Art to Science: Tools for Greater Objectivity in Resource Monitoring

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The Need for New Monitoring Tools

The earliest inventories of western rangelands were "ocular" estimates.[1] Such estimates are subjective; they are opinions, judgments, or guesses based on experience and feelings—"the art" of rangeland management (Fig. 1).

Now, our monitoring needs are different and the importance of objective data consistent with formal scientific inquiry is more essential; the goal is " ... consistent, uniform, and standard vegetation attribute sampling that is economical, repeatable, statistically reliable, and technically adequate."[2] From discussions with agency personnel, and through our own experience and reading, we believe meeting this goal has been mostly impractical due to: 1) the variation in data collected among observers and through time by single observers; 2) the high cost of conventional monitoring, which results in a) limited sampling, resulting in a high risk of false-negative results (i.e., finding no change, when change has occurred), and b) subjective selection of relatively small "representative" sample areas with a focus on specific resources rather than ecological systems[2]; and 3) a lack of statistical design and rigor in inventory and monitoring efforts.

These obstacles to effective data collection result from inventory and monitoring (i.e., surveys) technologies unsuited to a vast resource; from stresses on observers; and from shrinking budgets and limited survey workforce. Expert rangeland technicians recognize the importance of plant growth-stage (phenology) comparability when making across-year comparisons. However, the number of sample sites that can be visited and worked, using conventional survey methods during phenologically comparable time frames of a given year, is limited. Usually, there is inadequate time for a statistical science-based resource survey of extensive areas. In practice, conventional rangeland data collecting continues to be unverifiable, often highly variable, and from a limited number of nonrandomly selected sites. It simply has not been practical to do otherwise.[3]

The past decade has produced a number of new tools and methods for improving natural resource monitoring. The arrival of dependable digital cameras and the development of tools for using these cameras and resulting imagery are among the most important of these advances. Here we review the use of nadir (vertical) digital imagery and associated tools to highlight how these advances are making resource surveys more objective and adequate sampling and data acquisition more practical for landscape-scale management.

The Quest

If there has been a "holy grail" of ecological investigation, it is image-based data collection. As early as 1924, Cooper[4] described a camera stand for use in vegetation analysis (Fig. 2a). His work signaled that ecological imaging had moved past the landscape perspectives of late 19th and early 20th century photographers such as W. H. Jackson and H. L. Shantz, to the nadir perspective useful for measurements. Cooper's work was followed by an 80-year series of reports on very high-resolution imaging for detailed ecological analysis; but, it is only now, with the widespread use of digital cameras, that image-based methods for acquiring fine-scale information are replacing conventional point, plot, transect, and ocular estimates in ecological-monitoring tool boxes.

Photo Sampling

Methods for obtaining nonaerial, nadir digital images include staffs, stands (Figs. 2b and 2c), booms, and gantries, plus mounts for all-terrain vehicles and automobiles; also, there is a recently described free-hand method[6] (Fig. 2d). These tools allow for a range of camera positions above ground level and respective image resolutions.

Image locations should be documented with a Global Positioning System (GPS)[5] and images can be cropped to a desired area of interest before analysis. If a square area of interest is desired, a 3:4 aspect ratio will reduce image cropping compared to a more rectangular ratio (aspect ratio is the width:length of the digital-camera sensor).

Even where sampling is done primarily from aircraft, acquisition of ground images is an important part of monitoring.