vegetation Index) Change information associated with the following time periods: 1975 to 1990; 1975 to 2000; 1975 to 2005; 1990 to 2000; and 2000 to 2005.

MDA NaturalVue Satellite Imagery®: This dataset presents *NaturalVue®* 15 × 15 m satellite imagery of the world created by MDA Information Systems LLC. *NaturalVue®* is a natural color worldwide seamless mosaic derived over 8,600 Landsat-7 multispectral images. This single global dataset has a positional accuracy of better than 50 m RMSE.

Digital Elevation Data

Accurate digital elevation information is very important for many remote sensing and GIScience applications. A large number of commercial photogrammetric engineering firms and surveying/mapping companies provide access to high-quality digital-elevation information for a fee.

- DRG—Digital Raster Graphics (USGS at www.libremap.org).

Sometimes it is useful to analyze historical topographic information. Fortunately, the hard-copy USGS topographic maps created over many decades have been scanned to create digital raster graphics (DRGs) from the 1:24,000, 1:25,000, 1:63,360 (Alaska), 1:100,000, and 1:250,000-scale topographic map series. Coverage includes the standard USGS series quadrangle maps of the U.S. and its trusts and territories. Information inside the map neatlines is georeferenced to the surface of the Earth and fit to the Universal Transverse Mercator map projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. The maps were scanned at a minimum resolution of 250 dpi. Historical DRGs may be downloaded free from the U.S. Geological Survey at http://libremap.org/.

Several other important sources of digital elevation information are presented in Table A-1, including:

- GTOPO30—World digital elevation model (USGS)
- NED—National Elevation Dataset (USGS)
- Topographic and Bathymetric (USGS, NOAA)
- Topographic Change Information (USGS)
- SRTM—Shuttle RADAR Topography Mission (NASA JPL)
- ASTER Global Digital Elevation Map (METI and NASA JPL), and
- NEXTMap World 30 Digital Surface Model (Intermap, Inc.).

TABLE A-1 Digital Elevation Data.

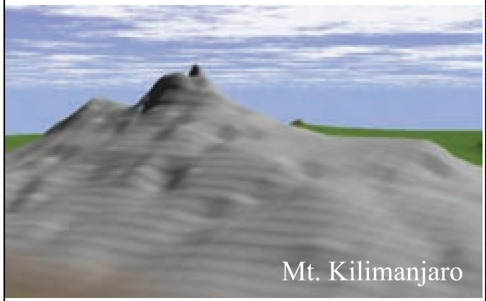
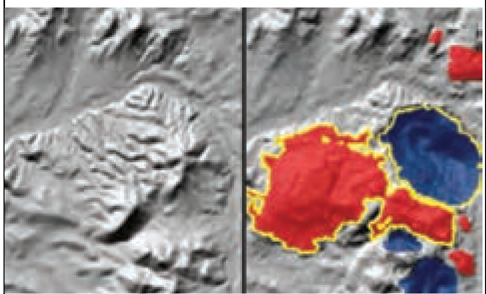
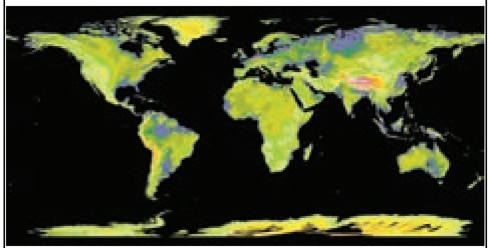
Data	Description	Example
GTOPO30	GTOPO30 is a global digital elevation model with a horizontal grid spacing of 30 arc-seconds (approximately 1 × 1 km). It was derived from numerous sources of topographic information. It has been used extensively for regional, continental, and global studies and for numerous global change applications. Compare this GTOPO30 DEM of Mt. Kilimanjaro with the SRTM DEM to appreciate the coarse resolution of the GTOPO30 data. Source: *http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30_info*.	
NED—National Elevation Dataset	The National Elevation Dataset is the 30 × 30 m resolution elevation layer of *The National Map*. NED has evolved into a multi-resolution dataset that provides the best available elevation data, including 3 × 3 m or better LIDAR-derived elevation data. Source: *http://ned.usgs.gov*. See Gesch (2007) for a detailed description of the National Elevation Dataset characteristics.	
Topographic-Bathymetric Information	Topographic-bathymetric (topobathy) data are merged topography (land elevation) and bathymetry (water depth) data in a single product useful for inundation mapping and other applications. Topography data come from the National Elevation Dataset (NED). Bathymetry data are provided by the NOAA GEOphysical DAta System (GEODAS) .The example depicts topobathy data of a part of the Puget Sound, WA. Source: *http://topotools.cr.usgs.gov/topobathy_viewer/*.	
Topographic Change Information	The need for information on the extent of human geomorphic activity resulted in the creation of the first-ever accounting of topographic change across the U.S. The primary types of topographic changes resulting from human geomorphic activity include surface mining, road construction, urban development, dam construction, and landfills. The example shows: (left) NED DEM of a gold mine in Carlin, NV; (right) cut (blue) and fill (red) areas identified using SRTM-derived DEM. Source: *http://topochange.cr.usgs.gov/topochange_viewer/viewer.htm*.	
SRTM—Shuttle RADAR Topography Mission	SRTM data were obtained by the Space Shuttle *Endeavour* in 2000. SRTM acquired data for over 80 percent of the Earth's land surface between 60 degrees N and 56 degrees S latitude. SRTM images are available at no charge as FTP downloads. Compare the GTOPO30 DEM of Mt. Kilimanjaro with the SRTM DEM to appreciate the fine spatial resolution of the SRTM-derived DEM. Source: *http://srtm.usgs.gov/index.php*.	

TABLE A-1 Digital Elevation Data (continued).

Data	Description	Example
ASTER Global Digital Elevation Model (GDEM V2)	The Japanese Ministry of Economy, Trade, and Industry (METI) and NASA released the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model Version 2 (GDEM V2) on October 17, 2011. ASTER GDEM coverage is from 83 degrees N to 83 degrees S latitude, encompassing 99 percent of Earth's landmass. The improved GDEM V2 adds 260,000 additional stereo-pairs, improving coverage and reducing the occurrence of artifacts. The ASTER GDEM V2 is in GeoTIFF format with 30-m postings and 1 × 1 degree tiles. ASTER GDEM V2 data are available free to users worldwide from the Land Processes Distributed Active Archive Center (LP DAAC) and J-spacesystems. The GDEM V2 coverage is shown. Source: *http://asterweb.jpl.nasa.gov/gdem.asp*.	
NEXTMap World 30 DSM (Intermap, Inc.)	Intermap Technologies, Inc., NEXTMap World 30 DSM is a combination of 90-m Shuttle Radar Topographic Mission (SRTM) v2.1 data, 30-m ASTER Global DEM v2.0, and 1-km GTOPO30 data which has been ground controlled using LiDAR data from NASA's Ice, Cloud and Land Elevation Satellite (ICESat) collection, resulting in a 25-cm RMSE dataset for vertical control of the DSM. The resulting product is a 30-m GSD DSM that covers the entire land mass of the planet.	*http://www.intermap.com/en-us/databases/world30.aspx*

Hydrography Data

Hydrologic information is critical to the successful modeling of many natural (e.g., streams) and human-made (e.g., canals) geospatial relationships. Table A-2 summarizes the availability of detailed hydrologic information from:

- NHD—National Hydrologic Database (USGS)
- EDNA—Elevation Derivatives for National Applications (USGS).

Land Use/Land Cover and Biodiversity/Habitat Data

Land use is the human use of the terrain. *Land cover* is the biophysical material present on the surface of the Earth such as vegetation, soil, water, rocks, etc. The land cover is the habitat for animals, birds, and aquatic species. Several of the more important land use/land cover and biodiversity/habitat resources are presented in Table A-3, including:

- NLCD—National Land Cover Database (USGS)
- C-CAP—Coastal Change Analysis Program (NOAA)
- GAP Analysis Program (USGS)
- NWI—National Wetlands Inventory (USFWS)

In addition, there is the *National Phenology Network*. Phenology is the study of nature's calendar. For example, the network contains information about when peach trees blossom, when alligators build their nests, when salmon swim upstream to spawn, or when corn is fully ripe. The National Coordinating Office of the Network is a resource center that facilitates and encourages widespread collection, integration, and sharing of phenology data and related information. Source: *USA National Phenology Network, 1955 East 6th Street, Tucson, AZ 85721*.

TABLE A-2 Hydrologic Information.

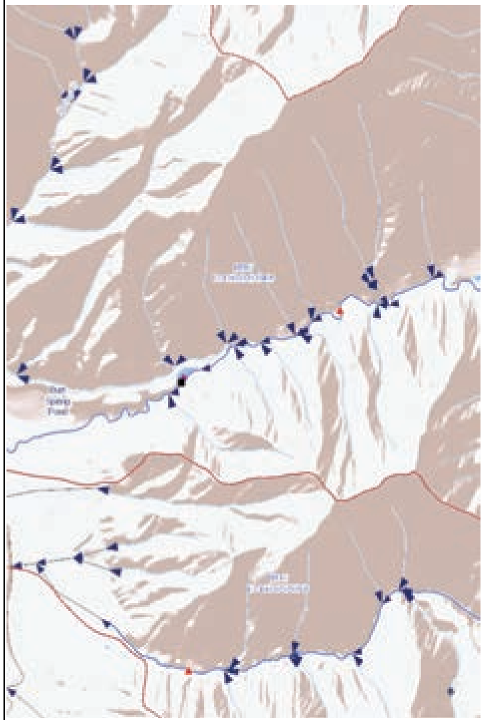
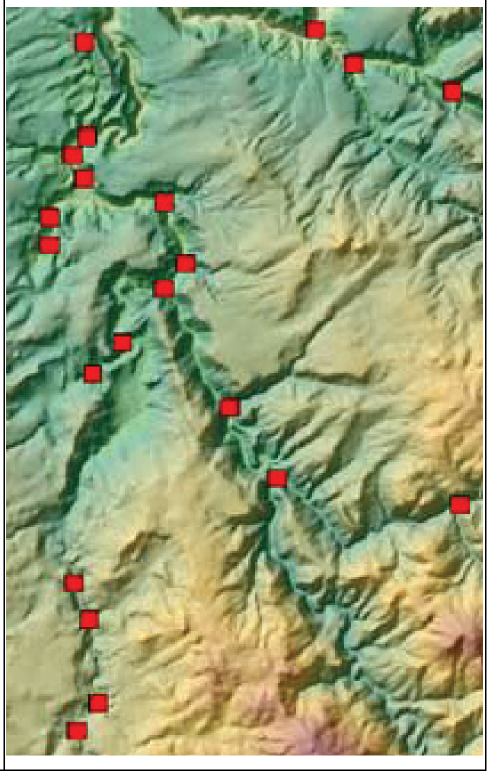
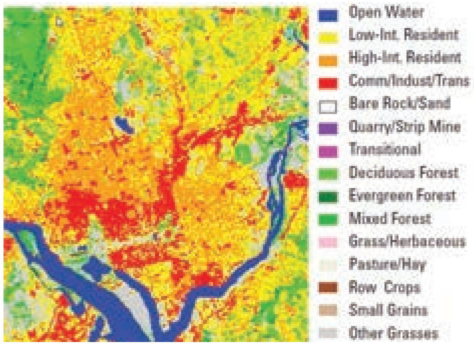
Data	Description	Example
NHD—National Hydrography Dataset	The NHD is the surface water component of *The National Map*. The NHD is a digital vector dataset easily used in GIS hydrologic analysis. It contains features such as lakes, ponds, streams, rivers, canals, dams, and stream gages. These data are designed to be used in general mapping and in the analysis of surface-water systems.The NHD contains vector-surface-water-hydrography information obtained from topographic maps and additional sources. It is available nationwide as medium resolution at 1:100,000-scale and as high resolution at 1:24,000-scale or better. In Alaska, the NHD is available at 1:63,360-scale. A few "local resolution" areas are available at varying scales. The hydrography of the U.S. is organized by drainage areas. The sub-basin 8-digit Hydrologic Unit Code (HUC) drainage area is the most practical area for high resolution NHD. Subregions (4-digit HUCs) are composed of varying numbers of subbasins. The NHD is available in an Esri personal geodatabase format known as NHDinGEO, a file-based geodatabase format, and in Esri shapefile format known as NHDGEOinShape. The NHD is organized by hydrologic units, but can be downloaded in various geographic extents. This map displays NHD data of Hobble Creek, UT. Source: *http://nhd.usgs.gov/.*	
EDNA—Elevation Derivatives for National Applications	EDNA is a multi-layered database derived from the NED, which has been hydrologically conditioned for improved hydrologic flow modeling. The seamless EDNA database provides 30 × 30 m raster and vector data layers including: Aspect Contours Filled DEM Flow Accumulation Flow Direction Reach Catchment Seedpoints Reach Catchments Shaded Relief Sinks Slope Synthetic Streamlines Hydrologically conditioned elevation data, processed to create hydrologic derivatives, can be useful in many topologically based hydrologic visualization and investigative applications. Drainage areas upstream or downstream from any location can be accurately traced, facilitating flood analysis investigations, pollution studies, and hydroelectric power generation projects. This is a map of reach catchment seedpoints. Source: *http://edna.usgs.gov/.*	

TABLE A-3 Land Use/Land Cover and Biodiversity/Habitat Information.

Data	Description	Example
NLCD—National Land Cover Database 1992, 2001, 2006, 2011	The Multi-Resolution Land Characteristics (MRLC) Consortium developed the NLCD, which is a 16 to 21 class land cover dataset of the U.S. derived from 30 × 30 m Landsat TM data. The NLCD state datasets are extracted from regional datasets that are mosaics of Landsat TM scenes. NLCD 1992 is a land-cover dataset. NLCD 2001 is a land-cover database composed of three elements: land cover, impervious surface, and canopy density. NLCD 2006 and 2011 are now available to the public. The land cover in Washington, DC, in 1992 is shown. Source: *http://www.mrlc.gov/*.	
C-CAP—Coastal Change Analysis Program	C-CAP is a database of land cover and land cover change for the coastal regions of the U.S. produced every 5 years. C-CAP provides inventories of coastal intertidal areas, wetlands, and adjacent uplands. The products consist of land cover maps for each date of analysis, as well as a file that highlights what changes have occurred between these dates. NOAA also produces high resolution C-CAP land cover products, for select geographies. C-CAP provides the "coastal expression" of the NLCD, and contributes to the Earth Cover layer of the National Spatial Data Infrastructure. The example shows C-CAP data of Pearl Harbor, HI. Source: *http://coast.noaa.gov/digitalcoast/data/ccapregional/?redirect=301ocm*.	
GAP Analysis Program	The GAP Analysis Program is part of the National Biological Information Infrastructure (NBII). The goal is to keep common species common by protecting them *before* they become threatened. GAP activities focus on the creation of state and regional databases and maps that depict patterns of land management, land cover, and biodiversity. These data can be used to identify "gaps" in conservation where an animal or plant community is not adequately represented on the existing network of conservation lands. The example depicts the U.S. GAP land cover map which contains 551 ecological systems and modified ecological systems. Source: *http://gapanalysis.usgs.gov/*.	
NWI—National Wetlands Inventory	The U.S. Fish & Wildlife Service's National Wetlands Inventory provides current geospatial data on the status, extent, characteristics, and functions of wetland, riparian, deepwater, and related aquatic habitats in priority areas to promote the understanding and conservation of these resources. The NWI serves on-line map information for 82% of the conterminous United States, 31% of Alaska, and 100% of Hawaii. The goal is to complete and maintain a seamless digital wetlands dataset for the entire nation that will become the Wetlands Data Layer of the NSDI. The NWI example is of Crayvik, FL. Source: *http://www.fws.gov/wetlands/*.	

Road Network and Population Demographic Data

Topologically correct road-network information is indispensable for navigation, business decision making and for use in various remote sensing investigations. The U.S. Census Bureau provides the MAF/TIGER—Master Address File/Topologically Integrated Geographic Encoding and Reference System free of charge to the public. Details are provided in Table A-4.

The Census Bureau also provides population demographic information aggregated to various spatial enumeration districts (Table A-4).

LandScan, created by the Oak Ridge National Laboratory, predicts the spatial distribution of people at different times of day anywhere in the world at a spatial resolution of 1 × 1 km (Table A-4).

Remote Sensor Data—Public

Remote sensing data are available from orbital and aerial platforms and sensors. Table A-5 provides information about some of the public remote sensing systems commonly used to collect data.

- ALI—Advanced Land Imager (NASA)
- ASTER—Advanced Spaceborne Thermal Emission and Reflection Radiometer (NASA)
- AVHRR—Advanced Very High Resolution Radiometer (NOAA)
- AVIRIS—Advanced Visible Infrared Imaging Spectrometer (NASA)
- Declassified Satellite Imagery (USGS)
- DOQ—Digital Orthophoto Quadrangles (USGS)
- Hyperion—Hyperspectral Imager (NASA)
- Landsat Multispectral Scanning System (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM^+), and Landsat 8 (NASA/USGS)
- LiDAR—Light Detection and Ranging (USGS)
- MODIS—Moderate Resolution Imaging Spectrometer (NASA)
- NAIP—National Agriculture Imagery Program (USDA)
- Suomi—NPOESS Preparatory Project (NPP) (NOAA).

Remote Sensor Data—Commercial and International

Remote sensor data available from selected commercial and international vendors are provided in Table A-6.

- CASI-1500, SASI-600, MASI-600 and TASI-600 (ITRES, Inc.)
- EROS A and EROS B (ImageSat Intl., Inc.)
- GeoEye-1 and GeoEye-2 (DigitalGlobe, Inc.)
- HyMap Hyperspectral imagery (HyVista, Inc.)
- IKONOS-2 (DigitalGlobe, Inc.)
- Indian IRS A-D, CartoSat 1-3, ResourceSat 1-2 (www.isro.gov.in)
- Korean KOMPSAT 1-5 (http://www.kari.re.kr)
- Pictometry (EagleView Technologies, Inc.)
- Pleiades-1 and Pleiades-2 (www.astrium-geo.com)
- QuickBird (DigitalGlobe, Inc.)
- RapidEye (RapidEye, Inc.)
- Sentinel-2 (European Space Agency)
- SPOT 1-6 (www.astrium-geo.com)
- WorldView-1, WorldView-2, WorldView-3 (Digital Globe, Inc.).

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Green, K., 2011, “Change Matters,” *Photogrammetric Engineering & Remote Sensing*, 77(4):305–309.

Moe, D. and R. Longhenry, 2013, “Metrically Preserving the USGS Aerial Film Archive,” *Photogrammetry Engineering & Remote Sensing*, 79(3):225–228.

USGS NGP, 2014, *National Geospatial Program*, http://www.usgs.gov/ngpo.

TABLE A-4 Road Network and Population Demographic Information.

Data	Description	Example
MAF/TIGER/ Line	TIGER/Linefi Shapefiles are spatial data extracts from the U.S. Census Bureau MAF/TIGER database (Master Address File/Topologically Integrated Geographic Encoding and Referencing System), containing features such as topologically correct roads, railroads, and rivers, as well as legal and statistical geographic areas. They are available to the public at no charge and are typically used to provide the digital base map for GIS software.The TIGER/Linefi Shapefiles do not include demographic data, but they contain geographic entity codes that can be linked to the Bureau's demographic data, available on American FactFinder described below. The TIGER /Line Shapefiles are provided in four types of coverages: County-based State-based Nation-based American Indian Area-based Source: *http://www.census.gov/geo/maps-data/data/tiger.html.*	
2010 Census Population Demographics	The 2010 Census reported that 308.7 million people live in the U.S., a 9.7 percent increase from the 2000 Census population of 281.4 million. Below are some of the most important 2010 United States Census products (tabular and feature-based). *American FactFinder (AFF)* The AFF is a data access system that will find and retrieve geographic information and plot the information on an interactive map. Source: *http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.* *Cartographic Boundary Files* Generalized, digital files suitable for use with GIS in small-scale thematic mapping. Source: *http://www.census.gov/geo/maps-data/data/tiger-cart-boundary.html.* *Census 2010 County Block Maps* Color maps, showing census blocks, voting districts, and other feature details. Source: *http://www.census.gov/geo/maps-data/maps/block/2010/.* *Voting District/State Legislative District Reference Maps* Color maps, showing voting districts and/or state legislative districts. Source: *http://www.census.gov/geo/maps-data/maps/reference-sld.html.*	
LandScan Population Distribution Modeling	*LandScan* was developed by Oak Ridge National Laboratory (ORNL) through funding by the DOD and the DOE. At approximately 1 × 1 km, *LandScan* is the highest resolution global population distribution data available and represents an ambient population (average over 24 hours). The *LandScan* algorithm uses spatial data and image analysis technologies and a multivariable dasymetric modeling approach to disaggregate census counts within an administrative boundary. *LandScan* population distribution models are tailored to match the data conditions and geographical nature of individual countries and regions. The *LandScan* dataset is available free to U.S. Government agencies. Others, such as educational institutions or research scientists, must register with *LandScan* to determine license fees (if any) for obtaining *LandScan* resources. The data are distributed in both an ESRI grid format and an ESRI binary raster format. The dataset has 20,880 rows and 43,200 columns covering north 84 degrees to south 90 degrees and west 180 degrees to east 180 degrees. Source: *http://www.ornl.gov/sci/landscan/index.shtml.*	

TABLE A-5 Remote Sensor Data—Public.

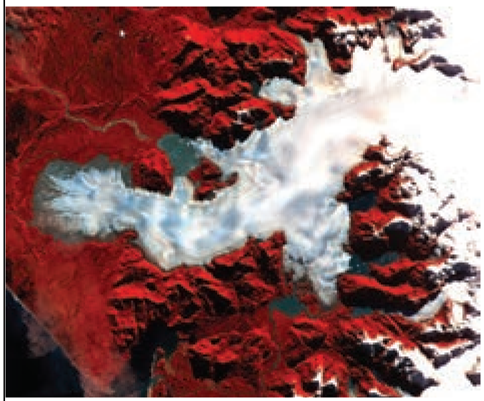
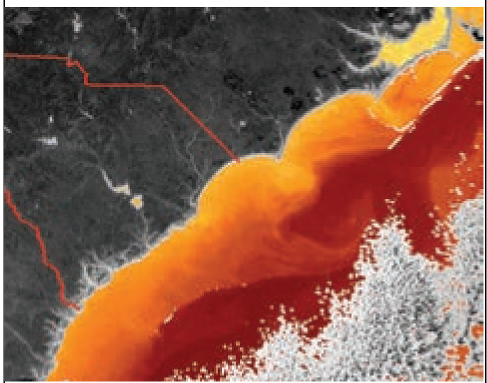
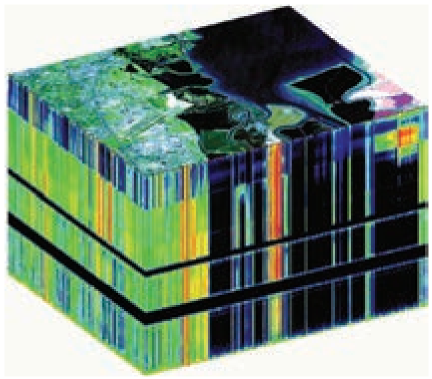
Data	Description	Example
ASTER—Advanced Spaceborne Thermal Emission and Reflection Radiometer	ASTER is carried onboard NASA's *Terra* satellite. ASTER began data collection in 2000 and consists of three sensors that obtain images in multiple spatial resolutions (15 × 15, 30 × 30, and 90 × 90 m). ASTER is the only high-resolution imaging sensor on *Terra*. The primary goal of the ASTER mission is to obtain high-resolution image data in 14 channels (including thermal infrared) over the entire land surface, as well as black and white stereo images. With a revisit time of between 4 and 16 days, ASTER provides repeat coverage of changing areas on Earth's surface. This is an ASTER image of the Patagonia Glacier in Chile obtained on May 2, 2000. Source: *http://asterweb.jpl.nasa.gov/gdem.asp*.	
AVHRR—Advanced Very High Resolution Radiometer	The Advanced Very High Resolution Radiometer (AVHRR) is an optical multispectral scanner flown aboard NOAA orbiting satellites. The instrument measures reflected sunlight and emitted radiation (heat) from Earth in the visible (Channel 1), near-infrared (Channel 2), and thermal infrared (Channels 3, 4, and 5) regions of the electromagnetic spectrum. There is fairly continuous global coverage since June 1979, with morning and afternoon acquisitions available. The resolution is 1.1 × 1.1 km at nadir. This is an image of the Gulf Stream off of North and South Carolina. Source: *http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/AVHRR*.	
AVIRIS—Airborne/Visible Imaging Spectrometer	AVIRIS is a unique optical sensor that delivers calibrated images of the upwelling spectral radiance in 224 contiguous spectral channels (bands) with wavelengths from 400 to 2,500 nanometers. The main objective of the AVIRIS remote sensing system is to identify, measure, and monitor constituents of the Earth's surface and atmosphere based on molecular absorption and particle scattering signatures. Research with AVIRIS data is predominantly focused on understanding processes related to the global environment and climate change. This is an AVIRIS image of the lower portion of the San Francisco Bay, California. Source: *http://aviris.jpl.nasa.gov/*.	
Declassified Satellite Imagery	Almost 90,000 declassified satellite images are maintained in the USGS EROS declassified satellite image archive. The images were captured by a variety of intelligence satellites, including CORONA, ARGON, LANYARD, KH-7, and KH-9 between 1960 and 1980. Coverage is global, but the geographic distribution is uneven. Some images are high resolution (although not georeferenced). This is an image of the western edge of Dakar, Senegal, Africa, acquired by the KH-7 satellite in 1966. Source: *http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/Declassified_Satellite_Imagery_-_2*.	

TABLE A-5 Remote Sensor Data—Public (continued).

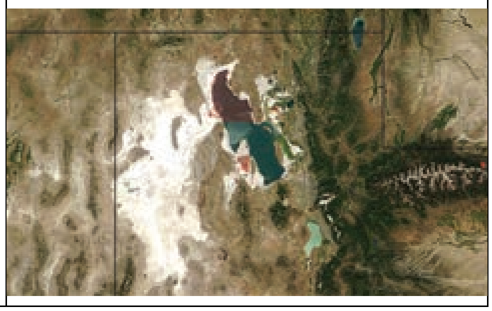
Data	Description	Example
DOQ—Digital Orthophoto Quadrangles	A Digital Orthophoto Quadrangle (DOQ) is a computer-generated image of an aerial photograph in which the image displacement caused by terrain relief and camera tilt has been removed. The DOQ combines the image characteristics of the original photograph with the georeferenced qualities of a map. DOQs can be black-and-white (B/W), natural color, or color-infrared (CIR) images with 1 × 1 m ground resolution. They cover an area measuring 3.75-minutes longitude by 3.75-minutes latitude or 7.5-minutes longitude by 7.5-minutes latitude. A CIR DOQ of downtown Washington, DC, is shown. Source: *https://lta.cr.usgs.gov/DOQs*.	
Landsat—MSS, TM ETM$^+$, Landsat 8	The first two Earth Resources Technology Satellite (ERTS) were launched in 1972 and 1975. They were subsequently renamed Landsat satellites. Additional Landsat satellites were launched in 1978, 1982, 1984, 1993 (did not achieve orbit), 1999 and 2013. The Landsat satellites have carried a variety of sensors, including the Multispectral Scanning System (MSS; 80 × 80 m), Thematic Mapper (TM; 30 and 60 m), and Enhanced Thematic Mapper (ETM$^+$; 15, 30 and 60 m). Landsat 8 was launched on February 11, 2013, with its Operational Land Imager; 15 and 30 m) and Thermal Infrared Sensors (100 m). All Landsat data acquired from 1972 are available at no charge from the USGS. A Landsat 7 image draped over an SRTM digital elevation model of southern Malawi, Africa, near the Mozambique border is shown. Source: *http://landsat.gsfc.nasa.gov/images/archive/f0005.html*.	
LiDAR— Light Detection and Ranging	LiDAR data collection is one of the most important sources of digital surface models that provide detailed information about the *x,y*, and *z*-location of masspoints for all features on the surface of the Earth. With accurate processing, the masspoints can be edited to produce bare-earth digital terrain models. Additional processing can yield biophysical information about the vegetation. LiDAR can also be used to obtain bathymetric information in shallow clear water. *Click* is the USGS Center for LiDAR Information Coordination and Knowledge at *http://lidar.cr.usgs.gov/*.	
MODIS—Moderate Resolution Imaging Spectrometer	MODIS is flown on both the NASA *Aqua* and *Terra* satellites. It collects data in 36 spectral bands at three spatial resolutions: 250 × 250, 500 × 500, and 1,000 × 1,000 m. MODIS collects imagery of the entire Earth every 1 to 2 days. The data are excellent for regional, continental, and global analyses of relatively small-scale problems such as dynamic land, ocean, ice, and atmospheric processes and global environmental change. Source: *http://modis.gsfc.nasa.gov/gallery/#*.	

TABLE A-5 Remote Sensor Data—Public (continued).

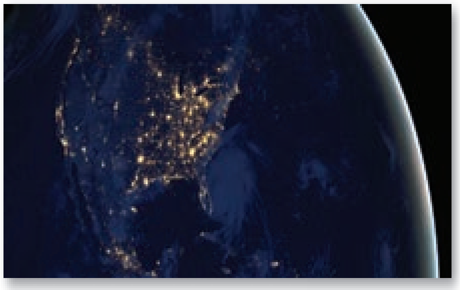
Data	Description	Example
NAIP—National Agriculture Imagery Program	The NAIP acquires imagery during the agricultural peak growing seasons for the conterminous United States. The "leaf-on" orthophoto images are at 1 × 1 m or 2 × 2 m spatial resolutions. The 1 × 1 m imagery provides updated digital orthophoto imagery. The 2 × 2 m imagery supports the USDA Farm Services programs that require current imagery acquired during the agricultural growing season but do not require a higher resolution. Included in this imagery category is 1 × 1 m data acquired through certain state programs as "leaf-off." Source: *http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai*.	
Suomi—NPOESS Preparatory Project	The Suomi NPOESS Preparatory Project (NPP) satellite was launched on October 28, 2011. It has five imaging systems, including: Visible Infrared Radiometer Suite (VIIRS) consisting of 22 channels between 0.4 and 12 μm; Advanced Technology Microwave Sounder (ATMS); Cross-track Infrared Sounder (CrIS); Ozone Mapping and Profiler suite (OMPS); and Clouds and the Earth's radiant Energy System (CRES) radiometer. This image of the continental U.S. at night is a composite assembled from data acquired by the Suomi NPP satellite in April and October 2012. The image was made possible by the "day-night band" of the VIIRS, which detects light in a range of wavelengths from green to near-infrared and uses filtering techniques to observe dim signals such as city lights, gas flares, auroras, wildfires and reflected moonlight. Credit: NASA Earth Observatory/NOAA NGDC. Source: *http://npp.gsfc.nasa.gov/*.	

TABLE A-6 Remote Sensor Data—Commercial and International.

Data	Description	Source
CASI-1500 SASI-600 MASI-600 TASI-600	ITRES, Inc. of Canada markets several airborne optical hyperspectral remote sensing systems: [CASI-1500 (0.37 – 1.05 μm) and SASI-600 (0.95 – 2.45 μm)], and hyperspectral thermal infrared systems: [MASI-600 (4 – 5 μm) and TASI-600 (8 – 11.5 μm)]. Typical ground spatial resolution is between 1 and 10 m.	*www.itres.com*
EROS A EROS B	EROS A was launched on December 5, 2000, with a single 1.9 × 1.9 m panchromatic band (0.5 – 0.9 μm). EROS B was launched on April 25, 2006, with the identical sensor.	*www.imagesatintl.com*

TABLE A-6 Remote Sensor Data—Commercial and International (continued).

Data	Description	Source
GeoEye-1 **GeoEye-2**	GeoEye-1 was launched on September 6, 2008, with a 0.41 × 0.41 m panchromatic band and four 1.65 × 1.65 m multispectral bands. GeoEye-2 has a 0.25 × 0.25 m panchromatic band and four 1.65 × 1.65 m multispectral bands. GeoEye, Inc. merged with DigitalGlobe, Inc. in February, 2013.	*www.digitalglobe.com*
HyMap	Airborne HyMap hyperspectral data are recorded in 128 bands in the region from 450 – 2,480 nm. Typical ground resolution is between 2 and 10 m.	*www.hyvista.com*
IKONOS-2	IKONOS-2 was launched on April 27, 1999. It has a 0.82 × 0.82 m panchromatic band and four 3.2 × 3.2 m multispectral bands. GeoEye, Inc. merged with DigitalGlobe, Inc. in February, 2013.	*www.digitalglobe.com*
Indian **IRS-1A** **IRS-1B** **IRS-1C** **IRS-1D** **CartoSat-1** **CartoSat-2** **CartoSat-2A** **Cartosat-2B** **Cartosat-3** **ResourceSat-1** **ResourceSat-2**	The Indian Space Research Organization (ISRO) launched IRS-1A on March 17,1988; IRS-1B on August 29, 1991; IRS-1C on December 28, 1995; and IRS-1D on September 29, 1997. CartoSat-1 was launched on May 5, 2005, with a 2.5 × 2.5 m panchromatic band on two cameras. CartoSat-1A will have 1.25 × 1.25 m pan band, 2.5 × 2.5 m multispectral bands, and 30 × 30 m hyperspectral bands. CartoSat-2 was launched on January 10, 2007, with a 1 × 1 m pan band. CartoSat-2A was launched on April 28, 2008, with the same specifications. CartoSat-2B was launched on July 12, 2010, with a 1 × 1 m pan band. CartoSat-3 will have a 0.25 × 0.25 pan band. ResourceSat-1 was launched on October 17, 2003, with three sensors recording imagery at 5.8 × 5.8 m, 23.5 × 23.5 m, and 56 × 56 m spatial resolutions. ResourceSat-2 was launched on April 20, 2011, with swath width improvements.	*www.isro.gov.in*
Korean **KOMPSAT-1** **KOMPSAT-2** **KOMPSAT-3** **KOMPSAT-4** **KOMPSAT-5**	The Korean Aerospace Research Institute (KARI) launched KOMPSAT-1 on December 21, 1999, with 6 × 6 m panchromatic band. It was retired in 2008. KOMPSAT-2 was launched on July 27, 2006, and has a 1 × 1 m panchromatic band and four 4 × 4 m multispectral bands. KOMPSAT-3 was launched on May 18, 2012, with a 0.8 × 0.8 m panchromatic band and a 4 × 4 m VNIR multispectral sensor. KOMPSAT-3A will have sensors similar to KOMPSAT-3 except for a 5.5 × 5.5 m thermal infrared band in the region 3 – 6 μm. KOMPSAT-5 is to have a Synthetic Aperture Radar (SAR) that can acquire data at 1 × 1 m spatial resolution.	*http://www.kari.re.kr (Korean)*
PICTOMETRY	Pictometry International and EagleView Technologies merged in 2013. Pictometry imagery consists of a single Nadir (vertical) image and four low-oblique images (North, East, South, and West) collected at each exposure station. Natural color and color-infrared imagery can be collected. The flightlines overlap by 20% to 30% resulting in a great diversity of views of each terrain object.	*www.eagleview.com/Products/ImageSolutionsAnalytics/PictometryImagery.aspx*

TABLE A-6 Remote Sensor Data—Commercial and International (continued).

Data	Description	Source
Pleiades-1 **Pleiades-2**	Pleiades-1 was launched on December 17, 2011, and Pleiades-2 was launched on December 2, 2012. Each satellite sensor has a 0.5 × 0.5 m panchromatic band and four multispectral bands at 2 × 2 m spatial resolution.	*www.astrium-geo.com/pleiades/*
QuickBird	DigitalGlobe, Inc. launched QuickBird on October 18, 2001, with a 0.65 × 0.65 m panchromatic band and four 2.62 × 2.62 m multispectral bands.	*www.digitalglobe.com*
RapidEye	Five identical RapidEye satellites were launched on August 29, 2008. Each RapidEye sensor system has five multispectral bands at 6.5 × 6.5 m spatial resolution (5 × 5 m when processed to become orthoimagery).	*www.rapideye.com*
Sentinel-2	The European Space Agency (ESA) is developing a new family of missions called Sentinels specifically for the operational needs of the Copernicus programme. Sentinel-2 will have a Multi-Spectral Instrument (MSI) with a total of 13 bands: 4 VNIR bands (400 – 750 nm) at 10 × 10 m, 6 SWIR bands (1,300 – 3,000 nm) at 20 × 20 mm and 3 bands at 60 m spatial resolution dedicated to atmospheric correction and cloud screening.	*www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2*
SPOT 1 **SPOT 2** **SPOT 3** **SPOT 4** **SPOT 5** **SPOT 6** **SPOT 7**	SPOT 1, 2, and 3 are retired and SPOT 4, 5, and 6 are operational. Archived SPOT 1, 2, and 3 data have a 10 × 10 m panchromatic band and three 20 × 20 m multispectral bands. SPOT 4 has a 10 × 10 m panchromatic band, three 20 × 20 m multispectral bands, and one 20 × 20 m SWIR band. SPOT 5 has a 2.5 × 2.5 m panchromatic band, three 10 × 10 m multispectral bands and one 20 × 20 m SWIR band. SPOT 4 and SPOT 5 have a unique 1.15 × 1.15 km Vegetation sensor with four multispectral bands. SPOT 6 was launched on September 9, 2012, with a 1.5 × 1.5 m panchromatic band and four multispectral bands at 6 × 6 m spatial resolution. SPOT 7 was launched on June 30, 2014, with the same payload as SPOT 6.	*www.astrium-geo.com/en/147-spot-6-7-satellite-imagery*
WorldView-1 **WorldView-2** **WorldView-3**	WorldView-1 was launched on September 18, 2007, with a 0.5 × 0.5 m panchromatic band. WorldView-2 was launched October 8, 2009, with a 0.46 × 0.46 m panchromatic band and eight multispectral bands at 1.85 × 1.85 m spatial resolution. WorldView-3 was launched on August 13, 2014, with a 0.31 × 0.31 m panchromatic band, eight 1.24 × 1.24 m multispectral bands, and eight 3.7 × 3.7 m SWIR bands. In June, 2014, DigitalGlobe received permission from the U.S. Department of Commerce to sell WorldView-3 imagery at their best available resolution: 0.25 × 0.25 m panchromatic and 1 × 1 m multispectral.	*www.digitalglobe.com*

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