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ERTS-1 EVALUATIONS OF NATURAL RESOURCES MANAGEMENT APPLICATIONS IN THE GREAT BASIN

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ABSTRACT:

The relatively cloud free weather in the Great Basin has allowed the accumulation of several dates of excellent ERTS-1 imagery. Mountains, valleys, playas, stream courses, canyons, alluvial fans, and other landforms are readily delineated on ERTS-1 imagery, particularly with MSS-5. Each band is useful for identifying and studying one or more natural resource features. For example, crested wheatgrass seedings were most easily identified and measured on MSS-7. Color enhancements simulating CIR were useful for depicting meadow and phreatophytic vegetation along water bodies and stream courses.

A lack of sequential ERTS-1 coverage during the growing season has precluded an evaluation of vegetation phenology changes. However, significant phenology comparisons have been made with U-2 data and offer promise of usefulness in making resource management decisions. Work is underway to inventory and monitor wildfire areas by age and successional status. Inventories have been completed on crested wheatgrass seedings over the entire State of Nevada, and inventories of playa surfaces, water surfaces, phreatophytic vegetation, snow cover, meadows, and other features is continuing. Most of this data is unavailable from conventional sources and would not be available without the possibility of rapid inventory on ERTS-1 imagery.

Vegetation ecotones are being delineated for vegetation mapping. The pinyon/juniper-northern desert shrub ecotone has been identified with considerable success. Phenology changes can be used to describe vegetation changes for management.

INTRODUCTION:

Cloud free weather in the Great Basin has allowed complete coverage of Nevada. Many areas are covered by several dates. A mosaic of the state has recently been constructed using 21 black and white prints at a scale of 1:1 million (24 by 36 inch sheet) and 1:2 million (12 by 18 inch sheet). The red band (MSS 5) was used to construct the mosaic because landform features appeared more striking. This mosaic is being used as a base to map resource features and compare changes on other imagery types and dates.

Ground coverage for single ERTS-1 frames is approximately 12,500 square miles. Resolution of MSS data was found to be excellent, although exposure problems have been encountered. One reservoir 275 feet across was identifiable on MSS 7. The cities of Reno and Las Vegas are easily distinguishable on all bands. Smaller towns like Elko and Battle Mountain were easily identifiable only on snow covered frames.

Limited numbers of roads and railroads are visible. Four lane paved roads and freeways were visible only when they were in high contrast with the adjacent terrain, as was true with two lane paved roads. Many wide dirt roads traversing valley bottoms were visible due to their high reflectance. MSS 7 was superior for identification of all roads.

USES:

Our initial evaluations of ERTS-1 were directed to identification and determination of resolution. Secondly, we have been studying uses. The first of these has been inventory of natural resource features. Thirdly, we are studying change detection, which goes a step beyond inventory and provides systematic time dependent data useful to resource managers. Examples of inventory and change detection are described below.

Mountains, valleys and playas, stream courses, canyons, and alluvial fans can be easily delineated on ERTS imagery. MSS 5 was found to be the most useful for identification of these general landform features. Steep canyons were identified easily on MSS 7 where thick phreatophytic vegetation occurred. The large valleys and playas were easily identified on all bands. Mapping of land use and of other natural resources features is not difficult. Early in our studies, we evaluated a single frame of 12,500 square miles in Central Nevada (Table 1). These data were extracted successfully in 3 man days.

Native vegetation has been plowed and planted to introduced grasses to increase grazing potential. These seedings have been quantified using a mid-September ERTS date (Table 2). The MSS 7 band was the most useful. Seedings were delineated by county and their acreage computed from dot grids, millimeter squares and a grid corresponding to sections (1 square mile). Acreage was determined by ownership or administration: public, private, county, Forest Service, Bureau of Land Management, Indian Reservations and other. This was derived by comparing locations on a newly published 1:500,000 scale land status map of Nevada. Intermediate scale photography over selected portions of the state and field checking by aircraft flights have confirmed identifications. We expect to update this data and possibly identify dates which are more interpretable. A recently received winter date with complete snow cover tended to make the seedings more obvious and additional ones were identified.

Numerous variations in reflectance were noticed among seedings and are attributed to condition (secondary successional patterns), age, recent precipitation, or grazing intensity. These factors will be further evaluated by analyzing sequential imagery during the growing season.

A major objective has been to map the natural vegetation of Nevada. The valleys are sparsely vegetated with shrubby, desert vegetation (Fig. 1). These areas appear fine textured on the ERTS imagery, and usually have a light gray tone on all bands, depending on soil type. Separations have not yet been possible for the northern desert shrub, southern desert shrub, or salt desert shrub vegetation except for geographical location and landform position. Soil surface colors produce more tonal differences than do the vegetation.

Table 1. Area in square miles of identifiable features for one frame of ERTS imagery (12,500 sq. mi.)* of Central Nevada.

Feature	Area (sq. mi.)	% Total Area
low or flat lying areas	1,852	14.6
alluvial fans	4,465	51.1
mountains	4,333	34.3
Total	12,650	100.0

Feature	Area (sq. mi.)	% Total Area
seedings	1,078	8.5
meadows	222	1.8
playas	1,284	10.2
irrigated fields	134	1.1

* Frame I.D. number 1018-17592-M

Table 2. Seedings within the state of Nevada broken down by county and land status.*

	Land Status					
	Public Land		Private Land		Acres	% of State
County	Acres	%	Acres	%	Total	Total
Churchill . .	1,235	100.0	-	-	1,235	.1
Douglas . . .	494	100.0	-	-	494	-
Elko	317,983	63.5	182,464	36.5	500,447	50.4
Eureka . . .	42,344	85.5	7,200	14.5	49,544	5.0
Humboldt . .	83,492	69.6	36,427	30.4	119,919	12.1
Lander . . .	42,849	94.7	2,400	5.3	45,249	4.6
Lincoln . . .	63,585	97.1	1,920	2.9	65,505	6.6
Lyon	7,343	79.3	1,920	10.7	9,263	.9
Mineral . . .	1,309	48.2	1,408	51.8	2,717	.3
Nye	36,810	86.8	5,600	13.2	42,410	4.3
Washoe . . .	4,693	100.0	-	-	4,693	.5
White Pine . .	141,270	93.2	10,240	6.8	151,510	15.2
Total	743,407	74.9	249,579	25.1	992,986	100.0

* Only those counties which have seedings are included.

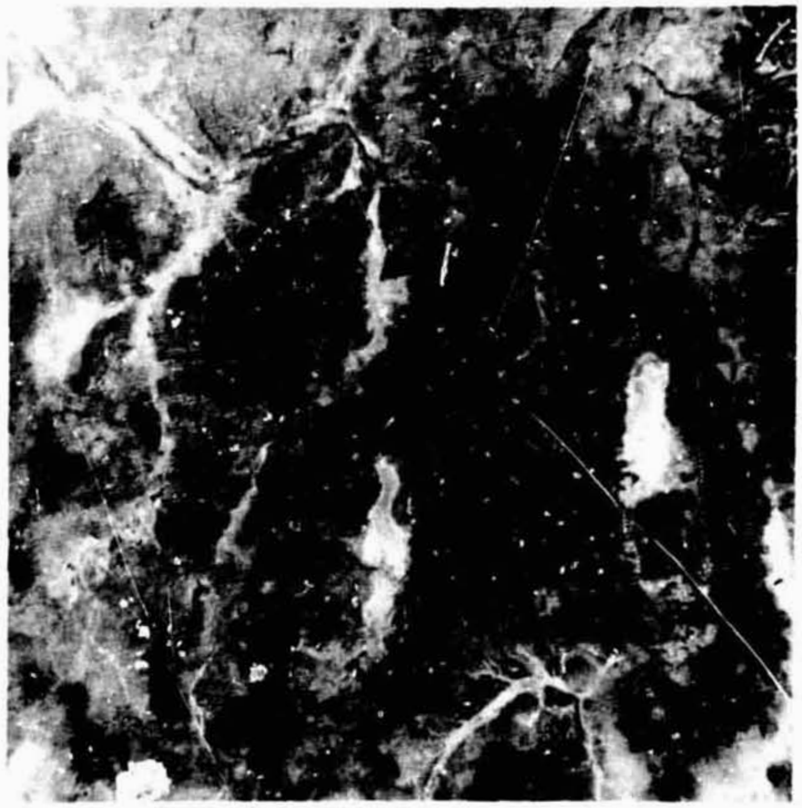

Fig. 1. Diamond Valley Frame (MSS 5). Vegetation mapping is possible on this frame. Crested wheatgrass (1) seedings and wildfire scars (2) are easy to delineate.

This task has been very difficult without the aid of color composites. Some images have been enhanced on the I^2S Corporation's Addcol viewer, and more recently, we have used color composites made from diazochrome transparencies. We found that pinyon/juniper can be mapped on winter color infrared composites because it is the only vegetation type exhibiting IR reflectance at this date. Aircraft photography is being used to compute different pinyon/juniper densities which are checked to determine if they can be identified on ERTS data. Plant communities will generally have to be larger than the 300 feet resolution due to low contrast between stands of different communities.

Chaparral and mountain brush communities were identified on late summer/fall imagery before it had lost its infrared reflectance due to leaf fall. Other types will be identified on spring and enhanced imagery. Salt desert shrub and sagebrush types are being identified by correlating with landform and soil types. Meadows larger than 300 feet in one dimension are readily visible on late summer imagery. For example, a 50 acre meadow at the base of the Ruby Mountains was readily visible on ERTS. Fence line contrasts were visible in this same area where a differential grazing intensity has caused a deterioration in meadow condition across the fence line. The color composite was required for this observation.

The pinyon/juniper-northern desert shrub ecotone is being evaluated by identifying individual ecotones of varying length. The success of accurately defining these ecotones on ERTS-1 imagery has been determined (Table 3). Color infrared has proven superior and was not as susceptable to error caused by the appearance of landforms as was the black and white imagery. Small amounts of infrared reflectance caused by the presence of pinyon/juniper is detectable with the Color IR imagery, thus preventing possible confusion with other features. Larger scale (1:110,000) RB57F photography and aerial reconnaissance have been used to verify the true locations of the ecotones.

With the use of a dot grid and RB57F photography, the minimum density of pinyon/juniper that can be recognized on ERTS-1 Color IR has also been determined. It was found that a density as low as 16.4 trees per acre could be seen on ERTS-1 Color IR imagery if the trees were close and continuous. Areas of pinyon/juniper as small as 55 acres could be seen with a density of 29.5 trees per acre. A discontinuous area of pinyon/juniper with a broken pattern having trees only on the lower slopes of many close ridges showed sufficient reflectance to be identified only when the density exceeded 43.9 trees per acre. Generally, a pinyon/juniper community with a density of 30 trees per acre and larger than 55-60 acres can be identified on ERTS-1 Color IR imagery.

Green, healthy fields reflect strongly in the infrared and are identified easily on color composites. Fallow fields appeared highly reflective on all bands and were therefore identifiable. Irrigated fields were separated from the non-irrigated fields and phreatophytic types by their constant tone and their characteristic straight line borders. Numerous variations in reflectance were noted from date to date on ERTS imagery corresponding to harvesting, watering, fertilizing, plowing, etc.

Wildfire scars, both recent and old, are being inventoried and monitored. A quantitative estimate of the number of acres burned may be obtained easily. We are identifying these burns by relative age: less than one year, 1-10 years, and over 10 years. These are fairly rough estimates and are based on secondary succession textural changes.

Phreatophytic vegetation has been cursorily quantified along the Truckee River and the Las Vegas Wash, using ERTS imagery. A more precise inventory of this vegetation will be made in the future and feasability has been established. Similar data are being obtained for meadow vegetation.

Standing water surfaces were inventoried using mid-September imagery as a base. Reservoirs, lakes and ponds were identified on MSS 7 images (Table 4; Fig. 2) and named from existing topographic maps. The surface

Table 3. Success of identifying the pinyon/juniper-northern desert shrub ecotones in the Great Basin.

Imagery	% Success	% Closure	% Failure	Total no. Evaluated
ERTS 1-Fall	39.4	45.5	15.1	33
ERTS 1-Fall (Color IR)	81.8	9.1	9.1	11
ERTS 1-Winter	54.5	33.3	12.2	33
RB57F - 1:110,000	100.0	0.0	0.0	33
Total (ex.RB57F)	51.9	35.1	13.0	77

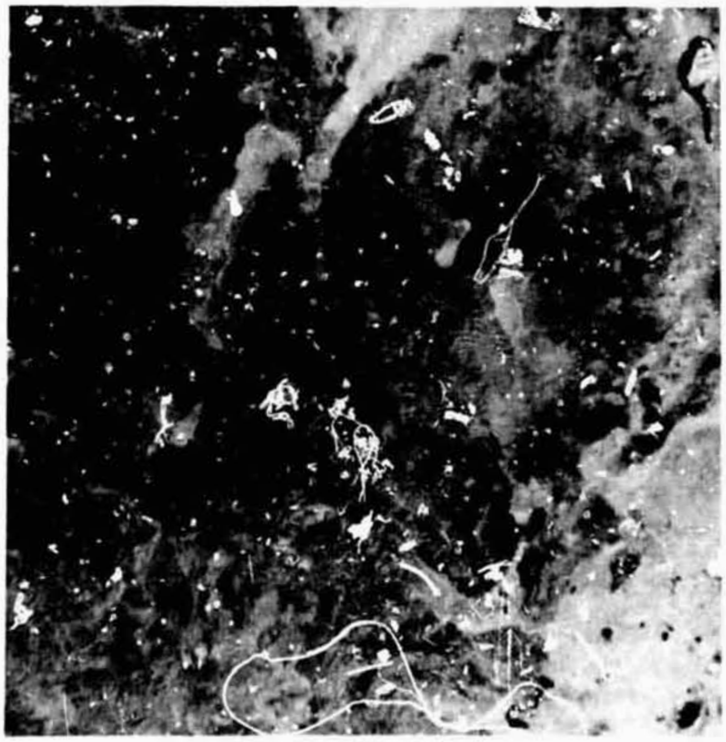

Fig. 2. Pyramid Lake Frame (MSS 7). The ease of inventorying water surfaces is strongly enhanced. Honey Lake in the center left was difficult to evaluate on MSS 5.

Table 4. Standing water resources inventory from selected Nevada Counties.

Counties	Acres	%
Washoe	128,488	43.4
Mineral	37,890	12.8
Clark	65,842	22.1
Douglas	18,949	6.4
Churchill	10,579	3.6
Pershing	9,657	3.3
Total	271,405	91.6
Total in Nevada	295,872	100.0

area was quantified by acreage using a system similar to that described earlier. Each water surface is being analyzed for area changes on new imagery as it becomes available. These changes can be related to water consumption, evaporation, climatic conditions, and amount of potential irrigation water available, all of which are important considerations in the arid Great Basin. Freezing and thawing are also being evaluated. A technique is currently being developed to assign a gray scale value to each water body on each MSS band to correlate with water turbidity.

Playas, numerous in Nevada, are interior drainage basins in which water drains into and stands until it evaporates. These playas are apparent on ERTS imagery whether dry or partially full. The MSS 7 band detects the water even though it may be only one inch deep. The MSS 4 and 5 bands tell us something about the quality of the water in these playas, which is often poor. The presence or absence of water in these playas gives a good indication of recent precipitation in and near the local watersheds.

Inputs on a few lakes or reservoirs that are being monitored can provide correlative data that can be extrapolated to remote water surfaces. For example, the thawing date of a reservoir will affect the type of recreation potential. The freezing date of another pond may limit its value for waterfowl use.

A lack of sequential ERTS-1 coverage during the growing season has precluded an evaluation of vegetation phenology changes. However, significant phenology comparisons have been made with U-2 data and offer promise of usefulness in making resource management decisions.

We have related plant phenology to signatures seen on pre-ERTS multispectral and color infrared U-2 photography flown by NASA. This photography covered our study sites on three to six dates between April 3,1972 and June 14, 1972.

The black and white multispectral U-2 bands were analyzed by assigning standard Munsell shades of gray to each vegetation type on each date. The infrared band was found to be most valuable in the detection of the various vegetation growth stages. Annual grassland (cheatgrass) and brushland areas

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in the Reno area showed a general increase in infrared reflectivity with increased vegetative growth. No imagery was available for the late summer dormant period for these areas to determine if the reflectance decreased as the plants became completely dry. Problems with exposure and insufficient sequential dates led to an incomplete analysis. Exposure differences may have masked the true values of date to date variations in gray scale.

The color infrared U-2 photography was also compared to the vegetation phenology. The annual grasses (cheatgrass) in the Reno area were identified on the sequential photography as green and healthy from April 19 to May 5 (the best time for cattle grazing). The May 31 photography revealed that this grass was completely dry (past optimum period for cattle grazing). Field observations supported this conclusion.

In the Ruby Marsh study site (Northern Nevada), several management units occur in which the water levels have been manipulated for control of the heavy stands of bulrush (for interspersion to promote duck nesting). On the April 20, U-2 black and white IR imagery, three of these units appeared identical. Later photo dates revealed higher infrared reflectance in one of the three management areas. Ground notes showed the water level to be equal in the three areas on April 20. Later, one area was dropped to a very low water level for bulrush control. On this area, the phenology was advanced with a corresponding increase in infrared reflectance.

A mountain brush community occurring in eastern Nevada was also studied on the ground and with U-2 color infrared photography. This important cattle and mule deer range was covered with 1 foot of snow on April 20. By May 3, the area was free of snow, but showed no infrared reflectance (showing a lack of spring growth). The June 14 imagery showed this area to be growing vigorously (high infrared reflectance). A practical use for these data would be to govern the date that cattle would be turned onto the range. Good range management requires that stock be kept off the range until the desirable plants have had time to start their spring growth.

Seasonal changes during the early part of the 1972 growing season were not significant. Late season reflectance might have provided significant changes in gray scale if they were available. Gray scales varied considerably among vegetation types (Table 5). Exposure variations confound gray scale site comparisons among dates for a single plant community.

Summary of Significant Results:

Accurate identification and delineation of crested wheatgrass seedings has enabled a broad but detailed inventory of these resources in Nevada. The wide coverage of ERTS-1 is extremely useful for putting these seeded areas into proper perspective for inventory. This constituted the first total inventory of this resource in the state and was accomplished in only 2 man weeks of labor. Automatic techniques can reduce this requirement. Irrigated fields, pastures, meadows, wildfire scars, water bodies, playas, land forms, and other resource features can be similarly inventoried. These total inventories, we feel, are not economically feasible with any known ground or aircraft inventory methods.

Table 5. "Gray Scale"* variations by date, area, and vegetation community on U-2 imagery (0.69 - 0.76 micrometers) in 1972.

	April 20	May 3	June 14
1. Big Sagebrush . . .	4.0	5.5	6.0
2. Low Sagebrush . . .	6.5	7.0	8.5
3. Mountain Brush . .	3.0	4.0	5.0
4. Cheatgrass	4.5	6.0	4.5
5. Marsh-drained . . .	4.0	6.5	4.5
6. Marsh-low water . .	4.5	6.5	3.5
7. Marsh - full . . .	2.5	3.5	2.0
8. Cattail	6.0	6.0	8.5

* Gray scale from 0.5-9.5 on the Munsell Scale.

ERTS-1 imagery is well adapted for a 1:1,000,000 scale base map or mosaic for mapping vegetation over large land areas. Even though all vegetation ecotones are not visible on the photography, the ERTS-1 base map is extremely valuable in and of itself. Field notes, reconnaissance flights, and larger scale photography can be used to map vegetation that cannot be distinguished on ERTS-1 imagery. Sequential dates, summer to winter, significantly increase the capacity for vegetation mapping in the Great Basin.

Phenological changes can be quantitatively described on ERTS-1 imagery. This provides the opportunity to exploit the sequential aspects of ERTS-1 to study the dynamics of natural resources features of wild lands and thus provide input to intial resource management decisions.