STATEMENT

FRANK J. SAPIO
DIRECTOR
FOREST HEALTH TECHNOLOGY ENTERPRISE TEAM (FHTET)
FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

BEFORE THE
UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SPACE AND AERONAUTICS
APRIL 7, 2008

CONCERNING

REMOTE SENSING DATA: APPLICATIONS AND BENEFITS

Mr. Chairman and members of the subcommittee, thank you for the opportunity to testify today on remote sensing data applications and its benefits for the US Forest Service.

Introduction

As Director of the Forest Health Technology Enterprise Team (FHTET), I am charged with managing the group's mission "To foster the development and use of technologies to protect and improve the health of America's forests". Remote sensing is one of the geospatial technologies we use to fulfill that mission.

FHTET is a Forest Service unit within State and Private Forestry. The team is comprised of two offices, one in Morgantown, West Virginia, and the other in Fort Collins, Colorado. In Morgantown, members of the team work on the biological control of invasive pests, pesticide application technologies, and the study of non-target impacts of pesticides. In Fort Collins, team members work on a variety of information gathering methods, including geographic information systems (GIS), spatial analysis, remote sensing and image analysis, pest and pathogen modeling, invasive species modeling, and quantitative analysis of the impacts of forest pests.

I have worked in forest pest management and forest health for over 26 years. My career began as a research associate in a university setting where I developed forest pest management methods. I then moved to state government where I worked on forest inventory, forest health monitoring, and forest pest management for most of my career. For almost five years, I have been the technology-development lead within Forest Health Protection, US Forest Service, as the Director of FHTET.

I will organize this testimony along the lines of the questions posed by Subcommittee Chairman Mark Udall's office in a letter to me dated March 26, 2008.

Questions and Answers

How is the Forest Service using data collected by remote sensing technologies to identify areas of high risk for forest fires and other factors, including insect infestations, disease, drought, and the proximity of forests to development that affect the health of forests in Colorado and elsewhere?

Remote sensing is used at three principal scales within the agency by both wildland fire and the forest health protection programs of the Forest Service.

Broad Scale

Our current data-collection methodologies for national insect and disease assessments rely heavily upon aerial sketchmapping surveys. These surveys are accomplished by aerial observers flying in light aircraft who sketch observations on paper or on pen-based portable computers. Though somewhat limited in spatial accuracy, this very low-cost survey provides a quick and timely assessment for many insect and disease events. This "low tech" approach of information acquisition is truly an "appropriate technology" for strategic regional and national assessments and is particularly well-suited for trend analysis. Digital sketch mapping uses a moving map display on which the observer marks the screen instead of marking on paper maps. This saves time in processing finished maps and improves location accuracy. We continually strive to improve the collection of these data and have implemented digital aerial sketch mapping systems to improve the quality and timeliness of these data sets.

Imagery collected at the broad scale also includes satellite images from the National Aeronautic and Space Administration (NASA) and National Oceanographic and Atmospheric Administration (NOAA) Geostationary Operational Environmental Satellites (GOES) and Polar-orbiting Operational Environmental Satellites (POES) to support domestic forestry and fire programs. The Moderate Resolution Imaging Spectroradiometer (MODIS) provides 250m-, 500m- and 1km-resolution spatial detail. MODIS is used to detect and monitor wildland fires, assist incident coordination, and to portray the fire situation to the public. MODIS is utilized with other geospatial layers and forest inventory information to produce large-area forest cover-type and biomass maps. These maps are used in national assessments and are designed for strategic assessments. For example, a cover map for all of America's private and public forests was recently completed by combining multi-resolution imagery from MODIS and LANDSAT with ground data from the Forest Service's Forest Inventory and Analysis (FIA) program. Much of this work is a continuation of interagency cooperative research and development activities spawned by the Multi-Resource Land Cover (MRLC) Consortium led by the Department of the Interior's Geological Survey. We are also applying these broad-scale synoptic mapping technologies to develop early warning systems and to produce very large area damage maps. We hope to be able to post forest disturbance maps on the web in near-real-time to guide our aerial surveys. The goal here is to augment and optimize aerial sketch mapping surveys (by providing near real time forest disturbance information to our aerial surveyors) that provide us with the majority of our national damage trend information.

Mid Scale

Mid-scale imagery such as LANDSAT, which is 30 meter resolution and is used with geospatial data and forest inventory information to produce individual tree species maps depicting the tree layers that host insect and diseases. These maps will be used in the production of national risk maps. Mid-scale imagery is a significant activity in the FHTET Fort Collins office as we are preparing the development of national host models to be used in the next development of the National Insect and Disease Risk Map, a five-year strategic assessment produced by Forest Health Protection. The 19-state, mid-scale hazard assessment for the Southern Pine Beetle Prevention Program is a good example of how this technology is currently being used.

LANDSAT also provides the predominant mid-scale imagery driving the LANDFIRE project. LANDFIRE is a five-year, multi-partner project that produces consistent and comprehensive maps and data describing wildland fuels and fire regimes across the United States. It is a shared project of the U.S. Forest Service and the Department of the Interior. The data products from LANDFIRE include layers for vegetation composition and structure, surface and canopy fuel characteristics, and historical fire regimes. LANDFIRE national methodologies are science-based and include extensive field-referenced data. LANDFIRE data products are designed to facilitate national and regional level strategic planning and reporting of wildland fire management activities.

LANDFIRE data products are created at a 30-meter resolution data set. LANDFIRE information is produced at scales that may be useful for prioritizing and planning hazardous fuel reduction and ecosystem restoration projects. LANDFIRE meets agency and partner needs for data to support large landscape, fire management planning and prioritization.

Satellite imagery is likewise used for the burned area emergency response (BAER) program for developing a burn intensity index to guide on-the-ground rehabilitation efforts. LANDSAT, ASTER (Advanced Space-borne Thermal Emission and Reflection Radiometer) and an increasing amount of commercial satellite imagery (such as Advanced Wide-Field sensor (AWiFS)) are being used to provide BAER teams with rapid assessment burn severity map products.

LANDSAT has also been used repeatedly within the agency in various change-detection analyses. One such notable effort is the US Forest Service Land Cover Mapping and Monitoring Program (LCMMP) in California, which addresses statewide vegetation mapping and long-term monitoring using remotely sensed data. Remotely sensed data and GIS are used to generate maps that describe the extent and condition of various land cover types and the magnitude and cause (e.g., urbanization, natural succession, wildfire, and timber harvest) of land cover changes. The LCMMP provides a single, consistent source of current land cover data from which the US Forest Service and California Department of Forestry (as well as other interested federal, state, and local governments and private citizens) can make informed resource management decisions. The LCMMP is a collaborative approach to land cover mapping and monitoring that includes coordinated acquisition of resource photography, satellite imagery, and geo-processing on a five-year cycle. Regionally, monitoring can identify critical causes of change or provide an early warning system for habitats being degraded. Locally, monitoring can assess county land use policies, identify areas of insects or disease problems, or assess the extent of timber harvest in a watershed.

Fine Scale

Aerial imagery is utilized to aid in the mapping of forest stands and damaged areas at a fine scale and is used routinely for forest inventory and local resource assessments. The US Forest Service participates in the USDA National Agricultural Imagery Program (NAIP), which collects 1-meter digital imagery on a five-year recurring basis. This imagery is used in mapping various resource conditions. Other than its use as an important mapping aid, NAIP's ability to determine resource conditions for fuel loading and forest mortality is very limited. For project-level planning, finer resolution imagery is required to achieve the desired assessment of forest resource conditions.

Forest Service and other cooperating field units often utilize digital high-resolution satellite imagery for local forest resource assessments. An example is a spruce-beetle mapping effort conducted in the early 2000s using 1-meter and 0.6-meter satellite data. Dead trees were discernable in both resolutions of imagery; however, recently dead or dying trees (known as faders) were not discernable in the coarser 1-meter imagery. To guide many insect and disease mitigation measures, the location and number of faders are needed. In addition to the identification of faders, identification of tree species and sub-canopy is often needed, and imagery with a resolution finer than 0.6 meters is required for these determinations. The imagery resolution of choice from our field practitioners is in the 6-inch to 1-foot spatial-resolution range. As of this moment, airborne imagery, usually photography (as opposed to satellite imagery) remains the imagery of choice for most field foresters.

The Research & Development arm of the Forest Service has been experimenting for several years with using Light Detection and Ranging (LIDAR) sensors. Similar to radar but using a laser instead of radio waves, LIDAR provides very high resolution images. Researchers are combining LIDAR with very accurate Global Positioning System (GPS) data to map stream channels, including pools, riffles, and down woody material that are essential to understanding the health of aquatic habitats, and forest canopies. LIDAR imagery can see beneath the over story, allowing researchers to map under story plants and help detect places where trees have been removed, such as through thinning operations.

Pre-visual detection of stress on individual trees is currently a major focus for forest health remote sensing specialists. In order to intervene early in a pest outbreak scenario, early indications of pest infestation—such as tree health at the edges of known infestations—are important. This is especially true for exotic invasive species. Unfortunately, at the present time we do not have a mature repeatable technology to fulfill this need. Hyper-spectral data for host mapping or tree health mapping has the potential to fulfill this need, though at the present time results are inconsistent. Alternatively, field surveys can be conducted to map positive detections and to identify pest. The surveys are conducted with global positioning system (GPS) coordinates and tree health ratings. However, early infestations are often missed during field survey as damaged trees initially are characterized by very subtle changes in the tree canopy. Trees stress signs, while present, often go undetected until they become obvious to the field specialist on-the-ground. Hyper-spectral imagery has been utilized by the Forest Service for limited developmental projects for stress-detection, and its use may be increased as the technology development progresses.

Proximity of Forests to Development that May Effect Forest Health
Urban and suburban growth has resulted in the development of an outlying metropolitan fringe that extends into rural areas with attractive recreational and aesthetic amenities. This is especially true for urban growth near forests. This land-use change has significant implications for wildfire and pest management. The WUI creates an environment with an increased likelihood that wildfires or pest outbreaks will threaten structures, trees around homes, recreation sites, and people. The spatial extent and location and, most importantly, the growth of urban and suburban areas are information that is sought by nearly all sectors of the natural resource management community.

A myriad of geospatial technologies—including geospatial modeling of census data, the “city lights” data set from the National Oceanic and Atmospheric Administration’s National Geophysical Data Center (NOAA/NGDC), and virtually all other remote sensing platforms mentioned thus far—are used to conduct analysis of the WUI at different spatial and temporal scales. This is typically done on a project-by-project basis with the structure density threshold varying accordingly.

Development Efforts and Refinement
The Forest Service has long used various remote-sensing methods to assess forest health and detect damage, and continuously investigates new technologies as a strategic and tactical aid to natural resources management. There are advantages and disadvantages to all such geospatial technologies. It is imperative that the right platform, imagery, and analysis be matched to the specific problems that natural resource professionals face. Remote sensing technologies have extended the ability of resource specialists to assess forest conditions, and these technologies are increasingly being used at various spatial and temporal scales to address natural resource management questions.

The future possibilities of "fusing" data from satellites with airborne LIDAR imagery and precise GPS coordinates offer great future potential for developing better maps in the future. In particular, the ability of LIDAR to create three-dimensional images of forest stand conditions instead of just the flat overhead look from satellites offers substantial promise for improving natural resource management.

Data acquisition and analysis in any form still requires a considerable investment of resources and expertise. The Forest Service continues to improve its suite of hardware and software tools for processing and analyzing remotely sensed data. Most national forest field offices now have such hardware and software, and are improving their expertise in using GIS or image analysis software to process and analyze geospatial data sets. Land managers are also improving in their ability to select appropriate remote sensing technologies to address their data needs, and they are supported by technology transfer efforts of the Remote Sensing Applications Center (RSAC), the Geospatial Technologies Service center (GSTC), and FHTET.

What are the benefits of using remote sensing data over data that are acquired by other techniques?

Remote sensing methods are effective tools to assess fire, forest pest and forest conditions. One of the benefits of using remote sensing data over data acquired by other techniques (for example, aerial survey and ground survey) is the spatial precision which allows for the analysis of other resource concerns, including the presence and distribution of threatened and endangered species or the occurrence of multiple threats through time. Also, ground surveys are often not cost-effective over very large areas. Another benefit of remote sensing lies in its consistency and objectivity; the data do not pass through the subjective filter of a human observer before being recorded. Compared with a ground survey, once collected, remotely sensed data can be easier to process and analyze, can cover more ground, and thereby reduce analysis time and improve overall planning productivity.

What, if any, are the challenges and impediments to the use of remote sensing data for these and other applications, and what are your recommendations for overcoming those barriers?

Performing remote sensing data analysis requires a wide-range of skill sets, from basic repetitive tasks to high-end analytical support. A typical field user of remotely sensed data needs to perform the full spectrum of skills from basic through advanced. Often, the skill-level for the advanced use of remote sensing technologies is very limited at the field level, though regional offices and national service centers can and do provide support for individual projects.

Basic tasks for the analysis of remotely sensed data are usually performed by technician-level employees. This capability has diminished over the last few decades as the workforce has shifted from technician-level employees to professional and administrative employees. Often, a field unit is left with little or no support for basic remote sensing processing – a field staff officer may be doing the work of a field technician due to staffing limitations. As these remote sensing skills evolve through workforce evolution, skill sets must continue to improve for the utility of remotely sensed data to increase. The national service centers for remote sensing applications (RSAC), geometronics (GSTC) and forest health (FHTET) are all working on technology transfer efforts to develop field ready methodologies, and improve workforce skills to meet today's needs.

The early signatures of most forest pests are ephemeral and the timing of data acquisition is another important challenge. Imagery must be acquired during the period of time during which pest damage signatures are most visible or when the information best supports managerial action. This is very often a very brief period, sometimes less than 2-3 weeks. Imagery acquisition during this "bio-window" is difficult in some parts of the country due to imagery acquisition schedules and the lack of suitable weather without clouds. Also, the effectiveness of on-the-ground treatments for a given forest health concern involve data timing considerations. Results from image analysis must be timely in order to facilitate time-sensitive on-the-ground treatments. Remotely sensed data need to be collected, processed, and evaluated within a given timeframe so that the forest health concern is observed and a response can be formulated and performed in a timely manner. For tactical on-the-ground operations, the required turn-around time of imagery acquisition, image analysis, and treatment prescription often exceeds the biological window available for the treatment to be effective.

Shortening the time to analyze remotely sensed imagery would significantly aid in the practical implementation of remote sensing in the US Forest Service. Efforts to develop ways to reduce this time could be accomplished through close cooperation of remote sensing commercial interests, researchers, field resource specialists, and the technology development community within the US Forest Service.

What remote sensing data, products or services, or supporting infrastructure would be most valuable for expanding the use of remote sensing data in the future?

The key to providing continued support for the mid-scale mapping and on-going forest condition monitoring is LANDSAT. Continued availability allows for the comparison of current conditions with reference conditions collected by previous LANDSAT sensors to identify changes and trends in forest canopy, including the new challenges associated with global climate change. LANDSAT imagery has been a significant component within our natural resource information programs. Trends detected through such an approach will yield insightful information which otherwise would not be detected through other monitoring techniques.

In order for high-resolution satellite imagery to be more routinely used, it must achieve finer resolution and be cost-competitive with aerial photography. Higher resolution remotely sensed data (airborne or satellite) can be utilized when determined to be cost-effective for the extent of coverage needed. Often, a project's spatial extent exceeds the practical capability available given the small image "footprint" of various sensors. Also, the cost of high-resolution satellite imagery must match the project area and not be cost-prohibitive. Lower-cost imagery (assuming useful interpretation) would ultimately yield better, more frequent monitoring of our forest resources.

The development of automated routines for preparing and interpreting imagery would help to shorten the turn-around time between imagery acquisition and treatments. This can help reduce the need for basic interpretive skills and improve the timeliness for deriving analytical information. Professional field specialists could then better focus on problem-solving, for which they are most skilled: that is to make natural resource decisions.

Image interpretation relies upon assigning certain characteristics, such as tree species, to specific parts of the image—a process called classification. Building accurate automated routines to classify an image requires sufficient data from ground plots to validate the classification routines.

Conclusion

The USDA Forest Service utilizes remote sensing and other geospatial technologies routinely to measure resource conditions. This is done both to assess current conditions and to predict future conditions. Assessments range from the strategic to the tactical and utilize imagery from a broad scale to a fine scale. Remote sensing technologies range from analog photography (true color or color infra-red) to the latest in hyperspectral imagery. Acquisition platforms range from government-owned systems to commercial systems. The agency maintains an active technology development effort and continually tries to fit the task at hand with the various remote sensing methodologies available. Sensor capabilities (spectral, spatial, temporal, and cost) must be carefully tailored to the project; if a match can be made, the Forest Service will likely use that technology in their resource assessment efforts.

Mr. Chairman, this concludes my prepared statement. I would be happy to answer any questions you or other members of the Subcommittee may have.

Acronyms and Abbreviations

FHTET	**Forest Health Technology Enterprise Team**
GIS	**geographic information system**
MODIS	**Moderate Resolution Imaging Spectro-radiometer**
BAER	**burn area emergency rehabilitation**
ASTER	**Advanced Space-borne Thermal Emission and Reflection Radiometer**
AWiFS	**Advanced Wide-Field Sensor**
LCMMP	**Land Cover Mapping and Monitoring Program**
NAIP	**National Agricultural Imagery Program**
UAS	**unmanned aerial systems**
WUI	**wildland-urban interface**
NOAA/NGDC	**National Oceanic and Atmospheric Administration/ National Geophysical Data Center**
RSAC	**Remote Sensing Applications Center**
GSTC	**Geospatial Technologies Service Center**