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Thematic Mapper Digital Data for Predicting Aboveground Tallgrass Prairie Biomass

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THEMATIC MAPPER DIGITAL DATA FOR PREDICTING ABOVEGROUND TALLGRASS PRAIRIE BIOMASS

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Abstract. Landsat thematic mapper digital data was found to offer an excellent potential for regular monitoring of the tallgrass prairie ecosystem by providing estimates of aboveground biomass production. Data from seven channels of a May thematic mapper scene were analyzed individually and in various combinations using stepwise regression in Statistical Analysis System (SAS). These procedures were used to determine the most appropriate multiple regression equation for estimating production of 1) total live aboveground biomass, 2) grasses, 3) forbs, 4) previous years dead, and 5) current years dead. Regression equations were based on satellite-derived estimates relative to ground level biomass values for watersheds on Konza Prairie Research Natural Area under a variety of burning treatments. Results suggest that multiple channel equations were most appropriate for measuring production of forbs and total live aboveground biomass. Channel one (0.45 to 0.52 μm) and channel four (0.76 to 0.90 μm) were applicable to estimate production of grass and levels of previous years litter, respectively. However, none of the channels were accurate in predicting current years dead. Further plans involve using thematic mapper data to estimate aboveground biomass over an entire growing season on Konza and exploring the potential of using satellite data to monitor grassland production across the Great Plains.

Key Words. tallgrass prairie, remote sensing, aboveground biomass, Landsat, thematic mapper, monitoring, Konza Prairie, Kansas

INTRODUCTION

Traditional techniques for estimating the productivity of grasslands are time consuming, destructive, costly, and do not lend themselves to evaluation of large geographical areas. Since the launch in 1972 of the first of a series of earth resources technological satellites named Landsat, the potential for utilizing remote sensing technology as a way of monitoring global resources has vastly increased. With improvement in Landsat resolution since 1982, via the onboard thematic mapper, refinements in levels of accuracy for measuring productivity with remote sensing techniques in grassland ecosystems have further increased [see Greegor (1986) for review]. The objective of this study was to determine which Landsat thematic mapper channels (Table 1) or combinations of channels would be most appropriate for predicting production of: 1) total aboveground biomass, 2) live grass, 3) forbs and woody plants, 4) current year's dead, and 5) previous year's dead (litter).

Table 1. Landsat thematic mapper bands and spectral characteristics.

Channel	*Spectral Ranges*	*Pixel Resolution*
	--------- um ---------	---------- m ----------
1	0.45 to 0.52	30
2	0.52 to 0.60	30
3	0.63 to 0.69	30
4	0.76 to 0.90	30
5	1.55 to 1.75	30
6	10.40 to 12.5	120
7	2.08 to 2.35	30

METHODS

Study Site

Data were collected on Konza Prairie Research Natural Area. Konza Prairie (3,487 ha) is tallgrass prairie dominated by big bluestem (*Andropogon gerardii* Vitman) located in the Flint Hills of northeastern Kansas. Because of the steep and rocky topography, the Flint Hills include the only extensive area of unplowed tallgrass prairie remaining in North America (Hulbert 1985). Konza Prairie has a mean annual precipitation of 834 mm and a mean annual air temperature of 12.8 C (Greenland 1987). A fire management plan initiated on Konza Prairie placed different watershed units under prescribed spring burning regimes in 1971 of 1-(annual), 2-, 4- and 10-year intervals (Hulbert 1973. There are also a number of watersheds which are not burned. All watersheds used in this study have not been grazed for more than 10 years.

Ground Clipping

Abrams *et al.* (1986), Gibson and Hulbert (1987), Gibson (1988) and Knapp *et al.* (1985) have discussed the methods used to collect aboveground biomass data on Konza. Briefly, during three times in the growing season (spring, summer, and fall), all aboveground biomass in 20 quadrats (10 x 20 cm) were collected by clipping at ground level on various watersheds. The number of quadrats clipped per watershed depended on the size of the watershed, but as least 20 quadrats were sampled at each sampling interval. The clipped material was separated into forbs and woody plants, live gaminoids, standing dead, and all loose litter (dead biomass from previous years). The separated material was oven-dried at 60 C for 48 hr prior to weighing. For this study, eight treatment areas were used: two annually burned watersheds, one burned every two years, one burned every four years and four unburned watersheds. For each of the watersheds, a mean value for each aboveground component was calculated.

Satellite Digital Data and Data Analysis

An 18 May 1984, Landsat thematic mapper scene of Konza Prairie Research Natural Area was obtained. This date was selected because it corresponded to the post-spring burning period and it matched the ground clipping date. Burned watersheds were used because they are easily differentiated from unburned watersheds using digital data (Nellis and Briggs 1987). For each of the watersheds from which ground clipping the had been completed, a mean reflectance value was obtained for each of seven channels of the thematic mapper using a micro-based image processing system. These values were analyzed individually and in various combinations using multiple regression (stepwise procedure) with PC-SAS at a 0.15 significance level for entry in the regression model. The stepwise procedure is a modification of a forward-selection procedure in which, after a variable is added to the model, each variable is tested again for inclusion at the 0.05 level (SAS 1985). A 0.05 significance level for the model was used to determine the relationships between the ground clipping data and the satellite derived digital data.

RESULTS

Table 2 summarizes the aboveground biomass data separated out into the various components by watershed with the respective mean reflective value of each of the seven channels. Channel one (0.45 to 0.52 μm) was the best predictor of mean live grass on watersheds with a regression equation of: mean live grass = − 224.01 + 3.14*channel one (r^2 = 0.79; P = 0.04; Figure 1). For previous years dead, Channel four (0.76 to 0.90 μm) was the only individual channel that fit the 0.15 selection level into the model criteria. However, it was not significant (r^2 = 0.57; P = 0.14).

Table 2. Mean reflective value of each channel and aboveground biomass data by watershed.

		Channel											
Watershed	*Burned*	*One*	*Two*	*Three*	*Four*	*Five*	*Six*	*Seven*	*Total*	*Grass*	*Forbs*	*Current Year Dead*	*Previous Year Dead*
001A	YES	132.0	56.3	61.5	73.1	113.0	111.3	58.8	247.0	153.9	13.4	81.1	——
001D	YES	121.8	50.6	53.0	66.5	88.4	110.8	45.0	272.7	155.6	19.1	97.3	——
002D	YES	109.8	45.0	46.0	58.4	85.1	123.8	44.7	285.9	220.3	29.6	36.0	——
004B	NO	136.3	57.6	60.7	75.7	97.6	95.9	44.2	373.3	221.2	102.2	49.4	261.1
000B	NO	132.0	56.3	61.6	78.1	102.8	101.5	43.9	327.0	195.2	71.3	56.8	613.0
N00B	NO	114.5	47.0	52.7	62.3	101.6	123.6	44.6	280.7	139.7	86.8	54.2	714.7
N01B	NO	133.3	56.6	61.1	75.6	105.8	101.5	47.3	306.3	174.0	70.9	61.4	576.6
N04B	NO	126.1	52.7	56.2	67.9	97.4	101.5	42.5	353.7	168.2	112.4	76.7	659.8

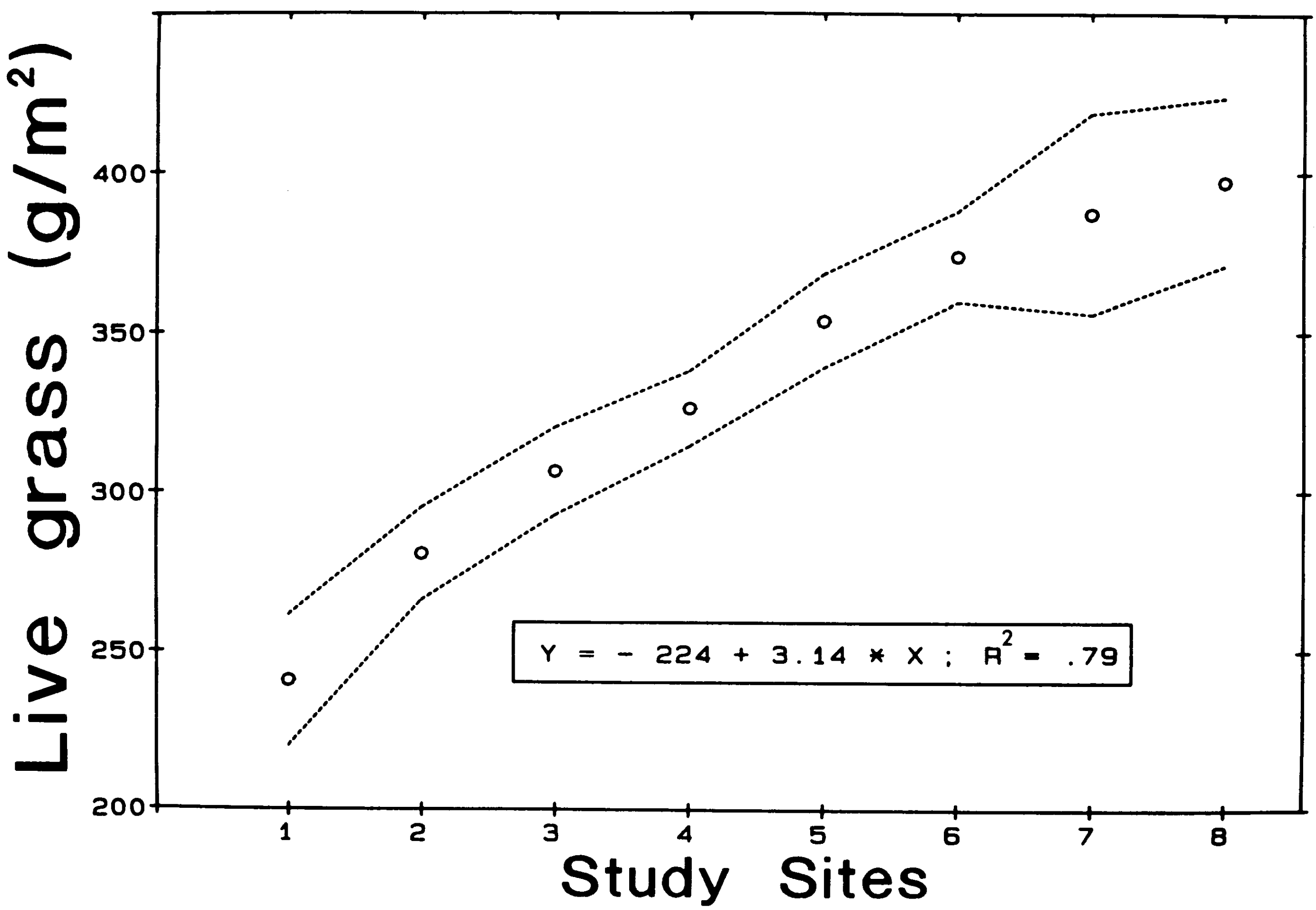

FIG. 1. Regression line and 95% confidence limits of the relationship between ground clipping data of live grass and satellite derived digital data on Konza Prairie Research Natural Area. Regression line = − 224.01 + 3.14*Channel one.

Multiple channel equations were most appropriate for measuring production of forbs and total live aboveground biomass. For forbs, the final equation was: forbs = 508.91 -1.84*channel three + 1.99*channel four biomass, the equation was total = 1016.98 + 2.79*channel two - 6.88*channel five - 1.38*channel six. However, this model only approached significance with a $P = 0.07$. The significance of combinations in the longer wavelength visible and near to mid-infrared electromagnetic energy for measuring forbs and aboveground biomass is due to the high reflectance of the healthy vegetation and low absorption in these portions of the spectrum. Obviously, the amount of infrared reflectance of the prairie canopies is going to be controlled, to a certain extent, by the stage of plant development. No individual channel or combinations of channels were applicable to predicting current years dead ($P > 0.15$). This is not surprising due to the irregular patchiness of the current years dead matter.

CONCLUSIONS

Although not all aboveground components were accurately predicated in this study, thematic mapper data were found to be valuable tools in non-destructive, large-scale assessments of important components of the tallgrass prairie. In particular, live grass, forbs and total aboveground biomass could be reasonably accurately assessed using various channel combinations.

Further plans involve monitoring the Konza tallgrass prairie over an entire growing season using remote sensing techniques and over several years to further expand and fine tune this technique. Furthermore, with the addition of bison on Konza, remote sensing will be used to study the interaction of fire and grazing at scales that could not be realized before. Remote sensing coupled with a geographical information system can address many questions that ecologists need to answer to understand the complex tallgrass prairie.

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