A New View for Resource Managers

Robert H. Haas

Introduction

In decades past, the rancher depended upon reports from cowboys to gather information he needed to make management decisions. Today, the vast open ranges of the cowboy era are mostly gone in the United States—fenced into pastures, paddocks, or fields that are now discrete management units. But fencing in the rangeland, while it has replaced much of the need for cowboys, has not replaced the need for information about the health and vigor of the forage on each parcel of land.

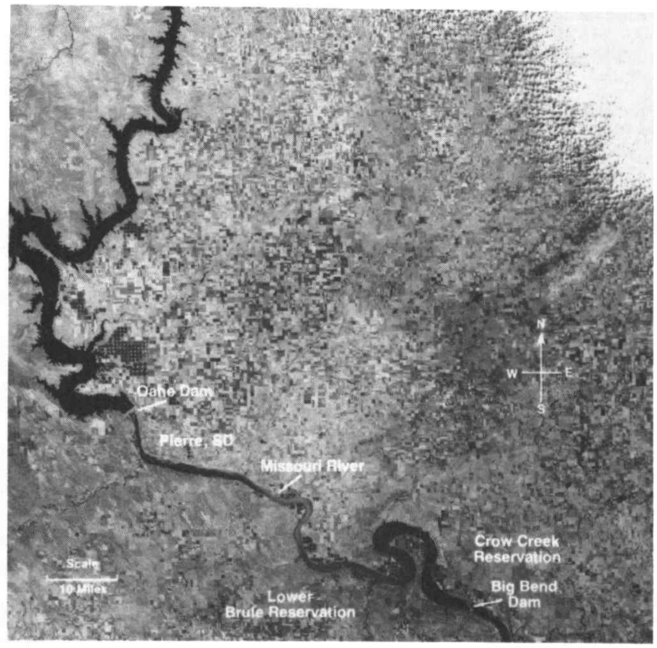
Can a satellite, orbiting at more than 400 miles in space, serve this purpose?

As ranchers and resource specialists are asked to make more and more complex management decisions, with less manpower for conducting inventories, they are wise to seek help in today's rapidly developing technologies. For the past few decades the range technician has accomplished most of his range assessment from a pickup truck, traveling periodically to each unit to determine its status. Now, satellite images of the Earth's resources might be able to help the modern range person do an even more efficient job of monitoring the availability of feed for livestock and wildlife. Yet some important questions need to be answered first. Can this new information source be used to evaluate the ecological condition of these lands? Or are satellite images of our Earth and its variety of landscapes just "pretty pictures," with little practical utility?

Resource Satellites

A series of five Earth resources satellites, known as Landsat, have collected more than 2,000,000 images of the world's landscapes since 1972. Today, Landsat 5 treks around the Earth with a potential for imaging the world's resources about every two weeks (16 days). Landsat's electronic sensors record the energy reflected from objects on the ground below its orbital track, producing images that cover an area approximately 100 miles square along each orbital path. The multispectral scanners (MSS), which have been aboard the five Landsat missions since 1972, look at an area as small as one acre. New instruments on Landsats 4 and 5, called thematic mapper (TM), have a resolution about five times better than this and can image an area as small as some gardens.

Another source of satellite data for resource monitoring is from the National Oceanic and Atmospheric Administration's (NOAA) weather satellites. They image the Earth every day, monitoring both the visible and infrared spectrum. The Advanced Very High Resolution Radiometer data from the weather satellites have a coarser ground resolution than Landsat, but summaries of the data are available on a worldwide basis every week.



Landsat 5 scene showing rangeland and cultivated crops along the Missouri River in central South Dakota from near Chamberlain to Pierre and includes: the Lower Brule and Crow Creek Indian Reservations, Big Bend Dam, and the City of Pierre and Oahe Dam, all along the Missouri River.

Satellite Data Products and Their Uses

An understanding of how satellite data can be used begins by considering that each picture element, or pixel, in a Landsat MSS scene represents an area of about 1.1 acres. In contrast, a Landsat TM pixel covers less than 0.2 acres, while the much coarser weather satellite pixel would cover an area of about 250 acres. Obviously, no such images would let you count the number of mesquite bushes in the back horse trap. Yet, many landscape features, including large rivers and lakes, mountain ranges, deserts, cultivated areas, rangelands, and forests are observable, even with the coarse resolution of the weather satellite images.

For rangelands, large-area monitoring is generally the name of the game. It is estimated that about 45 percent of the Earth's land surface is best used as rangeland, and conventional measurement approaches simply will not suffice for most applications. To follow deteriorating range conditions due to drought and desertification, regional monitoring is necessary. In many cases this can be done only with synoptic, large-area coverage provided by satellites.

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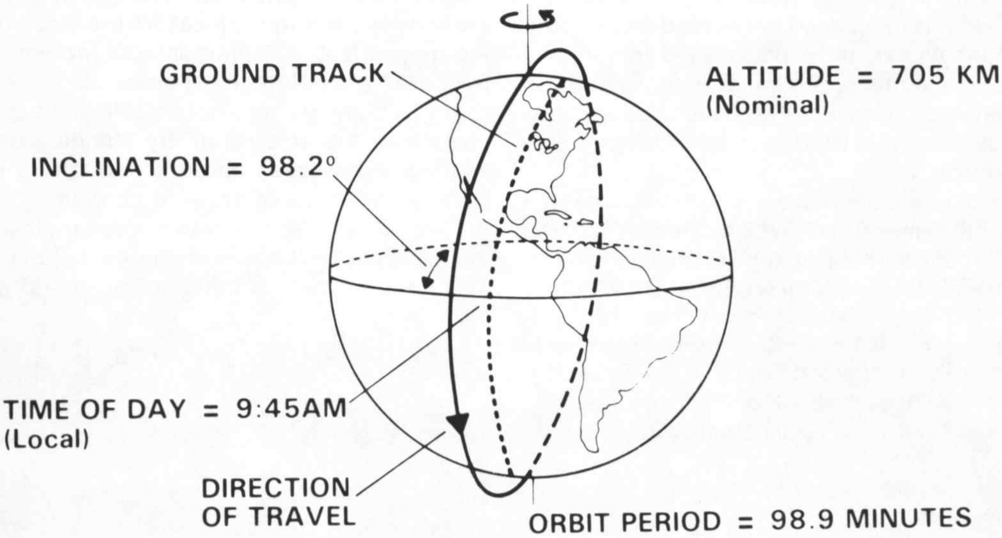
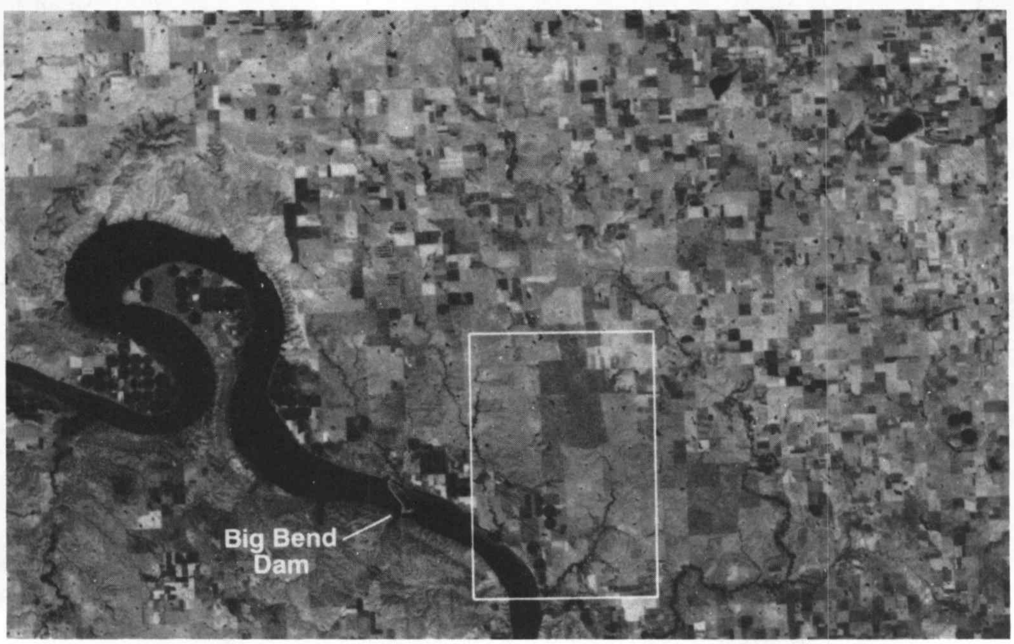


Thematic mapper and multispectral scanner sensors on Landsat 5 are in a position to take repetitive coverage of the Earth's surface every 16 days. Major orbital characteristics are shown above.

Rangeland areas are most often relatively arid regions. Consequently, cloud cover is not the problem for satellite remote sensing of rangelands that it is for some other applications of satellite imagery (such as over humid forest regions). Satellite images of rangelands can thus be acquired at critical times in most years. The time of acquisition is very important because the images recorded by Landsat during dormant or very dry periods show little contrast. In temperate climes, the most useful information for rangeland assessment seems to be from scenes taken near the end of the growing season. It is at this time of year that grasslands best show the degree of use, or conversely, the amount of standing crop remaining. In many ways, satellite-acquired data seem ideally suited for rangeland study.

Apart from the spatial and temporal characteristics that make satellite images potentially useful, there is a good deal of spectral information in every scene. Analysis of MSS data indicates that scene brightness and the greenness of the

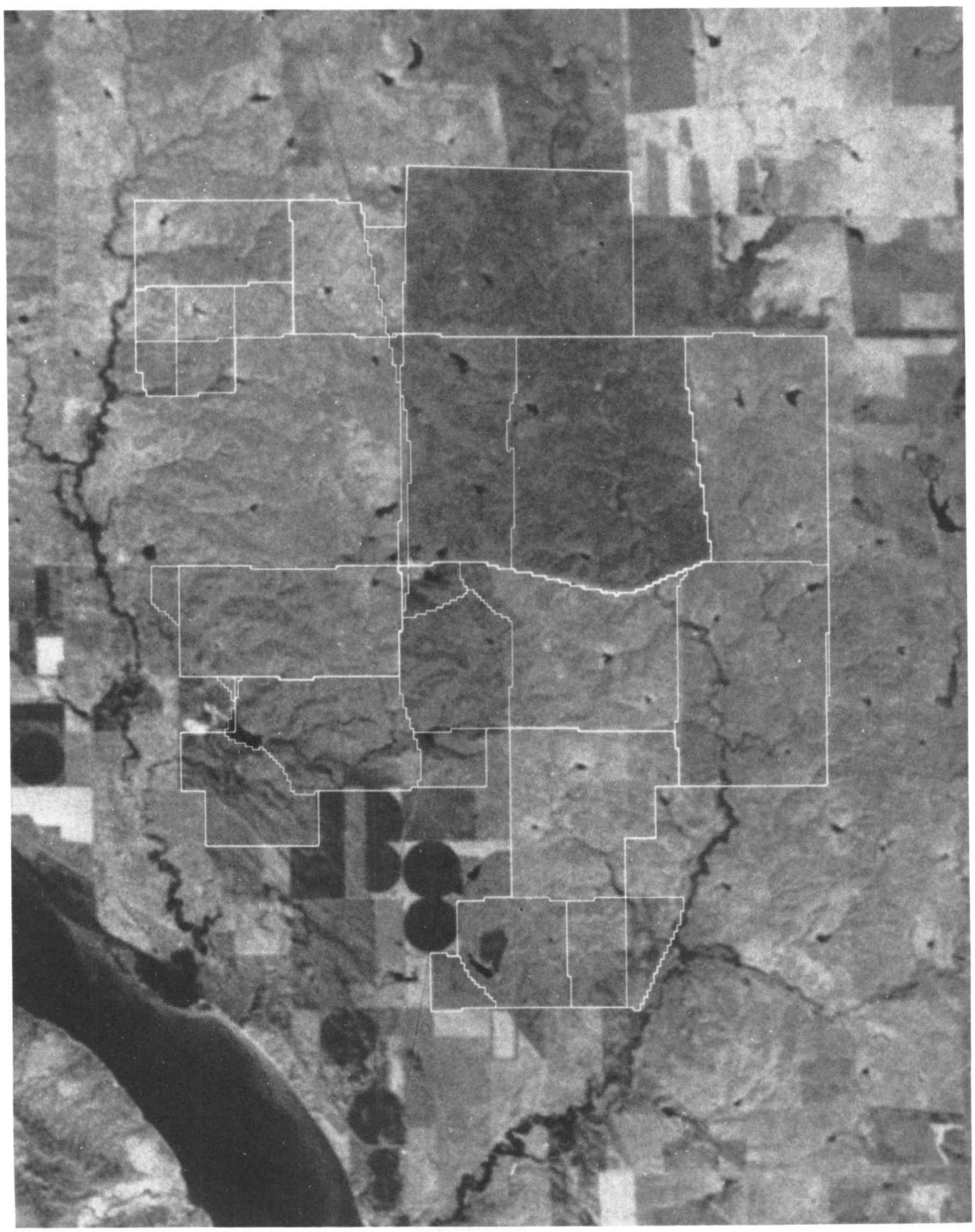


Brightness differences on rangelands in the September 12, 1984, Landsat TM images from Buffalo County, S. Dak., are directly related to the degree of use within pastures. White outline indicates study area included in following scene.

vegetation cover explain more than 95 percent of the reflectance variation in most Landsat MSS rangeland scenes. Brightness (or albedo) is influenced by the kind and amount of cover, the amount of litter, and especially the amount and kind of exposed soil surface. On most soils brightness increases with heavy use, or as range condition deteriorates. Therefore, brightness can be used to monitor serious erosion or vegetation loss.

Several indexes of greenness have been shown to be well correlated with ground-measured green biomass. All of the greenness indexes contrast reflectance in the red and near-infrared spectral bands. When weather satellite data are used this way the relative greenness of vegetation cover can be monitored continent-wide. The "green vegetation" indexes are sensitive enough to measure the amount of green standing crop in 250-300 pounds/acre increments, up to 3,000 pounds of green forage per acre.

At this point we have not established a reliable means for measuring the amount of dry standing crop with remote sensing. It has been possible, though, to monitor "greenness" as an index of growing conditions and to relate the duration of favorable growth to a volumetric accumulation of annual grasses. It has been suggested that greenness may also be a worthwhile indicator of the nutritional status of



An enlargement of the Landsat TM image (see preceding scene) showing brightness differences by pastures and grazing distribution patterns within pastures for a selected area in Buffalo County, S. Dak. White lines in computer generated overlay are pasture boundaries in a study area.

range forage.

Strategies for Future Use of Satellite Data

Landsat MSS and TM data both have adequate resolution to aid in most area-wide and regional vegetation and soils inventories. These data can be used in computer-aided analyses or can be manually interpreted to define important plant community boundaries. Much care must still be taken in characterizing range sites, and field sampling is essential for compiling reliable maps of the vegetation resources. Since vegetation boundaries often follow changes in soils closely, remote sensing data can also aid soil surveys on naturally vegetated range. Recent demonstrations have shown, in fact, that weather satellite data can be used to conduct continent-wide vegetation surveys.

We have tried, with mixed success, to use satellite data to accomplish conventional range management tasks. But since we usually cannot determine species composition with satellite sensors, some resource technicians have rejected satellite MSS data as a valid source of information. This rejection probably indicates that we need to examine the sanctity of our measurement concepts, as well as the information content of satellite images. Is species composition the only usable measure of the ecological status of a site?

In the past we have not always had a synoptic view of the site being evaluated; thus, we relied heavily on species composition data collected at sample points on the ground to determine the pattern of vegetation distribution. Satellite spectral data have provided the analyst with a new and powerful tool for mapping the boundaries of plant communities that may occur repeatedly across a landscape. Once the cover type boundaries are established, species composition may be inferred from the spectral data or determined from field sample measurements. Spectral data, even when collected by a distant satellite, may be able to provide more sensitive indicators of ecological trends than is possible to obtain by analyzing species composition alone. There is a need to document the ecological trends affected by management and weather and to relate them to associated changes in spectral reflectance. Using the satellite data as an aid in evaluating the ecological status of range vegetation holds much promise for efficient, long-term monitoring and documenting of range ecosystems conditions.

Satellite data have the potential for monitoring range condition trends on a pasture-by-pasture basis, and for helping the range manager to observe grazing distribution problems. On a regional basis, it is now possible to use greenness assessment to supplement regional range feed condition reports. Quick-look capabilities and long-term change detection can be used for many tasks on any area covered by a spatial data base that includes the satellite data. On a worldwide basis, weather satellite data are being used to monitor vegetation greenness weekly. Currently, the information is too coarse to assist range managers, but it seems usable for monitoring drought and even regional desertification. More intensive use of data from the earth resource and weather satellites could make the monitoring of range resources more effective on a local, regional, and even countrywide basis.

The potential for effective use of satellite data in range resource management must be realized in the administrative and managerial echelons if support is to be obtained for the research needed to make these new information sources available and usable. Resource specialists and ranchers, for their part, must undertake the training they will need to make the applications of these data pay off in terms of better forage resources and more profitable use of the range for all. It seems almost certain that the increasing pressures for efficiency that are being brought to bear on land management operations everywhere will be aided by the new view of range resources available from Earth resource satellites. ●