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A Statistical Model of Expansion in a Colony of Black-Tailed Prairie Dogs¹

R.P. Cincotta^{2,3}, D.W. Uresk⁴, and R.M. Hansen²

Abstract.-- To predict prairie dog establishment in areas adjacent to a colony we sampled: (1) VISIBILITY through the vegetation using a target, (2) POPULATION DENSITY at the colony edge, (3) DISTANCE from the edge to the potential site of settlement, and (4) % FORB COVER. Step-wise regression analysis indicated that establishment of prairie dogs in adjacent prairie was most likely to occur when an area was near a densely populated colony edge with high visibility through the vegetation.

INTRODUCTION

In order to control black-tailed prairie dog (*Cynomys ludovicianus*) colony expansion, managers must be aware of the environmental conditions that promote the establishment of prairie dogs in previously unoccupied areas. Since the mid-1950's, environmental and biological factors linked to colony expansion have been studied and reasons for the growth of black-tailed prairie dog colonies have been suggested (King 1955, Koford 1958, Smith 1958, Garret and Franklin 1982, Uresk 1985, Knowles 1985a). The objective of our study was to test a set of hypothesized variables [(1) POPULATION DENSITY at the colony edge, (2) VISIBILITY through the vegetation, (3) DISTANCE from colony edge, (4) % FORB COVER], suggested through prior research of prairie dog ecology, as predictors of black-tailed prairie dog town expansion.

STUDY AREA AND METHODS

Field work was conducted during a 3 yr. study (1981-83) of prairie dog colony expansion in Badlands National Park, southwestern South Dakota. The study site was a colony of approximately 12 ha. located along the northern boundary of the Park. The colony was located on land formerly grazed by livestock. A large component of shortgrasses, especially buffalo grass (*Buchloe dactyloides*), was present in the mixed-grass type vegetation characteristic of the area (see Agnew et al. 1985 for a detailed description of fauna and flora of prairie dog colonies in Badlands N.P.)

Four variables were chosen with which to predict establishment of prairie dogs in adjacent uncolonized areas. These potential areas were mapped and marked in a grid system of 25 m. grid squares. In 120 grid squares (1981-82: 55 samples; 1982-83: 65 samples) beyond the edge of the prairie dog colony, we measured: (1) VISIBILITY through the vegetation using a 1 m. x 1 m. target observed within each grid square, (2) POPULATION DENSITY of prairie dogs at the nearest edge of the colony using the number of active burrows as an indicator of population numbers, (3) DISTANCE from the edge to the potential site of settlement, and (4) % FORB COVER using estimates from ten randomly placed plots (20 cm. x 50 cm.) in each grid. The target mentioned in (1) was bright orange with fifty, equally spaced 2 cm. white squares.

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Visibility was equal to the average percentage of white squares not obscured when observed from the center to the two outer corners (away from edge of colony) of the grid square (approx. 18 m.) and from a height of 0.5 m. above the ground.

A regression model was developed for colony expansion using these variables and their interactions. Variables were left untransformed. A step-wise linear regression procedure eliminated those variables from the model that failed to contribute significantly (using *F*-tests) to the regression sum of squares, determined by successive testing of the reduced models.

RESULTS AND DISCUSSION

The model selected by step-wise regression included, in order of relative contribution to the regression sum of squares, POPULATION DENSITY ($P < .01$), VISIBILITY ($P < .01$), and the POPULATION DENSITY \times VISIBILITY interaction ($P = .03$). Where \hat{Y} is newly established presence (1), or absence (0) of prairie dogs in a grid square; X_1 is POPULATION DENSITY near the colony edge, and X_2 is VISIBILITY through the vegetation:

$$\hat{Y} = 0.1(0.02)^A X_1 + 0.01(0.004) X_2 - 0.001(0.0006) X_1 X_2 - 0.2;$$

Pearson's $r = 0.593^*$;

()^A Standard error of coefficient,
* Regression significant at $Q \leq .01$.

Results indicated that prairie directly adjacent to the study colony was likely to be colonized if it was near a dense population of prairie dogs and if there was high visibility through the vegetation.

Prairie dogs are likely to be sensitive to visibility because they depend heavily upon locating predators and using alarm calls to warn conspecifics (King 1955, Hoogland 1981). High population densities may force prairie dogs to expand into new territory. However, in other research conducted on the same colony most individuals that settled near population concentrations at the edges of colonies were from outside of the colony (similar observations were made by Knowles 1985a).

The presence or absence of forbs (% FORB COVER) did not contribute significantly to the regression model sum of squares. Analyses of prairie dog diets (Krueger 1986, Uresk 1984, Fagerstone 1982, Fagerstone et al. 1981,

Summers and Linder 1978) have shown black-tailed prairie dogs to be remarkably adapted to foraging on a wide range of plant species and plant parts; prairie dogs are known to consume the flowers, seeds, leaves and roots of grasses as well as parts of a wide variety of dicotyledonous herbs and dwarf shrubs that flourish within black-tailed prairie dog colonies. Though not included in the regression model, DISTANCE from the colony edge is obviously important to prairie dog establishment, since new burrows were not observed more than 55 m. from an existing colony edge.

Significant differences (contingency table X^2 ; $P < .10$) in the "establishment success" of black-tailed prairie dogs occurred at short (11-25 m.), medium (26-40 m.), and long distances (41-55 m.) from the edge of the colony for grids grouped both by POPULATION DENSITY classes (fig. 1a) and by VISIBILITY classes (fig. 1b). Among POPULATION DENSITY classes (high and low), highest establishment success was observed in areas at short and medium distances from the colony edge when these areas were adjacent to high density populations (>50 burrow entrances/ha). Among VISIBILITY classes (high, medium, and low), highest establishment success was observed, once again, in areas at short and medium distances from the colony edge where high VISIBILITY ($>30\%$) through the vegetation occurred.

Maintenance of a thick herbaceous cover has been suggested as a means of discouraging the rapid expansion of prairie dog colonies and even credited with the elimination of a small prairie dog colony (Osborn and Allan 1949, Snell and Hlavachick 1980). Visibility, as recorded using the target, has two components, (1) density of vegetation and (2) plant height. Management practices for vegetation along colony edges that maintain only tall plants without regard for high density stands, and *vice versa*, will probably prove ineffective; both components are necessary. Results of this study also suggest that colony expansion may be difficult to minimize without some control of prairie dog densities at the edge of the colony. Our research (Cincotta et al. [in press]) and other similar research (Knowles 1985a, Knowles 1985b, Garrett and Franklin 1982) suggest that expansion of colonies may be influenced by the proximity of other black-tailed prairie dog colonies that serve as pools for dispersers.

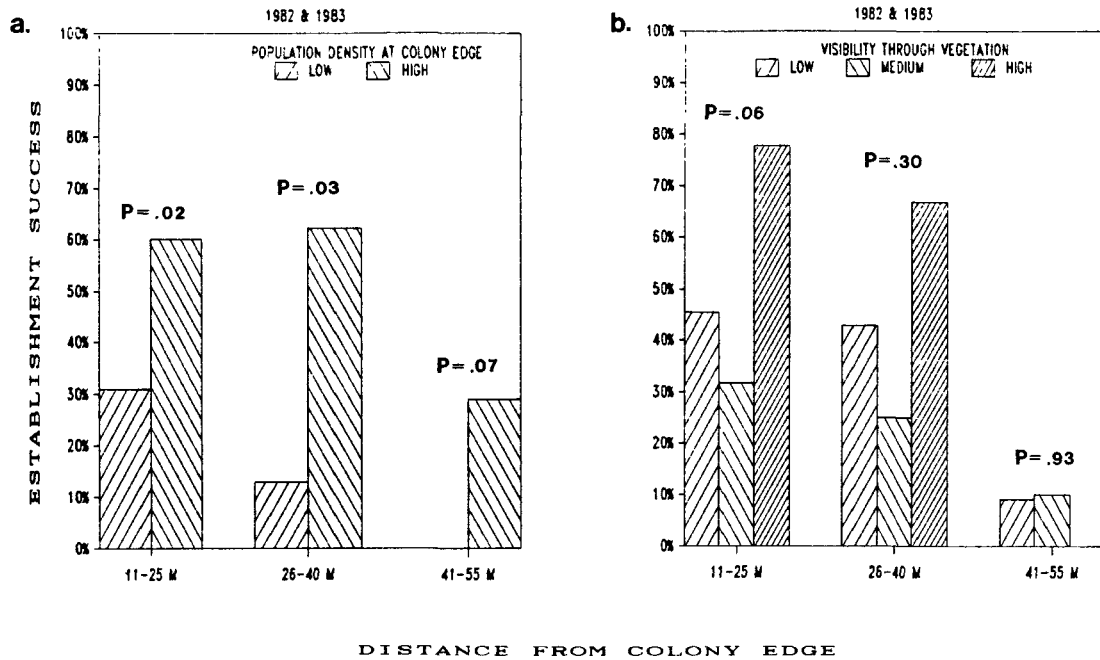


Figure 1.--The observed percentage of ESTABLISHMENT SUCCESS of prairie dogs in uncolonized grid squares adjacent to a colony. Squares were classed by the level of: a.) POPULATION DENSITY at the nearest colony edge, and b.) VISIBILITY through the vegetation. P-values represent the probability of homogeneity within the distance class (contingency table χ^2).

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