

The work from which this  
copy was made  
included the following  
copyright notice:

Copyright 2006

*Applied Geography Conferences*

Mail  
ODYSSEY



OKS TN: 882756

Oklahoma State University Interlibrary Loan  
**Journal Title:** Papers of the applied geography  
conferences.

**Volume:** 29 **Issue:**

**Month/Year:** 2006

**Pages:** 206-213

**Article Title:** Satellite Imagery and Internet Mapping Services in  
Support of Science-Based Adaptive Management of Grasslands in  
the Valles Caldera National Preserve

**Article Author:** Watson, R P

**Borrower:** IQU

**Patron:** Benedict, Karl

**ILL Number:** 110905115



**Lending String:** \*OKS,CUV,INT,TXI,TXA

**Call #:** 910.6 A652

**Location:** Main Library

**ARIEL**

**MaxCost:** 25.00IFM

**Shipped by:**

**Ariel:** 129.24.92.22

**Fax:** 505-277-5617

**Shipping Address:**

University of New Mexico

\*\*\*UPS GROUND\*\*\*

**SATELLITE IMAGERY AND INTERNET MAPPING SERVICES IN SUPPORT OF  
SCIENCE-BASED ADAPTIVE MANAGEMENT OF GRASSLANDS IN THE VALLES  
CALDERA NATIONAL PRESERVE.**

Richard P. Watson  
University of New Mexico, Department of Geography  
1 University of New Mexico  
Bandelier West, Room 111, MSC01 1110  
Albuquerque, NM 87131-0001

Karl K. Benedict  
University of New Mexico, Earth Data Analysis Center (EDAC)  
Bandelier West, Room 111, MSC01 1110  
Albuquerque, NM 87131-0001

Theresa R. Watson  
University of New Mexico  
Center for Rapid Environmental Analysis and Terrain Evaluation (CREATE)  
1 University of New Mexico  
Bandelier West, Room 111, MSC01 1110  
Albuquerque, NM 87131-0001

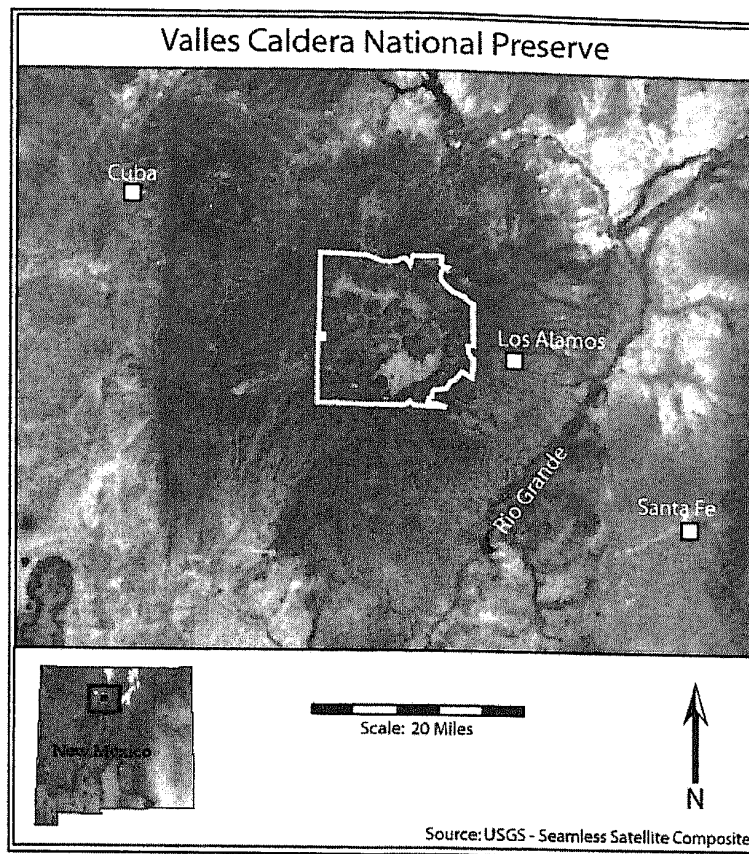
Kurt Menke  
University of New Mexico, Earth Data Analysis Center (EDAC)  
Bandelier West, Room 111, MSC01 1110  
Albuquerque, NM 87131-0001

Robert R. Parmenter  
Valles Caldera Trust  
PO Box 359  
Jemez Springs, NM 87025

## **1. INTRODUCTION**

The Valles Caldera Trust was created by the Valles Caldera Preservation Act of 2000, and was established to preserve and protect the historic Baca Ranch of New Mexico's Jemez Mountains (Figure 1). The ground-breaking legislation that provided for the federal purchase of this 89,000-acre ranch, which is nestled inside a collapsed volcanic caldera, also created a unique experiment in public land management. A nine-member board of trustees is responsible for the protection and development of the Valles Caldera National Preserve (VCP). Seven members are presidential appointments, and the remaining two board members are the Superintendent of nearby Bandelier National Monument and the Forest Supervisor of the Santa Fe National Forest.

FIGURE 1  
PROJECT AREA MAP OF VALLES CALDERA



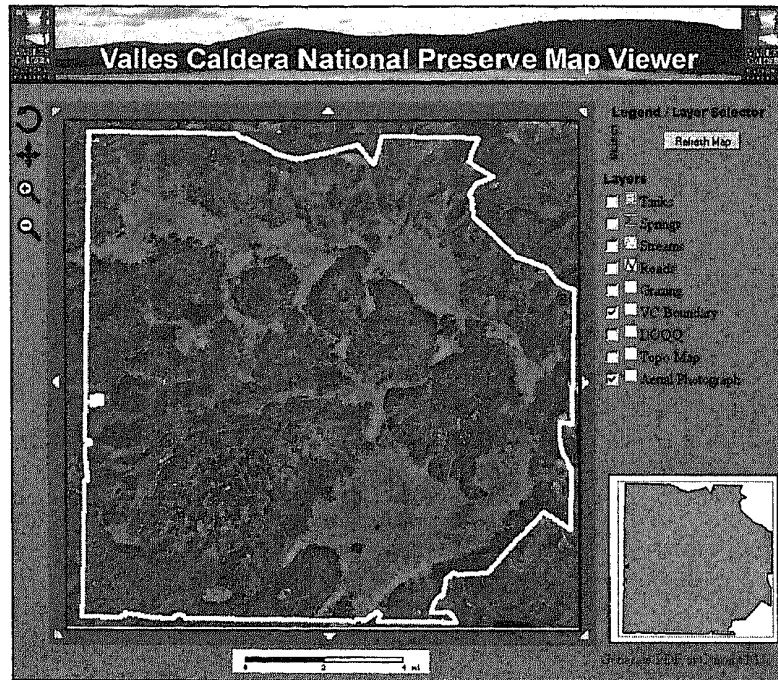
In August of 2002, the management authority for the Valles Caldera National Preserve was transferred to the Valles Caldera Trust. The Trust was charged to become self sufficient by 2015, and immediately the board began to identify sources of income including continuing ranch operations while opening the preserve to visitors and outdoor recreation. Use of science-based adaptive tools that allow managers to make informed decisions on the management of the Valles Caldera Preserve makes the Preserve a test-bed for new models of public land management. A key component of science-based adaptive management is the utilization of remotely sensed data products to monitor vegetation conditions for grazing lands within the Preserve. These data are used to allocate livestock to particular pastures and to monitor the impacts of grazing on Preserve rangelands.

The remotely sensed data products are accessed via through a web-based mapping service. This service is currently available to managers and field personnel at Preserve facilities, and ultimately throughout the Preserve using wireless internet access. This application can be used to aid decisions such as moving livestock from pasture to pasture based on of vegetation conditions. Incorporating static GIS data and dynamic environmental satellite data, the Earth Data Analysis Center of UNM has developed the Valles Caldera Preserve Internet Map Viewer (Figure 2).

In addition to grazing impacts, research on the ability of remotely sensed data to indirectly assess biomass in semiarid grasslands are also being conducted. Decisions regarding impacts of wildfire, erosion, and human use are also supported by near real-time monitoring of vegetation conditions. The extent to which these and other ancillary data are used for decision making is illustrated by the determination that no grazing will be allowed during the 2006-grazing season. On May 4, 2006, the Valles Caldera Trust announced that due to drought and poor range

conditions there would be no livestock grazing on the Preserve for the 2006 season (Cross, 2006; Parmenter, 2006). In spite of this change in focus the development and implementation of the VCP Map Viewer and related research continues with the goal of assisting managers and the VCP scientist in monitoring and studying the impacts of drought conditions and the absence of livestock grazing pressures on rangelands in the Valles Caldera National Preserve.

FIGURE 2  
VALLES CALDERA INTERNET MAP VIEWER



## 2. STUDY AREA

The VCP is home to a variety of wildlife, from the prairie dog towns that dot the preserve and coyotes hunting the myriad Valles rodents to golden eagles and nearly 60 species of birds that breed in the caldera. Wild turkey, black bears, bobcats, and even mountain lions live in the Preserve. By far the most impressive however, is the population of 2,500-3,500 elk that make the Preserve their summer home part of the second largest elk herd in the state. In addition to the more permanent wild residents are summer resident cattle that graze the pasture lands of the Preserve from June to October. Grazing leases play an important role in the sustainability plan for the Preserve and systematic management of forage is critical to balance the needs of both livestock and wildlife in the Preserve.

The total acreage assigned for livestock grazing include 14,227 acres of open grasslands in the three major valleys of the Preserve, Valle Grande, Valle San Antonio, and Valle Toledo on the south, northeast, and north sides of the floor of the collapsed crater, respectively. These valleys are partitioned into a dozen separate pastures that form the basis for grazing management. Active monitoring of forage and water conditions in each pasture is used to allocate livestock. These assessments have been conducted exclusively through on-the-ground measurements of vegetation and water availability in each pasture. This requires a substantial investment in fieldwork to locate and collect vegetation samples from each pasture and to process the samples to assess range condition and productivity. As in case of the ground-based sampling, the pastures are the primary analytical units for the assessment of forage condition through the analysis of remotely sensed vegetation indices.

### 3. DATA

Both static and dynamic data are included in the Valles Caldera Preserve Internet Map Viewer. The static framework data for the project area consists of GIS datasets provided by the Valles Caldera National Preserve. Dynamic data include vegetation indices derived from the Moderate-resolution Imaging Spectroradiometer (MODIS) sensor onboard the NASA Terra and Aqua satellites. The static and dynamic data are uploaded to a data server and Internet map server for delivery to the Valles Caldera Preserve.

#### 3.1 STATIC DATA

The static datasets include pastures/grazing allotment boundaries, stock tank locations, springs, and roads. In addition, a one-meter true color aerial photo derived from a mosaic of digital ortho-rectified quarter quads (DOQQ's) acquired in 1998 serves as the background image. These data allow the Preserve scientist and managers to observe changing vegetation conditions, provided at 250 meter resolution by the MODIS sensor, in the context of a more easily interpreted high resolution image showing important landscape features such as pasture boundaries, roads, and water sources.

#### 3.2 DYNAMIC DATA

The dynamic data that provide the ability to monitor vegetation conditions throughout the Preserve are acquired and processed daily through the Center for Rapid Environmental Analysis and Terrain Evaluation (CREATE) at the University of New Mexico. These data are uploaded from the CREATE data acquisition and processing system to the data and Internet map server housed at the University of New Mexico, Earth Data Analysis Center (EDAC). The MODIS imagery processed at CREATE consists of various data products including the NASA validated Normalized Differences Vegetation Index (NDVI) MOD13 product, which is a measure of the physiological activity of plants. NDVI is a calculation of the ratio of visible and near-infrared light reflected by the vegetation that indicates the level of chlorophyll present, and thereby indirectly the biomass of a given area. The calculation provides a normalized transform of reflectance values standardized to values between -1 and +1. NASA provides composites of this data averaged over 16 and 32 day intervals (Huerta and Justice, 1999; Weier and Herring, 2006). CREATE provides NDVI data on a daily basis, as well as composite datasets.

Another dynamic data set to be included in the analysis of the VCP rangelands and delivered using the VCP Map Viewer is the compiled ground based biomass and vegetation condition data. These data will be used to assess and validate the remotely sensed data by comparison to contemporary imagery and index values thus allowing the correlation of measured physical vegetation changes to those measured by the MODIS sensor.

### 4. METHODS

#### 4.1 DATA INTEGRATION

In addition to the integration of remotely sensed data, field verification studies are currently being conducted for the purpose of validating biomass and condition assessments. Random 25-cm hoop samples of grassland habitats are collected over the summer growing season. Clipping all surface vegetative materials from randomly, and non-randomly located samples throughout the Valles grasslands is used to collect these samples. In the absence of grazing pressures, such as during the current season, these data provide a critical baseline for vegetative growth under natural conditions. In addition, they are used to calibrate biomass assessments from the MODIS

imagery by allowing the definition of regression coefficients for the conversion of imagery data to biomass estimates. This is ongoing research but will play a crucial role in decision-making support. Once these coefficients are defined and calibrated they will be integrated into the Valles Caldera Preserve Internet Map Viewer. By providing these estimates of biomass in the Map Viewer the range managers will have direct and synoptic data on a daily basis from which to make decisions.

At the core of the newly developed capabilities, the Valles Caldera remote sensing data visualization system is the implementation of a services oriented architecture that is built upon a set of logically separate, but interacting tiers. These tiers consist of a data storage tier, a core service tier, a processing services tier, and an application interface tier (Figure 3). The foundation capabilities of the visualization system are based upon established standards and specifications.

## 4.2 DATA STORAGE TIER

The data storage tier (represented by the lowest [dark gray] box in Figure 3) provides the physical storage for the data that are used in the Valles Caldera application. In the case of the Valles Caldera application, the vector data used in the visualization interface are stored in a PostgreSQL/PostGIS geodatabase while the remote sensing data are stored as a GRASS GIS-based raster database. Access to these capabilities will provide key functionality to the Valles Caldera Preserve Internet Map Viewer as additional analytic and visualization capabilities are developed, transforming the Map Viewer to an integrated mapping and analysis system.

## 4.3 CORE SERVICES TIER

The core services tier for the Valles Caldera application (represented by the second [from the bottom] box in Figure 3) consists of OGC WMS built upon the GeoTIFF version of DOQQs and other imagery, vector datasets, and remote sensing data products. These services were developed using MapServer, an open source Internet mapping application, development, and hosting system.

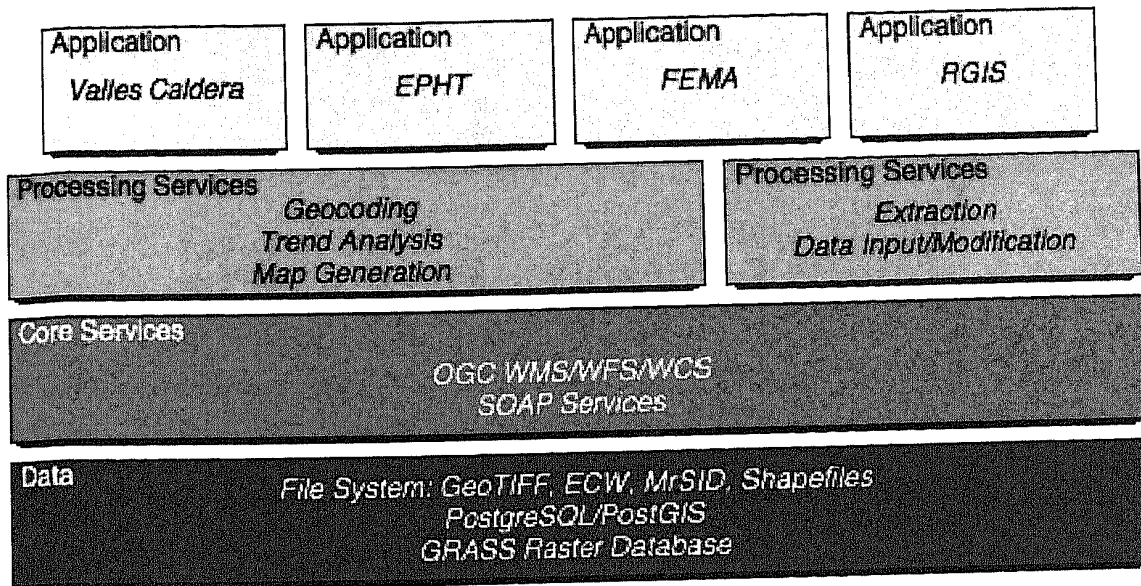
## 4.4 PROCESSING SERVICES TIER

Since this application is in the early stages of development, there are not yet any components within the processing services tier (represented by the third [from the bottom] box in Figure 3) that are specific to the Valles Caldera project. Eventually, processing components are envisioned that will provide regional summarization (statistical) processes, time-series visualization and analysis capabilities, and regression model implementation.

## 4.5 APPLICATION INTERFACE TIER

The application interface (generically represented by the top set of boxes in Figure 3) provides the actual human interface to the Valles Caldera Preserve Internet Map Viewer system. The interface developed for the Valles Caldera project is an interactive web mapping interface that provides the user with basic mapping capabilities that include zoom, pan, layer selection, and hardcopy map generation.

FIGURE 3  
VALLES CALDERA DATA VISUALIZATION AND SERVICES ARCHITECTURE



#### 4.5 IMPLEMENTATION OF THE VCP MAP VIEWER

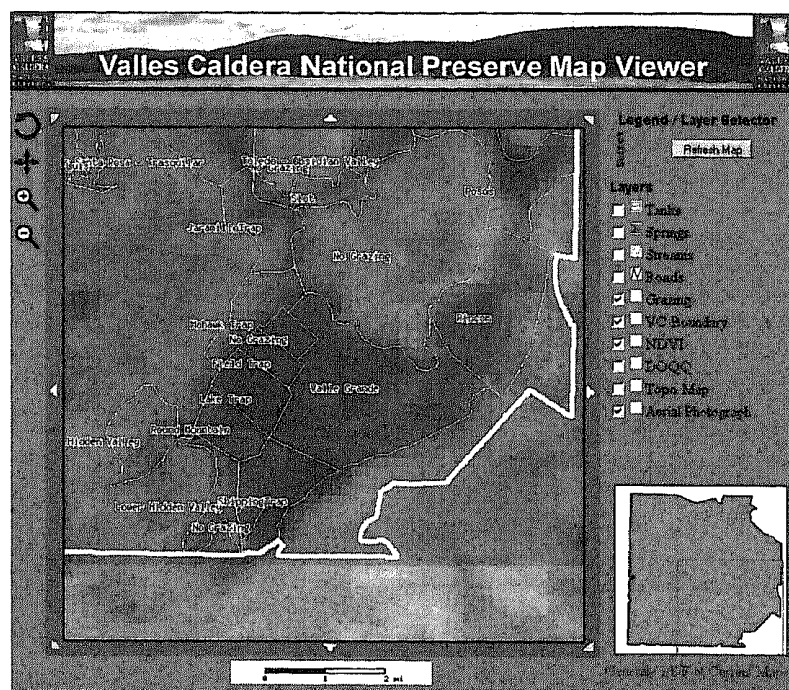
The Valles Caldera Preserve Internet Map Viewer site provides access and mapping capabilities for both the static and dynamic datasets described above. In order to provide the timely data needed for the active management of the Valles grazing lands the VCP Map Viewer system accesses the CREATE data server to obtain the latest daily NDVI imagery. These data are stored locally in the VCP system for subsequent display and analysis. The VCP Internet Map Viewer provides basic functionality to display different data layers for analysis and viewing as well as the capability to generate pdf files of displayed maps. This functionality is available to provide hardcopy printouts for use by management and field personnel.

An example of how range condition data are provided through the VCP Map Viewer is illustrated in Figure 3. This figure shows the integration of current NDVI values semi-transparently overlaid on the high resolution DOQQ imagery and annotated with pasture boundaries. The Map Viewer allows for customizable data selection and zoom to allow assessment of individual pastures and areas in the Valles Caldera National Preserve. The display of the most currently available vegetation indices overlain on pasture boundaries allows the VCP scientist, manager, and field personnel to assess range condition in a scientifically informed and timely fashion.

An examination of Figure 3 shows the variation in NDVI values in the pasturelands of the Valle Grande grazing area. These values represent the vegetative growth in each of the 250 meter ground cells as measured by the MODIS sensor. Lighter cells represent areas of higher vegetative growth while the darker cells are areas having lower vegetative growth or forage density. The VCP managers and scientist use this imagery, along with actual mean NDVI values calculated for each individual pasture, to assess range condition for the allocation of animal units to the various pastures.



FIGURE 3  
NDVI OVERLAY ON DOQQ IMAGERY IN VCP MAP VIEWER



## 5. CONCLUSIONS

By providing condition data to managers and field personnel, cattle can be relocated to pastures showing the highest productivity thus maximizing grazing efficiency and avoiding environmental damage through overgrazing. The VCP Map Viewer provides an efficient and cost effective means of delivering near real-time environmental data to the science and management personnel of the Valles Caldera National Preserve. The VCP web mapping service is designed to provide data delivery and mapping services to light-weight clients with only minimal processing capabilities. The ultimate goal is to provide data access and mapping on low-cost hand-held devices for delivery to field personnel using wireless internet protocols.

Planned future enhancements to the VCP Map Viewer include:

- daily estimations of biomass/productivity of grasslands,
- running seven- and fourteen-day composite NDVI data,
- zoom-dependent graphic display of NDVI values and productivity estimates for each pasture and remotely sensed ground cells,
- interactive queries and graphic display of temporal profiles of NDVI values and biomass estimates,
- rangeland condition warnings for areas falling below seasonally-adjusted minimum growth and productivity levels, and
- automated hotspot/wildfire detection and warnings for VCP and adjacent areas.

The Valles Caldera National Preserve is forging new approaches to the science-based management of public lands. The VCP Map viewer and associated research are providing a basis for near real-time integration of remotely sensed data and products into this process. The goal of this research is improved management of public lands for a sustainable future, balancing natural resources preservation with recreational and economic use.



## 6. ACKNOWLEDGEMENTS

This research is sponsored by the Department of Biology, at the University of New Mexico through NSF Funded research and the Valles Caldera Trust. MODIS Environmental Observation Satellite data is downloaded and processed at CREATE, a center funded by NASA. Thanks to the two anonymous reviewers whose contributions to this document significantly improved its focus and clarity. Very special thanks to Crystal M. Krause, who helped prepare the figures throughout their many versions and revisions.

## 7. REFERENCES

- Cross, J. 2006. Valles Caldera Trust Suspends Livestock Grazing for the 2006 Season. News Release 4 May 2006. [Http://www.vallescaldera.gov/newsmedia/news/news\\_2006Grazingfinal.pdf](http://www.vallescaldera.gov/newsmedia/news/news_2006Grazingfinal.pdf). Last accessed 1 August 2006.
- Huerta, A. C. Justice, C. and W. van Leeuwen 1999. MODIS Vegetation Index Mod13, Algorithm Theoretical Document (NASA EOS), Version 3, University of Arizona, NASA. [http://eospso.gsfc.nasa.gov/ftp\\_ATBD/REVIEW/MODIS/ATBD-MOD-13/atbd-mod-13.pdf](http://eospso.gsfc.nasa.gov/ftp_ATBD/REVIEW/MODIS/ATBD-MOD-13/atbd-mod-13.pdf). Last Accessed 1 August 2006.
- Parmenter, R. 2006. Range Readiness Analysis for VCT Livestock Program for Summer 2006. May 4, 2006. [http://www.vallescaldera.gov/ranching/grazing/grazing\\_readiness.aspx](http://www.vallescaldera.gov/ranching/grazing/grazing_readiness.aspx). Last Accessed 1 August 2006.
- Weier, J. and D. Herring. 2006. Measuring Vegetation (NDVI & EVI). NASA Earth Observatory. <http://earthobservatory.nasa.gov/Library/MeasuringVegetation/printall.php>. Last Accessed 1 August 2006.