Applying Hydrology to Land Management on the Valles Caldera National Preserve

Robert R. Parmenter –
Valles Caldera National Preserve

Since 2004, the Valles Caldera National Preserve (VCNP) in the Jemez Mountains of northern New Mexico has hosted extensive field hydrology research by scientists from the Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) at the University of Arizona. With the development of a detailed hydrologic understanding of VCNP's climate, geology, soils, vegetation, and hydrology, preserve managers have begun to incorporate research results into their management planning for rangelands, forests, and watersheds, including specific programs such as livestock grazing and management of fisheries and wildlife populations.

The Preserve

The Valles Caldera Preservation Act (PL 106-248), passed by Congress in 2000, provided for the acquisition of the privately owned Baca Ranch. The act designated these acquired lands as the VCNP, and created the nonprofit Valles Caldera Trust to manage the 88,900-acre tract. The preserve was established to protect and preserve the scientific, scenic, geologic, watershed, fish, wildlife, historic, heritage, and recreational values of the area, and to provide for multiple use and sustained yield of the renewable resources within it. VCNP operates as a working ranch and is to become financially self-sustaining by 2015.

The VCNP land is a collapsed magma chamber (caldera) approximately 15.5 miles across, and incorporates multiple resurgent lava domes that rose following the chamber's collapse around 1.25 million years ago. VCNP is characterized by these forested domes and grassland *valles* (valleys). Elevation ranges from 7,930 feet at the outflow of the Jemez River's East Fork to 11,254 feet on Redondo Peak, the highest dome in the caldera (see map, right). VCNP forms a single watershed draining from a breach in the caldera wall to the Jemez River's San Diego Canyon, southwest of the preserve.

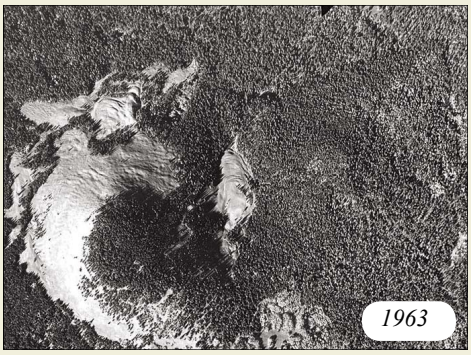
Legacies of Human Activities

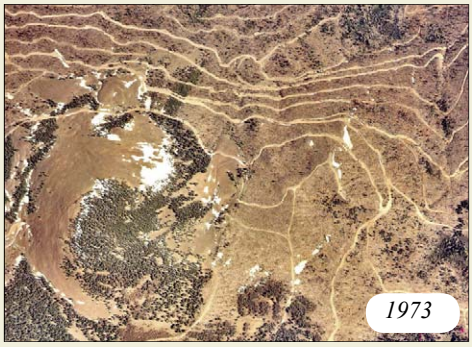
Humans have utilized the VCNP region for at least 10,000 years, harvesting plants and wildlife for food and collecting high-grade obsidian for tools and weapons. As a private land holding, livestock grazing and logging operations dominated human land use in the 19th and 20th centuries, significantly impacting the watersheds and riparian ecosystems. Extensive, long-term overgrazing by sheep (pre-World War II) and livestock (post-1950s) led to substantial degradation of streambanks and water quality; even today the major streams of the preserve are listed as "impaired" by the New Mexico Environment Department, with total maximum daily loads issued for temperature and turbidity as a result of past private ranch management practices. In addition, extensive clearcutting of the VCNP by the New Mexico Land and Timber Company occurred in the 1960s and 1970s (see photos), accelerating soil erosion and contributing to the turbidity loading of the streams. Today's forests are dense with second-growth stands of young pine, fir, and spruce, which pose a substantial influence on fire risk and watershed health.

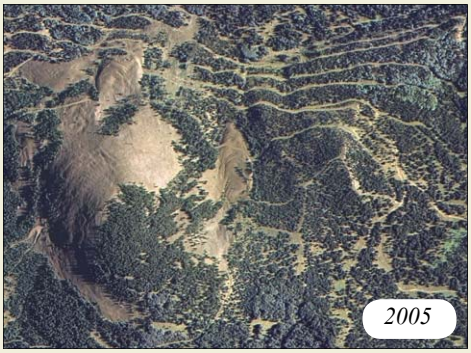
Hydro Research Informs Management

In this water-limited montane ecosystem, VCNP land managers are incorporating both the constraints and opportunities illuminated by new research. Given the poor condition of the preserve's extensive

Repeat aerial photography of Redondito Peak, VCNP, showing logging impacts. Left: prior to logging in 1963; center: after logging in 1975 (showing logging road system); right: near-closure of dense second-growth tree canoopy in 2005.





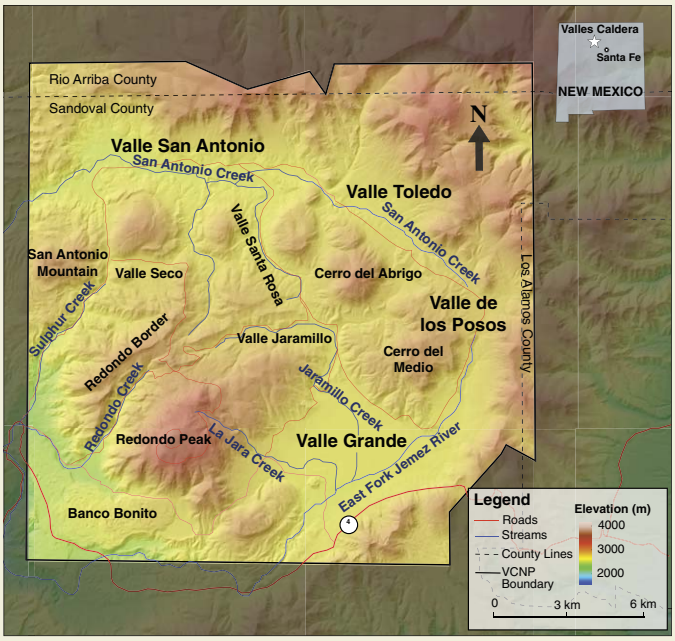


second-growth forests, managers have begun to thin and burn the "dog hair" thickets of young Ponderosa pine and white fir in an effort to reduce catastrophic fire risk and improve wildlife habitat. Recent measurements have shown that these dense, second-growth forests intercept much of the winter snowfall before it can hit the ground, and as a result, nearly 50 percent of the snow water equivalent (SWE) sublimates and is lost from the terrestrial hydrologic cycle.

By implementing thinning prescriptions, managers intend to increase the amount of water available to the terrestrial hydrologic cycle.

However, new research has also quantified how snow and SWE are distributed in microsites around trees. A field survey of 900 points found maximum snow accumulation occurs under canopy densities between 25 and 45 percent, corresponding to about 20 percent greater SWE than in open areas (Veatch, 2008). From these data, mathematical models are being developed to maximize SWE retention (minimize sublimation) through forest-thinning prescriptions. For each forest stand of a given age, size, and density structure on a known slope, aspect, and elevation, there is a unique solution to optimize open space (allowing snow to reach the ground) and still provide shade to reduce sun- and wind-driven sublimation. By implementing these thinning prescriptions, VCNP managers intend to increase the amount of water available to the terrestrial hydrologic cycle, enhancing growth of trees, shrubs, grasses, and forbs for wildlife food and habitat, and potentially providing additional streamwater discharge during spring snowmelt for downstream users. Preliminary estimates suggest that using these forest thinning prescriptions could reduce snow sublimation by up to 50 percent, thereby increasing stream discharge from the preserve by approximately 10 to 20 percent.

This enhancement of "ecosystem services" to society in the Rio Grande valley has significant monetary value. VCNP streams produce around 20,000 acre-feet of water each year: a 10 percent increase in stream discharge would equal 2,000 acre-feet. At current water rights prices (the city of Rio Rancho, New Mexico, recently purchased water rights for $11,000 per acre-foot), the capital value of 2,000 acre-feet would equal $22 million. If leased at 10 percent of capital value per year, this would equal an annual water benefit worth $2.2 million to downstream farmers, ranchers, and urban residents. Concomitantly, the financial benefit of reduced fire risk and increased forage for wildlife and livestock from forest thinning further enhances the collective value to society.



Location of the Valles Caldera National Preserve in New Mexico.

Hydrologic principles also are being incorporated into rangeland productivity assessments and forecasts for elk and livestock grazing on the VCNP. Currently, cattle stocking rates are predicated on available spring forage production, soil moisture profiles, and 3-month climate forecasts. Satellite-based MODIS remote-sensing imagery are used to evaluate forage biomass on 250 x 250-meter pixels on a daily basis, and managers can examine increasing and decreasing trends in forage to make real-time decisions on livestock distributions and movements, such as pasture rotations.

Future additions to these applications will include use of NEXRAD data to estimate storm-specific precipitation amounts and distributions, coupled with forage-growth models to forecast short-term (2-week) changes in forage amounts. Hydrologic models that depict watershed dynamics and soil-moisture changes following snowmelt and summer thunderstorm events will further increase the capabilities of this toolbox to accurately predict short-term trends in grassland productivity for grazing programs. These models also can be applied for fire risk assessment and fuels management.

Looking Ahead

The recent research has added significantly to the knowledge base of VCNP managers, with direct applications to forest and range management. Future models, incorporating remote-sensing, geographical information systems, and real-time monitoring of climate and vegetation dynamics, will greatly enhance our capability to manage public lands in a sustainable and economically efficient fashion. Continued development of basic scientific principles in hydrology and science-based applications to watershed management issues will ensure the successful management and long-term sustainability of the natural resources of the Southwest.

Contact Bob Parmenter at bparmenter@vallescaldera.gov.

Reference

Veatch, W., 2008. Quantifying the effects of forest canopy cover on net snow accumulation at a continental, mid-latitude site, Valles Caldera National Preserve, New Mexico, USA. M.S. thesis, Univ. of Arizona Dept. of Hydrology and Water Resources.