Application of Remote Sensing to Prairie Dog Management

K.J. DALSTED, S. SATHER-BLAIR, B.K. WORCESTER, AND R. KLUKAS

Abstract

The areal extent of prairie dog towns in Wind Cave National Park (WCNP) has increased at an alarming rate in the past 20 years. An inventory method was needed to replace the time and labor intensive ground survey method, i.e. rod and transit. Color infrared (CIR) aerial photography (1,370 m above ground) provided a useful product for rapidly and accurately delineating prairie dog towns. Extent was determined by measurements on the CIR film to be 608 ha or 5.3% of the total WCNP area. Ground measurements, taken near the time of the aircraft overflight, included general vegetation description of each prairie dog town and a vegetation sampling from 0.25 m² plot on a stratified, random basis. The ground data helped explain and identify the variations recorded on the CIR film. Soil and topographic information were used with the CIR film to determine likely expansion potential and probable direction of growth of the 11 major prairie dog towns in WCNP. The prairie dog town inventory and expansion potential of each town has probable usefulness in the development of management plans.

Accurate and current census data are needed for wildlife management programs. In an area of limited dimension, such as a national park, the maintenance of adequate habitat for indigenous wildlife species is essential and requires monitoring of the various wildlife populations. The black-tailed prairie dog *(Cynomys ludovicianus)* is an example of a wildlife species that can rapidly change vegetative composition of the habitat to the extent that other wildlife species are significantly affected.

Historically, prairie dog town surveys in Wind Cave National Park (WCNP) have been done on foot using a compass and measuring wheel or a rod and transit (Lovaas 1972). The recent, rapid growth of several towns within the park has made these conventional methods inadequate because of the time and labor requirements. A method of inventorying prairie dog towns that would be both time- and cost-effective was desirable for the WCNP wildlife management program.

In order to apply remote sensing to prairie dog town mapping, noticeable differences have to be apparent between the vegetation in the prairie dog town and in the "non-disturbed" area. Koford (1958) noted that significant variations in vegetation characteristics and composition exist between prairie dog towns and the surrounding range. Vegetation in prairie dog towns generally consisted of an abundance of short perennial grasses, a variety of forbs, and a scarcity of shrubs. Several investigators (Osborn and Allen 1949, Bonham and Lerwick 1976, Hanson and Gold 1976) reported that in prairie dog towns the proportion of mid and tall grasses decreased while the proportion of annual forbs and short grasses increased.

Authors are, respectively, assistant research soil scientist, graduate research assistant, and research soil scientist, Remote Sensing Institute, SDSU, Brookings; and research biologist, National Park Service, Wind Cave National Park, Hot Springs, South Dakota.

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Cheatheam (1973) found that black and white aerial photography (1:20,000) provided a very useful tool to census prairie dog towns in Texas, although, he had difficulty identifying prairie dog towns less than 4 ha in extent. Lovaas (1972) reported a successful correlation in WCMP between the delineation of one prairie dog town on black-and-white conventional aerial photography and the corresponding ground measurement. However, color infrared (CIR) and color aerial photography have been shown to be much more useful and easier to interpret than black and white photography for rangeland investigations or surveys. Additionally, discrimination and identification of vegetation is often better accomplished using CIR photography rather than color photography. Aerial CIR photography combined with ground data can provide an interpretative medium which can yield the following rangeland information: plant communities and their associated soils, species composition and foliage densities, and forage utilization (Poulton 1975).

The objectives of this investigation were: (1) locate and delineate prairie dog towns in WCNP using CIR photography; (2) compare costs of the remote sensing technique to the ground survey method; and (3) categorize the expansion potential of each prairie dog town according to interpretation of CIR film in concert with vegetation and soil data.

Study Area

The WCNP is located in southwestern South Dakota (Fig. 1) and encompasses 11,364 ha of range and forest land and associated ecotones. Almost all of the WCNP is situated in the Black Hills footslopes; the northwest corner is considered part of the Black Hills. Elevation ranges from 1,090 m to 1,520 m. Annual precipitation averages 45 cm with most occurring during the spring and summer months (Soil Conservation Service 1969).

Soils in the WCNP have formed in four discrete parent materials. The parent material regions from east to west are: sandstone hogback, red valley, limestone plateau, and granite-schist mountain area (SCS 1969). Forest vegetation in WCNP is predominantly ponderosa pine *(Pinus ponderosa)* while the grasslands are composed largely of climax plant cover consisting of short and mid grasses (e.g. *Stipa* sp., *Andropogon* sp., *Bouteloua* sp.) with the associated tall grasses, sedges, forbs, and shrubs.

Methods and Materials

Vertical aerial photography of WCNP was collected on July 19, 1978, from an above-ground altitude of 1,370 m. A Beechcraft D-18 aircraft with Hasselblad cameras (50-mm focal length) acquired three 70-mm film products. While four cameras were available for simultaneous exposure, only three cameras were used with the following film and Wratten filter[1] combinations: (1) CIR, Kodak 2443 with 15-30M; (2) color, Kodak 2448 with Hf3; and (3) black-and-white, red band, Kodak 2402 with 25A. A forward, or end, lap of 60% and a sidelap of 30% was maintained in acquiring full photographic coverage of WCNP; this produced approximately 150 frames of coverage.

[1]Inclusion in this report of registered tradenames or trademarks does not constitute an endorsement by the author or the Remote Sensing Institute.

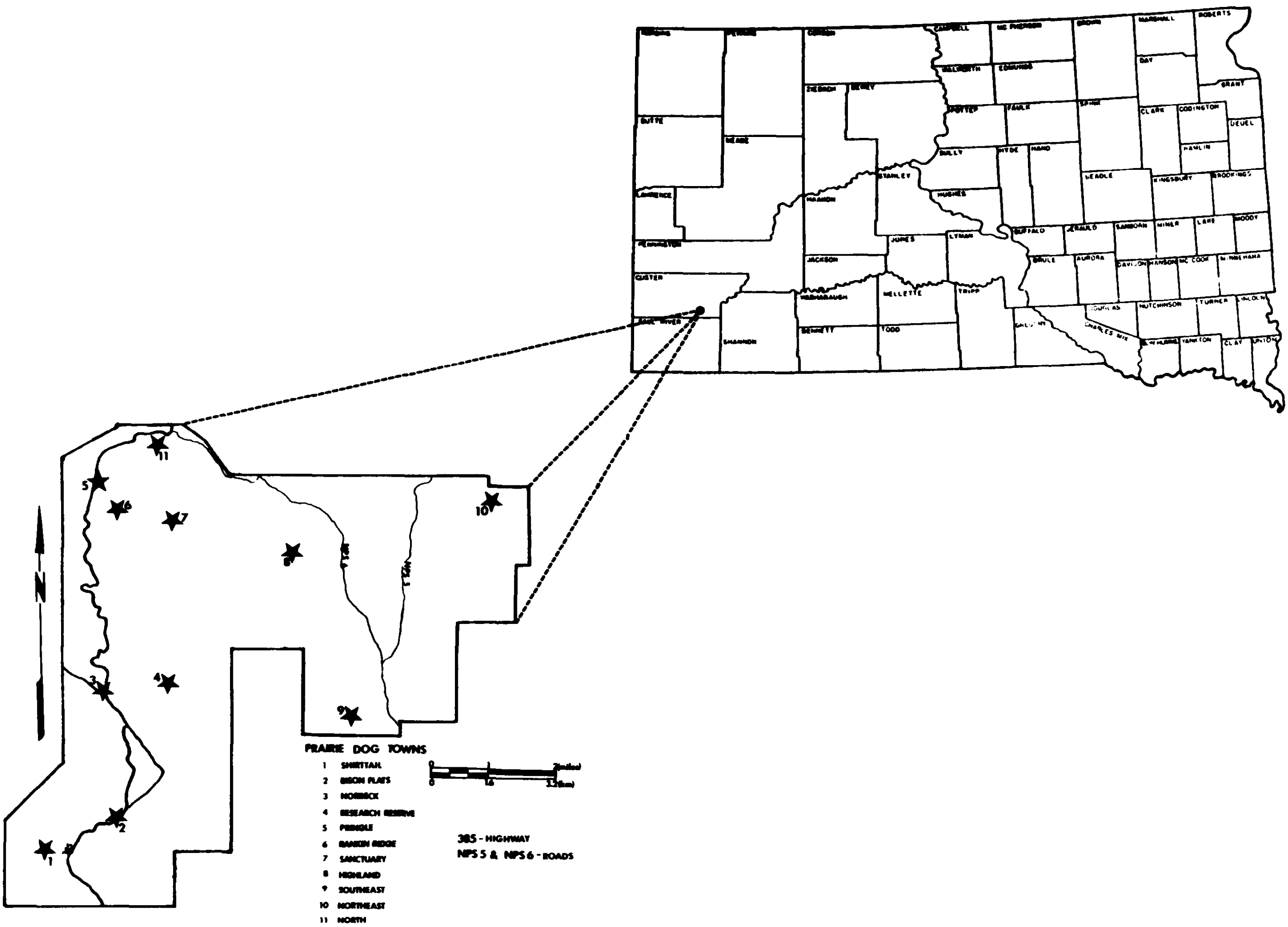

Fig. 1. *Eleven established prairie dog towns are located and identified in Wind Cave National Park, South Dakota.*

Ground data supporting the aerial photography were collected July 9 to 15, 1978, at nine of the eleven major dog towns. The emphasis of ground data was to provide quantitative and qualitative information for characterizing the vegetation in each prairie dog town. Sampling selection was a random process in representative areas of established prairie dog towns, border areas, and non-disturbed areas.

Vegetative parameters were measured at 32 sampling stations. These stations, which were 0.25 m^2, were located on a base map (1975 NASA high altitude photography) for eventual registration to the altitude photography. The number of stations per town varied with the size of the town and the heterogeneity of the town's vegetative communities. Vegetation composition was visually recorded by plant species, in order of predominance. Live vegetation was clipped at ground level to obtain further general composition information. A 1-meter, vertical color slide was taken at each station. Other general notes were taken at each prairie dog town to aid in later identification of features on the photography.

Clipped vegetation samples were divided into grasses and forbs and dried at 70° C for 48 hr. These data were stratified by station location, i.e. inside (20 samples), border (5 samples), and outside (7 samples) of the town. Statistical means and variances were determined by station position. A *t*-test statistic (unequal variances) was used to determine significance of the data groupings and their distributions (Nie et al. 1975). Percentage of bare soil was determined using a random dot grid (2.2 dots/cm^2); three measurements were made on each 10 × 13 cm print.

The eleven major prairie dog towns were outlined on the CIR positive film transparencies. Prairie dog town boundaries were defined as the visible limit of vegetation alteration conterminous to an existing town. The CIR film products were viewed at a 6.7x enlargement on an International Imaging System (I^2S) color additive viewer, and the prairie dog town boundaries were drawn on mylar overlays. Film scale of each prairie dog town was determined by relating film distance measurements to a known reference, United States Geological Survey 7½ minute quadrangles (USGS 7½ min. quad.). Prairie dog town boundaries were then measured three times with an electronic digital planimeter and mean acreage values determined. Prairie dog town area data, derived from the CIR photography, were compared with historical data to obtain growth rate estimates.

Qualitative estimations were made of each prairie dog town's growth potential on an individual basis using CIR photography and available topographic, soils, and vegetative information. Each prairie dog town was assigned a potential expansion rating (ad hoc) defined as: (1) adequate, contiguous habitat for the town to increase in size more than 50% (2) adequate contiguous habitat for town to increase in size from 25 to 50%; and (3) little available habitat for town growth or less than 25% expansion potential.

Results and Discussion

Comparisons among the CIR, black-and-white, and color film products were made, and CIR was chosen as the best overall product for our purposes. Although the black-and-white or color films were probably adequate for prairie dog town delineation, CIR film had additional discriminating capability in the vegetation areas and thus ease of interpretation was greatly enhanced with the CIR film. The sensitivity of CIR film to vegetation types was especially useful in determing exact boundary location.

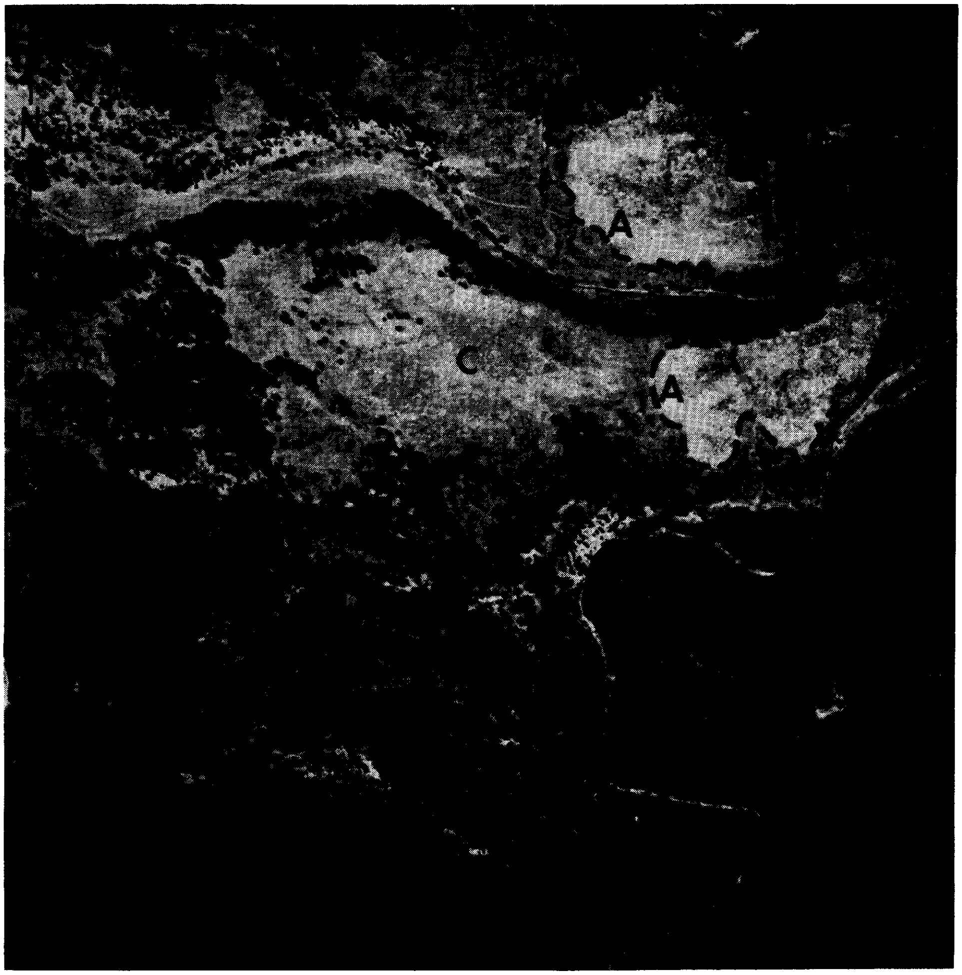

Fig. 2. *Shirttail prairie dog town is shown in a black and white reproduction of a color infrared photograph. The prairie dog town at (A) is outlined; not the vegetative heterogeneity. A patch of Japanese brome is shown at (B). At (C) reinvasion is taking place. Even reproduction in black and white reveals the differences between CIR and black and white photography (see Fig. 3).*

The clipping data collected indicated a dramatic increase in the percent of forbs within the prairie dog towns when compared to the surrounding range (Table 1). This agrees with the findings of other authors (Osborn and Allen 1949, Bonham and Lerwick 1976, Hanson and Gold 1976). As percent of forbs increased from outside to inside the town a corresponding decrease in percent of grasses was observed (Table 2). No significant differences was determined between % by weight of vegetation at the border and oustide the town; however, composition of species is generally noticeable at the interface of the border and outside the prairie dog town. It is these vegetation composition changes along with the bare soil around each burrow that made the possible photointerpretation of prairie dog towns from the photography. Percentage of bare ground in the prairie dog towns averaged 10%, while the border and outside readings averaged 1%.

Table 1. T-test analysis (two-tailed, pooled variance) of percent forbs by weight among the three sampling locations—outside the prairie dog town, at the border, and inside the town.

Location	X	Standard deviation	df	*t*-value	Significance
Outside	5.6	6.4	11	0.69	0.50
Border	3.7	2.7			
Inside	17.0	17.5	26	2.56	0.02
Border	5.6	6.4			

Koford (1958) in the late summer of 1955 reported 12 species of grasses and sedges, 23 species of forbs, and one each of shrub and cactus at Shirttail Canyon on WCNP. He described the town as ". . . a green piece of jigsaw puzzle fitted into a pale tan background." Shirttail Canyon is shown (Fig. 2 and 3) as it was recorded by black and white and CIR photography (reproduced on black and white); its present day vegetative heterogeneity is very apparent. Japanese brome *(Bromus japonicus)* is a dominant species on the edge of this town.

Cheatheam (1973) had difficulty identifying dog towns that were 0.4 to 4.0 ha in size on Agricultural Stabilization and Conservation Service (ASCS) black-and-white photography (1:20,000). During this study, interpreters using CIR imagery (1:24,000) had no problem locating and delineating the boundaries of Rankin Ridge Town, which is 4.2 ha in size. Detection of towns much smaller

Table 2. T-test analysis (two tailed, pooled variance) of percent grasses by weight among the three sampling locations—outside the prairie dog town, at the border, and inside the town.

Location	X	Standard deviation	df	*t*-value	Significance
Outside	49.5	35.2	11	1.69	0.12
Border	23.3	14.9			
Inside	11.4	14.5	26	1.78	0.09
Border	23.3	14.9			

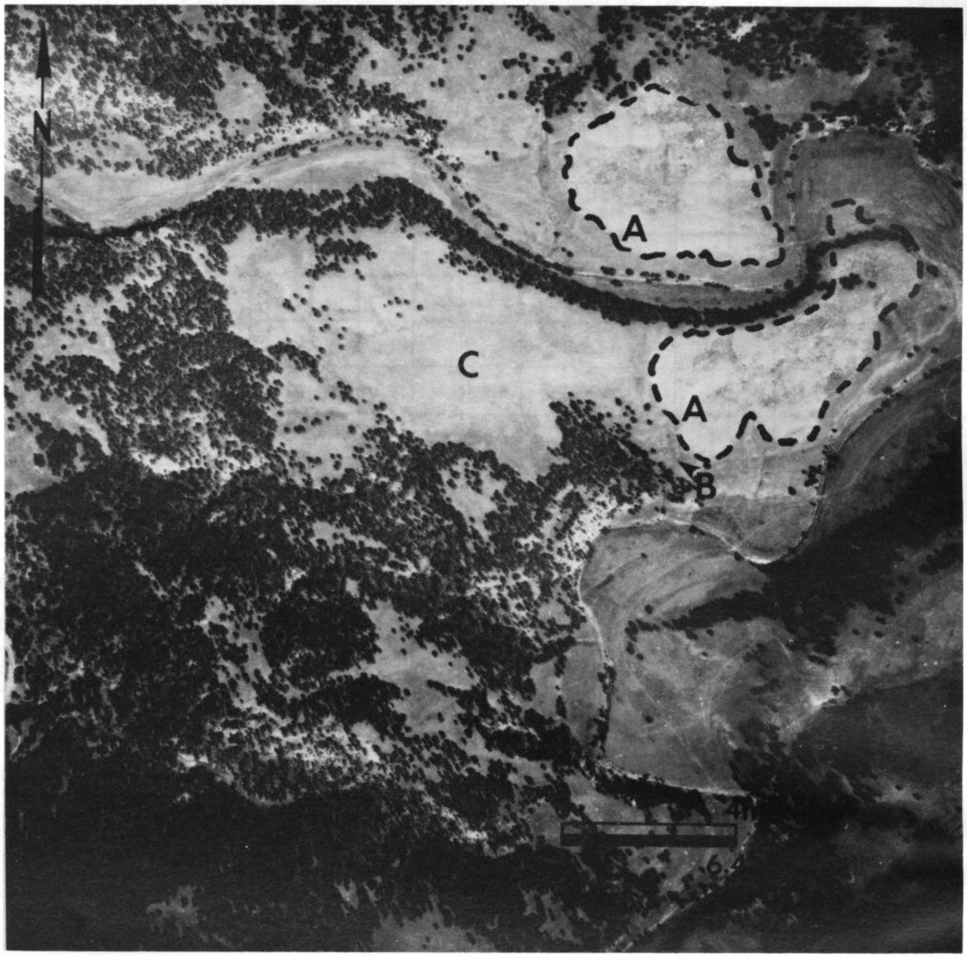

Fig. 3. *A black and white aerial photograph (red filter) of Shirttail prairie dog town. Contrast with Figure 2 for identification of the lettered and outlined areas.*

than this would have been possible provided they were established towns where prairie dog activity had significantly altered the vegetation composition. Three prairie dog towns in WCNP were not visible on the CIR film because of their small size, relative youth, and lack of vegetative alteration. The largest of the three towns measured 0.4 ha in size while the smallest was 0.1 ha.

Soils

The investigation of prairie dog towns identified the following site characteristics as important to a town's establishment and growth in WCNP: (1) deep soils free from excessive stoniness; (2) minimal flooding hazard; (3) moderate or better productivity of soils; and (4) slopes less than 9%. In the study area there were some exceptions to these criteria but they were rare. For example, a factor that appears to mollify the effects of steep slopes is the length of slope, i.e. the longer slopes often have dog mounds on lower extremities.

The soils, terrain, and vegetation differences between the southeast prairie dog town (Fig. 4) and the western part of WCNP (Fig. 3) are apparent. The persistance of soil and vegetative alterations due to the cultivation of soils in this area in the early 1900's is also apparent. Historical information indicated that many of the WCNP prairie dog towns had started either on such fields or where corrals and ranch buildings were previously located.

Potential Expansion of Prairie Dog Towns

The areal data indicated that in the last 17 years, the areal extent of dog towns has increased at a rapid rate (Table 3). In 1978 the eleven major prairie dog towns in WCNP occupied a total of 608 ha, as measured on CIR data, representing 5.3% of the WCNP's total area. This paper assumed that prairie dog populations, in general, will continue to grow as long as suitable, uncolonized habitat is available. With increasing populations prairie dog towns must expand to accommodate the additional numbers. The availability of suitable, expansion habitat around each town was determined according to resource criteria, i.e. soil, topography, and vegetation data. Each prairie dog town was categorized according to potential expansion ratings (Table 4).

Shirttail Canyon prairie dog town (Fig. 2), for example, had a high expansion rating. Combining soils and topographic information with the amount of detail available from the CIR film, the interpreter had little difficulty in discerning that prime expansion direction was west. Other smaller expansion areas exist to the northeast and downstream on small terraces. In this example, habitat next to the stream is not suitable for prairie dog town expansion because of its flooding hazard. In other prairie dog towns similar alluvial soils are occupied by prairie dogs because of a less severe flooding hazard.

Cost Comparisons

During 1977 three prairie dog towns were surveyed by WCNP ground crews. Cost per hectare varied inversely with size, ranging from Bison Flats (225 ha) at $6.20/ha to Northeast (15.8) at $22.79/ha. The remote sensing-CIR approach, on the other hand, resulted in an average per hectare cost of $3.70. In reality, the whole of WCNP was flown and the total coverage resulted in considerably lower cost per hectare. Included in the remote sensing costs were: (1) 1,062 km round trip for aircraft; (2) flight time during photography collection (only over prairie dog towns); (3)

Table 3. Area of eleven major prairie dog towns in WCNP from 1961 1978. Percentage column indicates growth. Historical data were gathered using ground survey technique; 1978 data were from remote sensing inventory.

Prairie dog town	1961		1963		1964		1966		1967		1970		1971		1974		1975		1977		1978		Total increase (%)	Mean yearly increase (%)
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%		
Shirttail			8.8	—			8.9	0.4			13.0	4.6							11.5	-11.5	14.1	22.8	59.8	4.0
Bison Flats	62.3	—	83.6	34.2					99.3	18.7			165.6	66.7					225.2	36.0	246.4	9.4	295.1	17.4
Norbeck	27.5	—	34.0	23.5			38.0	11.9					51.4	35.1							62.5	21.6	127.1	7.5
Research Reserve			25.5	—							64.6	153.2									108.7	68.4	326.3	21.8
Pringle													8.9		16.2	83.2	21.6	32.5			29.0	34.3	225.9	32.3
Rankin Ridge			3.9	—							4.5	16.5									4.2	-8.0	7.2	0.5
Sanctuary					49.7	—			61.1	23.0	71.3	16.7									54.8	23.2	10.3	0.7
Highland											4.0										12.2	203.0	203.0	29.0
Southeast					23.3	—	26.5	13.7			49.9	88.2									59.4	19.0	154.7	11.1
Northeast													1.6						15.80	875	13.8	-12.3	755.0	107.9
North													6.4								10.7	66.3	66.3	9.5

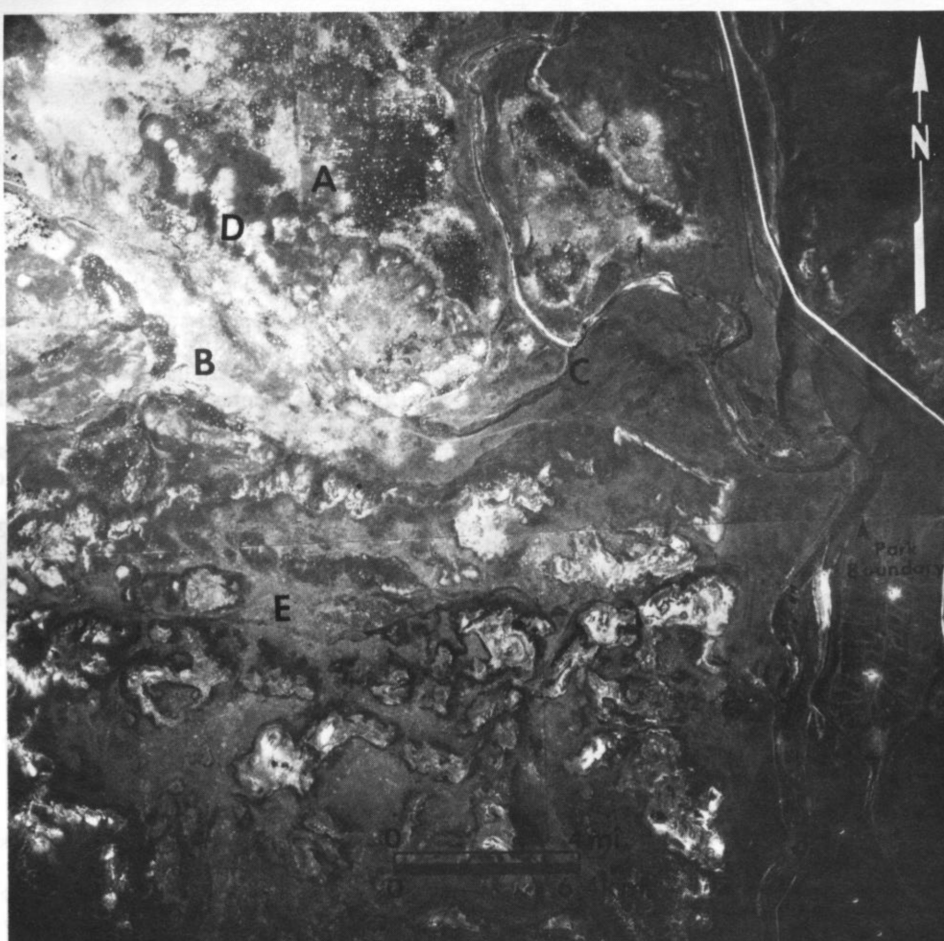

Fig. 4. *A CIR photograph reproduced in black and white of Southeast prairie dog town is shown. An old field pattern is visible at (A). Variable usage of an alluvial soil is shown at (B) and (C). The town's expansion has bypassed topographic obstacles (D). Possible expansion regions are shown in (E).*

Table 4. Potential expansion of the eleven prairie dog towns in WCNP. Ratings are: 1—excellent; 2—good, and 3—poor potential.

Prairie dog town	Expansion rating
1. Shirttail	1
2. Bison Flats	2
3. Norbeck	3
4. Research Reserve	2
5. Pringle	1
6. Rankin Ridge	3
7. Sanctuary	3
8. Highland	2
9. Southeast	1
10. Northeast	1
11. North	1

film (Kodak 2443), film processing, and one set of CIR prints at 1:15840 scale; (4) one day of photointerpretation by a professional; and (5) three days in the field by a professional (includes commercial flight, transportation, per diem, and salary). Three days of ground observation for this type of interpretation is conservative, since the photointerpretation will have indicated the specific areas to investigate. Vegetation sampling is not required for interpretation of the photography. The accuracy of the film interpretation can be made by ground measurements from reference points to the prairie dog town boundary and compared to film-derived distances.

It should also be noted that application of remote sensing techniques can yield other valuable information. The photography serves as permanent record of vegetative conditions of WCNP at a given time and will no doubt be important to future reseachers. Such photographic records of the entire WCNP area are of considerable value in general vegetation inventories and in planning for current management and research projects.

Conclusions

The present study has shown that low altitude, color infrared photography is a valuable aid in conducting inventories of rapidly expanding prairie dog towns in a relatively large area. The inventory was accomplished in a very time effective manner and the data was acceptably accurate to WCNP personnel.

Combining the color infrared imagery with other available data such as soil maps and topographic maps permitted interpretation of not only the growth potential of the prairie dog towns but also the possible direction of growth. Information of this nature is important if realistic prairie dog management plans are to be formulated. Collection of similar information by standard ground survey methods is very expensive and time consuming. Color infrared aerial photography, therefore, seems to offer the best means of measuring and monitoring the growth of prairie dog towns onto rangeland in areas such as Wind Cave National Park.

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