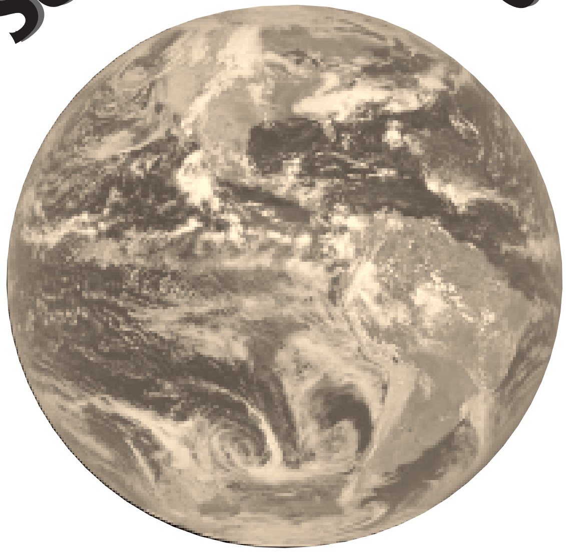
Science Writers' Guide to Landsat 7



From monitoring croplands in Arizona to mapping ice streams in the Antarctic, Landsat 7 will advance earth science research.

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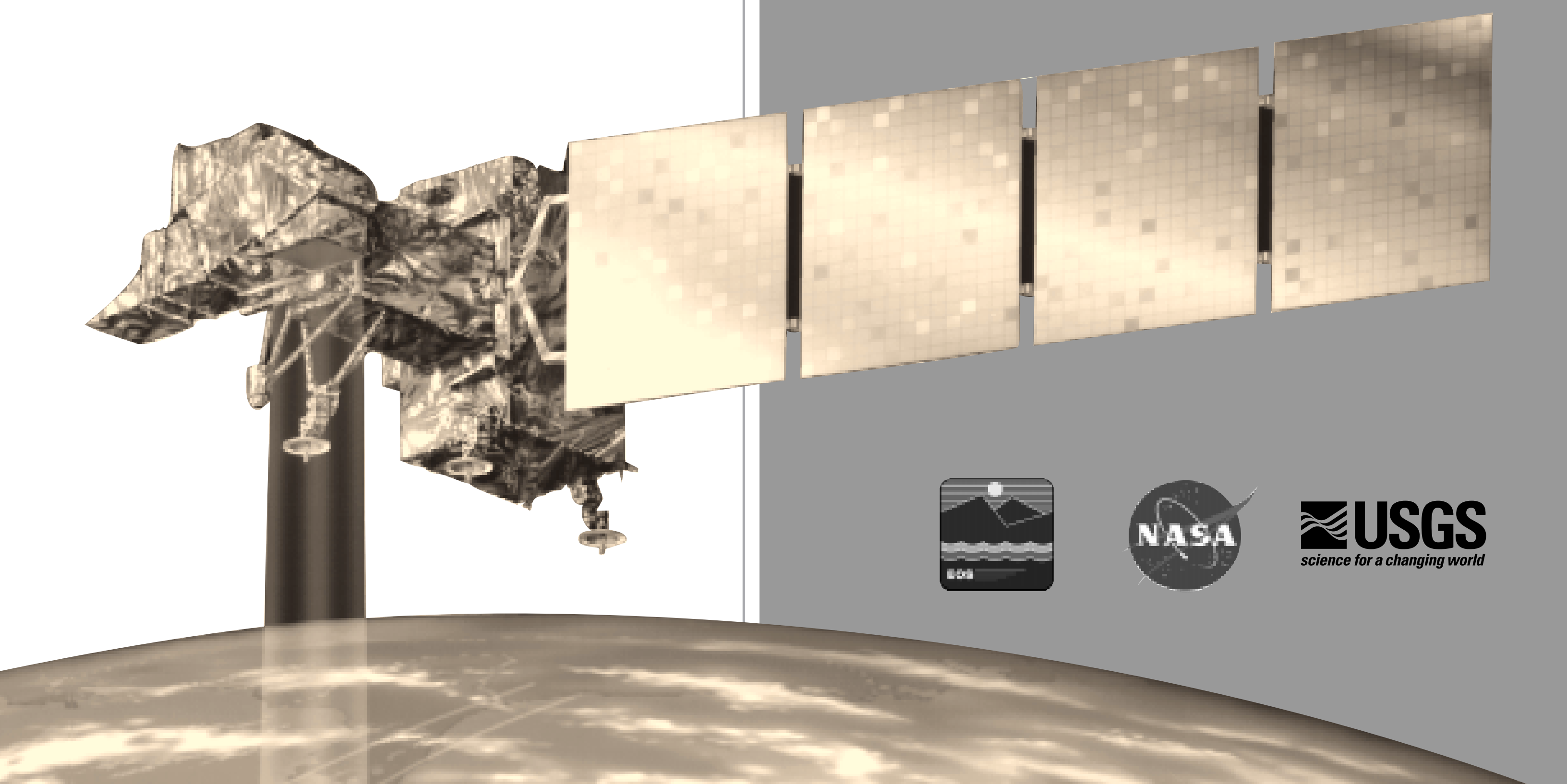

NASA's Earth Observing System

The Earth Observing System (EOS), the centerpiece of NASA's Earth science program, is a suite of spacecraft and interdisciplinary science investigations dedicated to advancing our understanding of global change.

The flagship EOS satellite, Terra (formerly EOS AM-1), scheduled for launch in July 1999, will provide key measurements of the physical and radiative properties of clouds; air-land and air-sea exchanges of energy, carbon, and water; trace gases; and volcanoes. Flying in formation with Terra, Landsat 7 will make global high spatial resolution measurements of land surface and surrounding coastal regions.

Other upcoming EOS missions and instruments include QuikSCAT, to collect sea surface wind data; the Stratospheric Gas and Aerosol Experiment (SAGE III), to create global profiles of key atmospheric gases; and the Active Cavity Radiometer Irradiance Monitors (ACRIM) to measure the energy output of the Sun. The second of the major, multi-instrument EOS platforms, PM-1, is scheduled for launch in 2000.

Interdisciplinary research projects sponsored by EOS use specific Earth science data sets for a broader investigation into the function of Earth systems. Current EOS research spans a wide range of sciences, including atmospheric chemistry, hydrology, land use, and marine ecosystems.

The EOS program has been managed since 1990 by the Goddard Space Flight Center in Greenbelt, Md., for NASA's Office of Earth Science in Washington, D. C. Additional information on the program can be found on the EOS Project Science Office Web site (http://eospso.gsfc.nasa.gov).

Evolution of the Landsat Program

Landsat is the United States' oldest land-surface observation satellite system. Although the program has scored numerous successes in scientific and resource-management applications, Landsat has had a tumultuous history of management and funding changes over its 26-year history. Landsat 7 marks a new direction in the program to reduce the costs of data and increase global coverage for use in global change research.

The diversity of Landsat applications makes it unique among Earth observation satellites. Images acquired by Landsat satellites were used to produce the first composite multispectral mosaic of the 48 contiguous United States. They have been used to monitor timber losses in the U.S. Pacific Northwest, map the extent of winter snow pack, and measure forest cover at the state level. In addition, Landsat has been used in to locate mineral deposits, monitor strip mining, and assess natural changes due to fires and insect infestations.

NASA launched the first satellite in the Landsat series (originally called the Earth Resources Technology Satellites) on July 23, 1972. The program was given the name Landsat in 1975. Efforts to move the Landsat program into the commercial sector began under the Carter Administration in 1979 and resulted in legislation passed in 1984 that charged the National Oceanic and Atmospheric Administration (NOAA) to transfer the program to the private sector. The Earth Observing Satellite Company (EOSAT) took over operation in 1985 and was given rights to market Landsat data.

Landsat 5 was launched in March 1984 and is still returning images. Landsat 6, which was commercially built and managed, was destroyed after launch in October 1993 when the rocket's upper stage failed to fire.

With the passage of the Land Remote Sensing Policy Act in 1992, oversight of the Landsat program began to shift from the commercial sector to the federal government. Management was transferred from NOAA to NASA and the Department of Defense. President George Bush authorized Landsat 7 in the same year. The Department of Defense withdrew from the program in 1994, and NASA was named the lead agency working with NOAA and the U. S. Geological Survey (USGS).

NASA integrated Landsat 7 into its EOS program in 1994. The agency is responsible for the development and launch of the satellite, and the development of the ground system. As the operational era begins, Landsat 7 is transitioning to a dual-agency program between NASA and USGS. Future management will be governed by a joint agreement between the two agencies.

As part of NASA's EOS series of satellites, Landsat 7 will provide a unique suite of high-resolution observations of the terrestrial environment. While other sensors onboard the Terra satellite, to be launched in July 1999, will characterize daily changes at coarse resolution, Landsat will provide data at a finer resolution to allow for investigations of the causes of land-surface change.

Landsat 7 will gather remotely sensed images of land surface and coastal regions for global change research, regional environmental change studies, national security uses, and other civil and commercial purposes. The Landsat 7 project is part of NASA's long term, coordinated research effort to study the Earth as a global environmental system.

The Landsat Science Team, composed of 14 scientific investigators, was selected in 1996. These researchers are conducting a range of studies designed to exploit the characteristics of Landsat 7 for global change research. The satellite will fly in near-formation with Terra, observing the same ground track just a few minutes apart. Landsat 7 will capture and store in a U. S. archive global landmass data once per season.

Following an initial 60-70 day checkout period, Landsat 7 will begin normal operations. Daily commands will be sent to the spacecraft defining which images to record and when to downlink data either to U.S. or international ground stations. NASA will continue to manage day-to-day operations until October 2000, when they will be turned over to USGS.

The Landsat 7 system will collect and archive an unprecedented quantity of high-quality multispectral data each day. This dataset will, for the first time, provide a high-resolution view of both seasonal and interannual changes in the terrestrial environment. The USGS Earth Resources Observation Systems Data Center (Sioux Falls, SD) will process, archive, and distribute all U.S. Landsat data. U.S. data will be acquired primarily at the EROS Data Center; supporting ground stations in Alaska and Norway will also be used.

The Landsat Project, located at Goddard Space Flight Center (Greenbelt, Md.), manages Landsat development for NASA's Office of Earth Science in Washington, D.C. USGS operations will be performed at a Mission Operations Center at the Goddard Space Flight Center and at the EROS Data Center.

A New Era of Landsat Technology

The instrument on board Landsat 7 is the Enhanced Thematic Mapper Plus (ETM+). ETM+ is a passive sensor that measures solar radiation reflected or emitted by the Earth's surface. The instrument has eight bands sensitive to different wavelengths of visible and infrared radiation and has better resolution in the thermal infrared band than the Thematic Mapper (TM) instrument carried by Landsats 4 and 5. The instrument's calibration is good to within 5 percent, making the ETM+ far more accurate than its predecessors.

Landsat 7 data will be used to build and periodically refresh a global archive of Sun-lit, essentially cloud-free images of the Earth's landmass. With an upgraded data system on the ground, Landsat 7 will collect 250 scenes per day, each scene containing enough digital data to fill a powerful home computer's hard drive. The Landsat 7 receiving station will handle 4-5 times more data than the existing program's receiving station.

During the Landsat program's management as a commercial operation, it became increasingly expensive to gather data. As a cost saving measure, Landsat imagery was only collected when a user requested it instead of as an ongoing process, which is essential to scientific studies. Landsat 7's commitment to collecting and archiving all scenes in the United States including Alaska and Hawaii is a significant change in the program.

Processing, distributing, and archiving Landsat data will also be significantly improved. Previous Landsat data was often too expensive for widespread scientific use. All Landsat 7 data received at the USGS EROS Data Center receiving station will be archived and available electronically within 24 hours and will be sold at cost. In addition to the main U.S. receiving station, several international ground stations will collect Landsat 7 data around the globe, archive it, and make it available through on-line Internet browsers. Steps are being taken to link the browsers and give users a single point of entry to the network and easy access to Landsat catalog information.

Launch and Mission Profile

Launch of Landsat 7 is scheduled for April 1999 from the Western Test Range at Vandenberg Air Force Base, Calif., on a Delta-II expendable launch vehicle. The Landsat 7 satellite consists of a spacecraft bus being provided by Lockheed Martin Missiles and Space (Valley Forge, PA) and the Enhanced Thematic Mapper Plus instrument built by Raytheon (formerly Hughes) Santa Barbara Remote Sensing (Santa Barbara, Calif.).

Continuity of data with previous Landsat missions is a fundamental goal of the Landsat program. To accomplish this, images will be taken that are consistent in terms of data acquisition format, geometry, spatial resolution, calibration, coverage characteristics, and spectral characteristics with previous Landsat data. Landsat 7 will image large areas of the sunlit Earth daily, revisiting the same areas every 16 days to refresh a global archive. Digital copies of all images in the archive will be available to users for the cost of fulfilling the request.

At launch, the satellite, including the instrument and fuel, will weigh approximately 4,800 pounds (2,200 kilograms). It is about 14 feet long (4.3 meters) and 9 feet (2.8 meters) in diameter.

After being launched into a sun-synchronous polar orbit, the satellite will use on-board propulsion to adjust its orbit to a circular altitude of 438 miles (705 kilometers) crossing the equator at approximately 10 a.m. on its southward track. This orbit will place Landsat 7 along the same ground track as previous Landsat satellites. The orbit will be maintained with periodic adjustments for the life of the mission. A three-axis attitude control subsystem will stabilize the satellite and keep the instrument pointed toward the Earth to within 0.05 degrees.

Daily commands will be sent to the spacecraft defining which images to record and when to downlink data either to U. S. or international ground stations.

Research Profiles

Volcanic hazards and lava lakes

Luke Flynn, University of Hawaii

To understand the complex "plumbing" beneath active volcanic lave lakes and determine the amount of lava flowing from them, Luke Flynn of the University of Hawaii has been using time series of Landsat images. Much of his work has focused on the persistence of volcanic eruptions at Hawaii's Kilauea volcano, which has been continually erupting since 1983. Another objective of Flynn's research – and one critical to many residents of Hawaii – is to map active lava flows and provide advance warning to public safety officials about these natural hazards.

Flynn and other volcanologists have been using remote-sensing data from the geostationary GOES satellite to monitor volcanic eruptions in remote areas in real time. The higher resolution of Landsat data (30 meters as compared to 4 kilometers for GOES) can produce maps of lava flows with pinpoint accuracy, according to Flynn. With these maps researchers can study the evolution of individual eruptions while they are taking place.

With Landsat observations of the heat emitted during eruptions, Flynn can distinguish active lava flows from older flows that have already begun to cool. With this data, Flynn's colleague Andrew Harris is generating estimates of the amount of lava erupting onto the surface. Using similar Landsat data, Flynn produces maps of the leading edges of wildfires.

Flynn and Harris have also been working with Landsat data of active volcanic lava lakes around the world. In addition to their work in Hawaii, they are studying long-term observations of eruptions in Mexico (Popocatepetl) and Guatemala (Santa Maria and Pacaya). Once they have compiled extensive observations of an individual volcano, they create a database of areas on the volcano that are most prone to lava flow hazards. Flynn plans to produce even higher resolution maps of active lava flows (15 m) with Landsat 7.

Flynn plans to collect Landsat 7 data at a ground station in Hawaii as the satellite passes over the state. He plans to produce new Landsat 7 volcano (and wildfire) hazard maps for the State of Hawaii every 8 days.

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Active lava flows can be distinguished from older flows that have already begun to cool.

Growth patterns of urban sprawl

Jeffrey G. Masek, University of Maryland

How do zoning policies and environmental pressures influence the expansion of urban populations?

Traffic jams and air pollution in large metropolitan areas are sure signs of expanding populations. Across the globe, 50 percent of the world's population now lives in urban areas, a gain of over one billion individuals in the last 30 years. In the United States, urban growth can be counted in a census, but how do these expanding populations affect the landscape? Are urban areas making good use of limited space or are they succumbing to urban sprawl? How do factors like zoning policies and environmental pressures influence the expansion of populations over the land?

Jeffrey Masek and Frank Lindsy, geographers from the University of Maryland, are using Landsat data to study land use efficiency, which is the amount of land area used by increasing populations. Using Landsat data acquired between 1973 and 1996, Masek and Lindsy mapped the growth of the Washington D.C. metropolitan area.

They found that the Washington area has expanded at a rate of 8.5 square miles (22 square kilometers) per year with notably higher growth during the late 1980s, a trend that followed the regional and national economy. They also found distinct variations in the efficiency of land use among neighboring counties in Maryland and Virginia, in part reflecting the land use policies of these jurisdictions.

Observing urban areas over time with satellite imagery can also be used to make predictions about future growth. Landsat imagery can show where the growth is taking place and help geographers evaluate how different urban planning programs effect population growth and land use, according to Masek. Cities such as Portland, Ore., have strict planning and environmentally sensitive zoning laws, while many Southwestern cities have grown with few planning guidelines.

With Landsat 7 observations, Masek and colleagues intend to evaluate growth patterns of other cities around the world. With a greater number of images available, Masek can compare cities once every two years to capture detailed records of land use changes.

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"Dune reactivation" in the U. S. High Plains

Alexander F. H. Goetz, University of Colorado at Boulder

More than 10 percent of the United States' High Plains region is made up of sand dunes and sand sheets that are currently stabilized by the natural grasses growing on them and by irrigated farming. If future climate change leads to increased temperatures and less rainfall in this arid region, as some climate models predict, these sandy landscapes could be "reactivated" and begin blowing as they did in the "dust bowl" years of the 1930s.

Information about the dunes in this 800,000 square-kilometer region – encompassing parts of Colorado, South Dakota, Nebraska, Kansas, Oklahoma, Texas, and New Mexico – has been available for decades. However, a systematic study of the relationship between humans and the land and land-use change on a large geographic scale is only now possible utilizing satellite observations.

Alexander Goetz, professor of geological sciences at the University of Colorado is leading a research team to create an effective way to assess how the High Plains will be affected by future climate change. Using Landsat 5 data from 1984 to the present, Goetz' team has completed a detailed study of land cover change in northeastern Colorado and is creating a 15-year database of land cover and human-induced land cover changes in the region.

One of the more striking observations is the dramatic shift from dry-land farming and flood irrigation to center-pivot irrigation since 1985. Some of the pivots are located in the dune areas and these spots would become dune reactivation sites if the irrigation were discontinued, according to Goetz.

Combining land-cover data with meteorological and future climate data in a regional climate model, Goetz plans to produce a model-based method for estimating future dune reactivation and identifying the areas with the highest potential for reactivation. The team will also investigate the potential effect of abandoning farmed and irrigated lands on dune reactivation.

Landsat 7 data will provide the researchers with many more images than are currently available, since the team will acquire images from every pass of the satellite over the region. With multiple images during a growing season, they can more precisely distinguish crop types and change. Goetz expects that by extending the Landsat dataset beyond 2000, he will be able to catch a significant drought year, which will help to validate models for the effect of low rainfall in the High Plains.

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Some climate models predict these sandy landscapes could begin blowing as they did in the "dust bowl" years.

Spring run-off contaminants in lakes

John Schott, Rochester Institute of Technology

In large lakes the "thermal bar" can become potentially toxic to plants and animals.

As snow begins to melt at the close of winter, large lakes receive warm spring river run-off carrying pollutants that are potentially harmful to phytoplankton and the fish that feed on them. The warmer water initially stays near the shoreline, not mixing with the cold winter lake water. Salt, sediment, fertilizer and chemical pollutants in the run-off are concentrated in a small band of warmer water close to the shore called the thermal bar. By June, the lake's waters are well mixed, and pollutants brought into the lake are very dilute.

Most lakes in regions that have cold winters and warm summers have an annual episode of thermal bar formation. But only in large lakes does the thermal bar persist for two months and become potentially toxic to lake plants and animals.

John Schott, of the Rochester Institute of Technology's Digital Imaging and Remote Sensing Laboratory, is using Landsat imagery to help predict the extent, duration, and impacts of the thermal bar formation in the Laurentian Great Lakes. For the two months that the bar persists, it controls most of the fluid flow in the lakes and has a dramatic impact on water quality. Landsat offers the unique opportunity to study both the thermal bar processes and the direct impact on the water quality at both whole lake scales and localized scales. The combination of spectral coverage, synoptic perspective, and high resolution is a unique asset that may be used to further understand the water quality issues affecting Great Lakes coastal waters.

Schott's work may eventually be helpful in understanding how the release of industrial pollutants into the Genesee and Niagara rivers during the thermal bar formation in Lake Ontario effect the lake's ecosystem. Thermal bar formation occurs during the spring when plants and animals in the lake are in the early stages of development.

Schott and his research team are using Landsat data to determine how large-scale hydrodynamic processes in the Great Lakes control water quality. The thermal bar formation is modeled using Landsat data and three-dimensional hydrodynamic models. Eventually, the models will track the annual evolution of the thermal bar and attempt to predict the bar's formation several months in advance.

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Land use in tropical rain forests

David Skole, Michigan State University

Even though tropical deforestation is a well-known problem, the rate of deforestation in the tropics is currently known to only a very general degree. Recent research using Landsat images of forest loss over a decade from the mid-1970s to mid-1980s found that an average of 6200 square miles of forest were lost each year in the Brazilian Amazon. The annual rate in the smaller Southeast Asia region was estimated to be 4800 square miles per year. A key problem facing scientists today is determining deforestation rates and understanding their causes and effects.

David Skole of Michigan State University is involved in several initiatives to study the rates, causes, and effects of tropical deforestation in the Amazon Basin, Southeast Asia, and Africa. Using Landsat imagery, his research analyzes changes in forest cover at a 30-m resolution and models the effects of this on the carbon cycle. By combining satellite imagery with socioeconomic data, Skole is also searching for the economic and social causes of deforestation.

Using three different wavelength bands of Landsat Thematic Mapper imagery to quantify the vegetation characteristics, Skole's team categorizes land cover into primary rain forest, regrowing rain forest, agricultural clearings, and other classes. These data are manipulated using a geographic information system to explore patterns and rates of land cover change. The geospatially referenced information is then fed into socioeconomic and terrestrial ecosystem models to explore the causes and effects of deforestation.

Skole's team is currently analyzing Landsat 5 imagery from the 1990s for the Brazilian Amazon and Southeast Asia to develop estimates of recent tropical deforestation. In addition, they are performing multi-year studies in the Amazon basin to determine the year-to-year changes in deforestation rates. These data will be important not only in yielding the rate of deforestation but for the analysis of carbon uptake by tropical rain forests and for understanding the social and economic causes.

With the launch of Landsat 7, the amount of data available for this research will increase dramatically. Highly detailed, near-real-time analysis will be possible with the new imagery, allowing for rapid assessment of land use and land cover change.

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The cause of deforestation is being studied with socio-economic and ecosystem models.

Precision farming and land management

Susan Moran, U.S. Department of Agriculture

Crop yields can be increased by monitoring plant health and plant cover from space.

For farmers and land managers, increasing crop yields and cutting costs while reducing environmental pollution is a constant challenge. To accomplish this goal, many farm managers are looking for new technologies to help them decide when and where to irrigate, fertilize, seed crops, and use herbicides. Currently the decisions are based on very limited data collected in "spot checks" from the ground.

Recent technological advances in geographic information systems (GIS) and computer modeling are playing a part in farm management and precision farming. Using data collected by satellites, important agricultural factors like plant health, plant cover and soil moisture can be monitored from space, providing a much bigger picture of the land surface that can be combined with other technologies to help cut costs and increase crop yields.

Susan Moran, a US Department of Agriculture Agricultural Research Service soil scientist, based in Phoenix, Ariz., developed a method to help farmers with resource management by combining Landsat images with radar data from several polar orbiting satellites. Although Landsat sees the surface very clearly, its usefulness is limited because it can't see through clouds, and it only flies over a particular area once every 16 days. Most farm management decisions require information on a daily or biweekly basis. Radar can see through clouds and be collected daily, but the resolution is not as good as Landsat. The combination of radar and Landsat gives a continuous record of the land surface and vegetation health.

The thermal band on Landsat can detect crop health by seeing plants transpire, or lose moisture through their leaves—a factor directly related to plant health. When plant transpiration rates decrease, growth rates decrease and the plants appear unhealthy. Managers use this information to target where to fertilize and irrigate. Other Landsat bands can see the extent of vegetation cover while radar can pick up moisture in the soil.

The methods developed by Moran are already in use by land managers through a Cooperative Research and Development Agreement with a commercial image supplier. The 24-hour turnaround of the new Landsat 7 data will enable expanded applications of remote sensing in agricultural and natural resource monitoring.

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Health of temperate conifer forests

Curtis E. Woodcock, Boston University

Fire, drought, and humans all can destroy forests and their ecosystems. While much attention is paid to deforestation in tropical rainforests, very few comprehensive studies have been done to address changes in the Earth's temperate conifer forests. Temperate conifer forests lie at latitudes above tropical forests and below boreal forests and account for much of the forested area in the United States and Europe.

Understanding changes occurring in temperate conifer forests is important for understanding environmental issues including wildlife habitat protection, watershed management, timber harvest, and understanding the role of human activities on changes in regional climates.

Previously, researchers have only been able to monitor changes in specific locations with Landsat data due to its limited availability. Boston University geographer Curtis E. Woodcock and colleagues used Landsat to monitor how drought in the late 1980s and early 1990s affected forests in California's Sierra Nevada. During the drought, Woodcock found that Landsat images could recognize areas where trees were dying due to lack of water, a factor making the trees more susceptible to disease and the forest more susceptible to fire.

With the help of the frequent and comprehensive coverage of Landsat 7, Woodcock and colleagues plan to create a global monitoring system for temperate conifer forests. The monitoring system will measure the rates of destruction of conifer forests due to natural causes such as drought and fire and anthropogenic clearing due to harvest or development of forest lands. The monitoring system will also track the regrowth of forests and successional change in vegetation.

The new system will work in conjunction with NASA EOS land cover change studies based on the EOS Moderate-resolution Imaging Spectroradiometer (MODIS). The MODIS instrument will fly aboard the Terra satellite set for launch in July 1999, and will be used to identify large areas of significant changes in forest lands. Following up with the finer spatial resolution data from Landsat will allow determination of the type of changes and their geographic extent.

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Forest destruction from natural causes can be distinguished from human activities.

Gradual changes in the Antarctic ice sheet

Robert Bindschadler, NASA Goddard Space Flight Center

Ice flows may move more quickly and slide into the sea if the forces driving them change.

The stability of the West Antarctic Ice Sheet is an issue of active research and societal concern because of the potential economic impact resulting from an increase in global sea level. The West Antarctic Ice Sheet, riddled with deep crevasses and flowing ice streams, contains over 700,000 cubic miles (3 million cubic kilometers) of ice.

Researchers are studying how the ice moves and what forces cause the ice to flow. If the forces change, the ice sheets may flow much more quickly and slide off the continent into the sea. Monitoring these changes from the ground is difficult because treacherous conditions allow researchers to collect only a limited amount of measurements.

Robert Bindschadler, a glaciologist at NASA's Goddard Space Flight Center, uses Landsat data in a variety of ways to make more information available for determining the ice sheet's behavior. Landsat's high spatial resolution allows individual crevasses to be tracked over time. Using these natural markers not only provides many more velocity data to be collected, but concentrates the measurements in the most rapidly moving and most dangerous areas.

Other surface features such as flowstripes formed by rapid ice flow are also being used to uncover the history of the ice sheet. Bindschadler and colleagues have analyzed surface features on the Ross Ice Shelf, a vast area of ice attached to the continent but floating on the ocean, to determine the past 1000 years of ice flow over much of West Antarctica.

Recently Landsat data have increasingly been used to create more useful maps for scientific research. Bindschadler is combining Landsat data with past surveys of the latitude, longitude, and elevation of known locations around the Antarctic continent to create a library of image control points. The library is available on the Internet for use by researchers.

Landsat 7 data will enhance techniques developed at Goddard to study ice motion and flow history by providing finer spatial resolution, more continuous spatial coverage, and an updated view of the ever-changing Antarctic ice sheet.

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Mapping wildfire hazards in Yosemite

Jan van Wagtendonk, U. S. Geological Survey

In recent years, wildland fires have become more intense resulting in increased loss of human life and natural resource damage. An important factor in dealing with this problem is information on the amount and condition of dry biomass on the ground, which acts as fuel that feeds wildland fires. With information about fuels, fire managers can better predict potential fire behavior, make more informed tactical and strategic decisions, and conduct treatments to reduce the amount of dry biomass.

U. S. Geological Survey researcher Jan van Wagtendonk from the Western Ecological Research Center's Yosemite National Park station, and Ralph Root, from the USGS Center for Biological Informatics in Denver, have been examining the use of time series of Landsat Thematic Mapper imagery for developing a technique to identify fuel types based on seasonal changes in plant condition. Six Landsat scenes at one-month intervals during the 1992 growing season are being examined using hyperspectral analysis, a type of analysis that deals with large data sets with several spectral bands.

Using the time series, changes in annual grasslands, for instance, can be traced as the plants green up in the spring and dry during the summer. This fuel type can be distinguished from alpine meadows which dry at a different rate. Similarly, biomass from deciduous hardwood can be distinguished from evergreen hardwood, which retains its leaves.

Van Wagtendonk has also used single-scene Landsat images to classify different types of fuels over the past five years. Maps produced from this analysis have been used to predict the behavior of two large wildland fires in 1994 and 1995 that were being allowed to burn to meet resource objectives.

The addition of a panchromatic band on Landsat 7 will enhance the capability to distinguish tree density classes, which directly affects fuel moisture content and wind speeds near the ground. Seasonal changes can also be tracked more easily with the more frequent observations Landsat 7 will make.

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Landsat imagery is being used to identify different types of dry biomass on the ground.

Glossary

Band (channel). A band is a slice of wavelengths from the electromagnetic spectrum. Landsat ETM+ has eight bands which collect radiation from different parts of the electromagnetic spectrum. Of the eight bands, three bands are visible light, one band is panchromatic, three bands are infrared, and one band is thermal infrared.

Enhanced Thematic Mapper Plus (ETM+). The sensor aboard Landsat 7 that picks up solar radiation reflected by, or emitted from the Earth.

Electromagnetic radiation. Energy transfer in the form of electromagnetic waves or particles that propagate through space at the speed of light.

Electromagnetic spectrum. The entire range of electromagnetic radiation. The spectrum usually is divided into seven sections. From the longest wavelengths to the shortest: radio, microwave, infrared, visible, ultraviolet, x-ray, and gamma-ray radiation.

Geostationary orbit. An orbit in which a satellite is always in the same position with respect to the rotating Earth. The satellite travels around the Earth in the same direction, at an altitude of approximately 22,000 miles (35,800 kilometers).

Infrared radiation. Electromagnetic radiation with wavelengths between about 0.7 to 1000 micrometers. Infrared waves are not visible to the human eye. Longer infrared waves are called thermal infrared waves.

Multispectral image. A remote sensing image created using data collected from more than one band.

Panchromatic. Sensitive to all or most of the visible spectrum, between 0.4 and 0.7 micrometers. Landsat 7 has a panchromatic band.

Passive sensor. One type of remote sensing instrument, a passive sensor picks up radiation reflected or emitted by the Earth. ETM+ is a passive remote sensing system.

Polar orbit. An orbit with its plane aligned parallel with the polar axis of the Earth. Landsat's polar orbit is 438 miles (705 kilometers) above the Earth.

Radar. Short for "radio detection and ranging," radar sends out short pulses of microwave energy and records the returned signal's strength and time of arrival.

Resolution. A measure of the amount of detail that can be seen in an image.

Scenes. Each Landsat image collected is called a scene. Each scene is 115 x 106 miles long. The globe is divided into 57,784 scenes.

Synoptic view. The ability to see large areas at one time, such as an entire metropolitan area.

Thermal infrared. Electromagnetic radiation with wavelengths between 3 and 25 micrometers.

Visible radiation. The electromagnetic radiation that humans can see as colors. The visible spectrum is made up of wavelengths between 0.4 to 0.7 micrometers. Red is the longest and violet is the shortest. Landsat 7 has three visible bands in red, green, and blue.

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Web Sites

The Landsat 7 Program
http://geo.arc.nasa.gov/sge/landsat/landsat.html
Information on Landsat satellite data, program news, program history and chronology, and instrument details.

Landsat 7 Gateway
http://landsat.gsfc.nasa.gov/
Program and technical information, educational materials, an image gallery, and NASA organizational information.

Landsat 7 Science Team
http://www.inform.umd.edu/geog/landsat7/
The "Public information about Landsat 7 Science Activities" section contains instrument details, how images are acquired, and contact information for science team members.

Landsat 7 Images

Individual stills of new Landsat 7 images can be obtained by contacting Ron Beck, USGS EROS Data Center, Sioux Falls, SD 57198; tel. 605-594-6551; beck@usgs.gov.

A "pre-launch resource videotape" of Landsat scenes and animations is available for media use from the Goddard Space Flight Center's Public Affairs Office. Contact Deanna Corridon for more information; tel. 301-286-0041.

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