REMOTE SENSING OF VEGETATION RECOVERY IN GRASSLANDS AFTER THE 1988 FIRES

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♦ INTRODUCTION

Traditional methods for measurement of vegetative biomass can be time-consuming and labor-intensive, especially across large areas. Yet such estimates are necessary to investigate the effects of large scale disturbances on ecosystem components and processes. One alternative to traditional methods for monitoring rangeland vegetation is to use satellite imagery. Because foliage of plants differentially absorbs and reflects energy within the electromagnetic spectrum, remote sensing of spectral data can be used to quantify the amount of vegetative biomass present in an area (Tucker and Sellers 1986).

In 1987 we found that Landsat Multispectral Scanner (MSS) imagery could be used to quantify green herbaceous phytomass (GHP) on ungulate summer range in the northeastern portion of Yellowstone National Park. Estimates of GHP in the study area were well within values reported for the habitat types sampled (Mueggler and Steward 1980). Annual variation in GHP was related to winter snow accumulation probably due to the timing of snow melt (Merrill et al. 1988). Additionally, we found that GHP explained a significant amount of the variation in the per capita growth rate of elk and bison populations from 1972 to 1987 (Merrill and Boyce 1991).

The extensive fires that occurred in the Park in the summer of 1988 provided an opportunity to determine whether remote sensing could be used to monitor grassland vegetation recovery in the Park and to explore the effects of the 1988 fires on ungulate populations using models we developed in 1987. Previous studies have used Landsat imagery to monitor succession of seral stages after fire in pine (Jakubauska et al. 1990), but no studies to our knowledge have used this approach to quantify herbaceous recovery in grasslands.

The objectives during this study period were:

(1) to develop a model for predicting GHP in sagebrush-grassland communities using 1989 Landsat TM spectral information and field data on GHP

(2) to validate the 1989 model by comparing predictions made from it using 1990 Landsat data to actual field data collected in 1990 and 1991.

Once we have validated our model, our objectives are to compare vegetation recovery in burned areas relative to unburned areas, and to apply the results of this analysis to the ungulate summer range model developed in 1987 to predict the effects of the fires on ungulate populations.

♦ STUDY AREA

The study was conducted in the northeast portion of Yellowstone National Park with major focus on the upper Lamar, Cache and Calfee River drainages and the Mirror Plateau. Elevations range from 1,500 to 3,300 m. Descriptions of vegetation communities in the park are given by Despain (1990). Our work focused on the non-forested plant communities within the study area. These included sagebrush (*Artemisia tridentata*) communities which have an understory of bluebunch wheatgrass (*Agropyron spicatum*) in dry areas and Idaho fescue (*Festuca idahoensis*) on the more mesic sites. Silver sagebrush (*Artemisia cana*) with an Idaho fescue co-dominant is found on areas associated with high water table such as streambanks and seeps. High elevation grasslands are dominated by Idaho fescue/tufted hairgrass (*Deschampsia cespitosa*) and tufted hairgrass/sedge (*Carex* spp.). At intermediate elevations, Idaho fescue/wheatgrass (*Agropyron spicatum* and *A. caninum*) communities are encountered with the latter dominating in the more mesic sites.

♦ METHODS AND RESULTS

VEGETATION DATA COLLECTION AND ANALYSIS

Vegetation data were collected at 40 ground-truth sites from 25 July-10 August, 1989, 30 July-11 August, 1990, and 29 July-10 August, 1991 across two elk summer ranges (Norris/Cache/Calfee Ridge complex and Mirror Plateau). Twenty-two sites have been resampled each year while 18 new sites have been sampled each year (Table 1). Each site encompassed at least 0.81 hectares (approximately 9 landsat pixels) of homogeneous vegetation. At each site physiographic characteristics were recorded using topographic 1:24,000 maps. Grassland habitat types followed Yellowstone National Park habitat mapping (Despain 1990).

Vegetation was sampled and analyzed using a double sampling approach (Merrill et al. 1988). At each site, percent cover of graminoids, forbs, bare ground, rock, moss, lichens and wood were estimated. Average heights of plants within forage classes were also measured and an index to plant volume was calculated as canopy cover x average plant height. Shrub cover was measured using line intercept method.

Ten of the 30 microplots at each site were clipped to ground level. Vegetation was separated into green graminoids, green forbs and standing dead. A criterion of > 25% "green" was used to differentiate green from senesced (standing dead) plants. Biomass samples were dried at 70° for 48 hours and weighed to the nearest 0.1 gm. All weights are reported as oven-dry weights. The relationship between plant volume and biomass was determined using a least squares multiple regression analysis.

LANDSAT DATA ACQUISITION AND ANALYSIS

Landsat Thematic Mapper (TM) imagery of the study area was acquired for 2 August 1989, 13 August 1990, 30 July, 1991 from EOSAT by the National Park Service. Due to mechanical problems with the receiving stations, EOSAT was unable to provide us with data from our projected 6 August 1990 overpass. The closest date for which there were available data was 13 August 1990. Data from this overpass are less than ideal because the date is outside our sampling window and there are considerable clouds in the scene. Nonetheless, it is the most accessible data for comparing our field sampling information among years.

Digital Landsat data were transferred from 9-track computer tapes to the Micro-computer Image Processing System (MIPS) for data processing. At each of the 40 sites the spectral values of 9 contiguous pixels were averaged for each of the 6 TM bands. Linear combinations of TM spectral values as well as published vegetation indices are being developed. The perpendicular vegetation index (PVI), and the green vegetation index (GVI) will be derived using the Graham-Schmidt Orthogonalization process (Frieberger 1960, in Jackson 1983). Jackson (1983) showed that these indices minimize soil background variations while improving green vegetation signals. Relationships between the averaged TM band spectral values and their various vegetation indices and phytomass estimates are being determined using linear and nonlinear least squares multiple regression analysis. However, to conduct these analyses, Landsat data from the different years must first be calibrated for differences related to changes in instrument sensitivity, electronic gain and bias (Markham and Barker 1986).

Table 1. Summary of plots sampled 27 July-10 August, 1989.

Plot	Location	Burn[1]	Elev	Plot Characteristics Asp	Slope	CT-DD[1]	Azm
101	Lower Norris	T3	7520	180	15	TFG	135
102	Lower Norris	No	7720	196	25	TFG	322
103	Middle Norris	T1	7800	254	20	TFG	190
104	Middle Norris	T2	7520	328	10	TFG	34
105	Lower Cache	T2	7460	250	10	TFG	280
106	Lower Cache	No	7680	235	5	FN	298
107	Upper Cache	No	8100	230	20	FN	290
108	Upper Cache	No	7940	230	1	TFG	234
109	Upper Cache	T3	8025	283	5	TFG	190
110	Upper Cache	No	7960	195	20	TFG	80
111	Upper Cache	No	7850	184	3	TFG	200
112	Upper Cache	No	7760	295	4	TFG	218
113	Upper Cache	T3	7750	230	10	TFG	322
114	Lamar Flat (52)	T1	6630	0	0	TF	165
115	Lamar Flat (51)	No	7160	206	25	TFG	36
116	Upper Lamar Flat	T4	6710	0	1	TF	65
117	Floating Island (28)	No	6480	0	0	TFG	137
118	Floating Island (29)	T2	6680	0	0	TFG	135
119	Y-L Confluence (30)	T1	6120	80	2	TF	255
120	Y-L Confluence (31)	No	6080	310	4	TF	210
121	Opal Creek	T2	8800	145	5	FNG	50
122	Opal Creek	T2	8740	95	15	FNG	8
123	Opal Creek	T4	8800	95	7	FNG	11
124	Above Opal Camp	No	8960	90	7	FNG	130
125	Above Opal Camp	No	8880	190	15	FNG	120
126	Above Opal Camp	T3	8760	356	3	FNG	170
127	Opal Creek	T4	8800	15	1	FNG	15
128	Opal Creek	No	8660	305	6	FNG	32
129	Specimen ridge Trail	T2	8770	90	5	TFG	8
130	Mirror Plateau	No	9120	192	20	FNG	272
131	Mirror Plateau	No	9170	0	2	FNG	23
132	Top Specimen Ridge Tr	No	8840	150	20	FNG	76
133	Above Norris Hot Sp	T2	6980	233	5	TFG	138
134	Lower Norris	T1	7250	230	12	TFG	148
135	Lower Noris Rdge Top	No	7800	218	1	FA	136
136	West Of Norris Cliff	T2	7440	180	15	FA	238
137	Upper Norris	No	8130	121	5	TFG	196
138	Pk Midway To Norris	No	8250	171	10	FNG	247
139	Top/Draw Mid-Norris	No	7880	338	10	TFG	326
140	Norris/Next To Cliff	No	7760	302	5	TFG	220

[1]Burn descriptions:
T1= hot fire, all shrubs & litter burned, ground fire complete.
T2= all shrubs killed but some aboveground woody material not consumed, ground fire mostly complete.
T3= some shrubs survived or at least some leaves present, ground fire >50% complete.
T4= light burn, >50% ground vegetation survived.
Vegetation types follow D. Despain cover map.

♦ FUTURE WORK

Currently we are analyzing our 1991 vegetation data and are waiting for the 1991 TM data to arrive. Once we have the 1989-1991 data, we will select 1-4 spectral models based on the 1989 data which meet the following criteria: show significant F values ($P < 0.05$); account for > 50% of the variance in the field data collected; are the most precise relationships having the lowest standard error of the estimate. Models which meet these criteria will be evaluated by comparing their predictions using 1990 and 1991 Landsat data to our 1990 and 1991 field data.

We would like to thank John Baldwin, Jon Hak, Greg McDaniel, Bob Brennen, Verda Shingleton for help in collection of field data. We also thank Rich Kluckus, Don Despain, Francis Singer, John Varley, Jennifer Whipple, George McKay, and Jack Norland of Yellowstone National Park for assistance. Lyman McDonald and Jeff Pontius of the University of Wyoming provided statistical advice.

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