Evaluation of Three Surveys Assessing Prairie Dog Colonies in Northwest Kansas

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Matt Peek, Kansas Department of Wildlife and Parks, P.O. Box 1525, Emporia, KS 66801, (620) 342-0658, MattP@wp.state.ks.us

Mike Houts, Kansas Applied Remote Sensing Program, University of Kansas, 129 Higuchi Hall, Lawrence, KS, 66045, (785) 864-1515 MHouts@ku.edu

Summary

In July of 2006, aerial prairie dog surveys were conducted in an area of northwest Kansas consisting of approximately one quarter of the prairie dog range in Kansas (29,635 km^2, 11,442 mi^2,). Both line transect and line intercept data were collected. High spatial resolution aerial imagery acquired as part of the Farm Service Agency's (FSA) National Agricultural Imagery Program (NAIP) for crop assessment from 2006 was also used to visually identify and manually delineate prairie dog colonies within the same portion of northwest Kansas. Estimated acreage of active prairie dog colonies and the standard error associated with each estimate for each survey technique were as follows: line transect = 1757 colonies (SE = 220) and 79,289 ac (SE = 17,942); NAIP = 2,480 colonies (SE = 230) and 97,011 ac (SE = 17,034); and line intercept = 116,530 ac (SE = 24,471). The line intercept technique was not adequately evaluated to explain its higher estimate. However, a second aerial survey was conducted in July of 2008 to evaluate inconsistencies in colony identification between the line transect and NAIP techniques. This analysis produced extremely similar results for the two techniques: line transect = 2452 colonies and 88,536 ac, NAIP = 2542 colonies and 85933 ac. Corrected estimates for the line transect technique increased mainly due to failure to detect active colonies whereas the NAIP technique decreased mainly due to misclassification of gophers in CRP as prairie dogs. Most of the error can be removed from the NAIP technique by excluding the CRP layer in GIS. Based on the results of this research, the NAIP technique, which is considered more efficient and cost-effective than aerial surveys, is recommended for surveying prairie dogs in Kansas. However, an immediate aerial survey evaluation of NAIP results on a portion of the transects surveyed should be conducted in other parts of the state to evaluate potential errors in this technique in slightly different landscapes.

Introduction

One of the primary objectives of the Kansas Black-Tailed Prairie Dog Conservation and Management Plan is to establish a long-term protocol for monitoring prairie dogs in Kansas (Kansas Black-Tailed Prairie Dog Working Group, 2002). In 2000, Kansas Department of Wildlife and Parks personnel conducted aerial line transect surveys over the majority of the historical prairie dog range in Kansas – the area west of the Flinthills physiographic province, which constitutes approximately the western three-fifths of Kansas.

This survey provided an estimate of the number and area of prairie dog colonies in the state (Pontius, 2002). The major drawback of this survey technique is that its accuracy is largely dependent upon the ability of the observers to accurately estimate during flight the acreage of prairie dog colony within the one mile transect width. The ability to compare surveys across years also comes into question as observers change. Consequently, while satisfactory results were achieved through the 2000 survey effort, there was an interest evaluating other survey techniques.

Sidle et al. (2001) described an aerial line intercept technique that based the prairie dog colony area estimate upon the percent of the transect that is flown over prairie dog colonies, so rather than having to visually estimate colony area as with the line transect survey, the surveyor's primary responsibility is to accurately mark a waypoint at the beginning and end of each colony flown over. The line intercept technique was considered prior to the 2000 Kansas surveys, but has been considered preferable where large colonies are prominent. White et al. (2005a) indicated the plane often had to circle back to allow time for the GPS to process the initial waypoint prior to taking a waypoint at the proximal edge of the colony for colonies less than 200m in length (a 200m circular diameter = 7.8 ac). Consequently, there was some concern about this technique due to the potential difficulty of obtaining accurate waypoints over small colonies (most of the prairie dog colonies in Kansas are <20 ac). However, the decision was made to evaluate the feasibility of the line intercept technique for prairie dog surveys in Kansas.

Since the 2000 surveys, the availability of visual imagery has improved. Detailed aerial photographs (Lee and Henderson, 1988) and Agricultural Stabilization and Conservation Service (ASCS) aerial transparencies (Powell, 1992; Vanderhoof and Robel, 1994) have been used to estimate the number and acreage of prairie dog colonies in Kansas in the past, but their feasibility is limited by their availability and in the case of the latter, time and difficulties associated with interpreting the slides. Satellite imagery was recognized as a technique with potential prior to the 2000 surveys, but was considered cost prohibitive and analysis techniques were not sufficiently developed at that time. However, in 2005, Farm Service Agency (FSA) National Agriculture Imagery Program (NAIP) 2-meter resolution imagery for the state of Kansas was made publicly available for free download off the internet. In addition, advances in GIS technology made interpretation and analysis of the imagery more feasible. Preliminary viewings indicated that prairie dog colonies could be identified with imagery of that resolution.

Objectives: This project was intended to provide a comparison of three different survey techniques designed to estimate the number and area of prairie dog colonies in northwest Kansas. The surveys included 1) the aerial line transect survey, 2) the aerial line intercept survey, and 3) manual interpretation and delineation of prairie dog colonies in GIS from 2-meter FSA NAIP satellite imagery. The intent of the comparison was to determine which methodology was most appropriate for future statewide survey efforts.

Methods

Study area: During the 2000 surveys, the historical prairie dog range was separated into four quadrants to facilitate flight departures and returns and other aspects of flight coordination. The northwest quadrant had the highest density of prairie dogs in the previous survey (Pontius, 2002), and was chosen as the quadrant upon which to repeat survey efforts during the 2006 survey. This 29,635 km^2 (11,442 mi^2) quadrant consisted of all or portions of 17 counties in Kansas north of Hwy 96 and west of Range 24 (Figure 1).

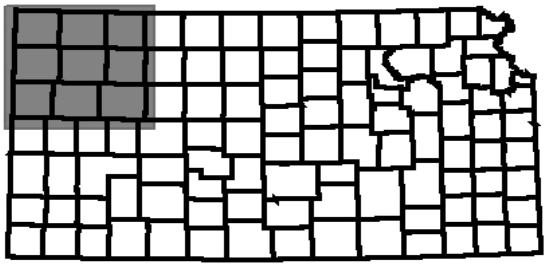


Figure 1. Survey area consisting of portions of 17 counties in northwest Kansas.

Aerial Surveys: A Cessna 172 was used to conduct aerial surveys. The plane flew at an altitude of approximately 400 feet and at a speed of approximately 100 mph. Following an evaluation of transect spacing (Senne, 2006), the decision was made to use sampling scheme as was used in 2000. Transects were spaced 6.44 km (4 mi) apart, and a total of 27 north/south transects were flown in July of 2006. Each transect was approximately 173 km (107 mi) long. Accompanying the pilot was one observer on each side of the plane. The same two observers were used throughout the survey to limit observer variability. Both observers were experienced at conducting aerial wildlife surveys, but neither had aerially surveyed prairie dogs.

Prairie dog colonies were identified and distinguishable from other species as described in previous literature (see White et al., 2005a). The location of all colonies on either side of the flight line was recorded, and as per the recommendation of White et al. (2005b), both active and inactive colonies were identified based on the observation of live prairie dogs or the presence of fresh diggings around burrows. Each colony's total area within the 1-mile transect width (1/2 mile on either side of the plane) was also estimated by the observers in acres.

Data recording was accomplished through a computer program initially designed for the 2000 Kansas prairie dog survey (GISEDGE, Inc., Wichita, KS). A Global Positioning System (GPS) was connected to a laptop, which used ArcView Tracking Analyst to display a real-time ArcView StreetMap image. Transects were overlaid onto the map, which was used to keep the plane on course, as were the location of colonies from the 2000 survey. The location of prairie dog colonies was recorded on the laptop in one of two ways. For the line transect technique, colonies were recorded by placing the cursor at the approximate location on the StreetMap image and hitting enter, thereby creating a waypoint at the location of the cursor. For the line intercept technique, beginning and ending waypoints were created by hitting enter at the beginning and end of any prairie dog colony flown directly over. By treating the multiple line intercept points

for each colony as a single point, this data was incorporated into the line transect data prior to analysis. Switching between survey techniques required only a single click (enter) on one of two icons. Upon entering a waypoint in the line transect method or entering the ending waypoint in the line intercept technique, a pop-up was automatically prompted within which the estimated acreage and activity status were entered. A database including all information for each point was saved at the end of each flight.

Following the survey, the databases were parsed and formatted for import into ARCGIS. The point file was reprojected to UTM zone 14, NAD 83. Processing of the aerial survey data began by first sorting the data into two categories: single point colony locations and colony beginning/end coordinate sets. For the beginning/end sets, a center point was calculated for each set and was used to create a new center-point dataset. The new center-point data and the single point colony locations were merged to create a single point file of prairie dog colony locations. The distance between the beginning and end points of colonies that were intercepted was calculated in ARCGIS, and added to the point file. The flight line transects were buffered by 0.5 miles on either side to identify colonies that were outside the ½ mile buffer area or outside of Kansas.

GIS Mapping: The second phase of this project focused on using high spatial resolution aerial imagery acquired as part of the Farm Service Agency's FSA NAIP for crop assessment. In most years, this dataset consists of two-meter natural color imagery collected in the early summer across the entire state. In 2006, however, the natural color imagery was collected at one-meter resolution, and an additional dataset of near inferred imagery was also acquired. These datasets were available for free download via the state geospatial data clearinghouse (DASC) as county level MRSID images. All imagery was already georeferenced and projected as UTM 14, NAD83 so no image processing was necessary.

Processing began with the one-meter natural color imagery, since this is the standard NAIP product and commonly available. Assessments and colony delineations were conducted using the county tiled MRSID imagery. For each county, the flight transects and 0.5 mile buffer lines were overlaid on the imagery to focus mapping efforts on the same area as was assessed during the aerial survey. To eliminate interpreter bias and simulate future mapping efforts where point location data may not be available, colony point locations were not overlaid on the imagery. Scanning for colony locations was done at a scale of 1:8000, and a magnification window was occasionally used to aid in identification and digitizing.

The imagery was interpreted along each flight line, and when a prairie dog colony was identified, on screen digitizing in ArcGIS was used to delineate the perimeter of the colony. The perimeter was defined as the area just beyond the outermost burrows, often consisting of the distinct area in which prairie dog impacts on vegetation were visible.

Prairie dog colony reassessment: In July of 2008, approximately one-third of the survey area was re-flown in an attempt to evaluate the accuracy of the different techniques. In particular, we wanted to determine the status of colonies identified by one technique but not the other. Since this survey was conducted nearly two years after the initial surveys, emphasis was on whether or not the identified colonies were actually prairie dogs, and not on the activity status of the

colonies, which could not be assessed that long after the initial surveys. The computer program used for the previous aerial surveys was employed, and prairie dog colonies identified by each of the survey techniques were overlayed onto the Streetmap image, allowing previously identified colonies to be easily relocated and classified as prairie dogs or something else. Transect segments were selected to maximize the coverage of colonies unmatched between NAIP and aerial surveys, and to provide thorough coverage across the survey area. Flight transects encompassed portions of 16 of the 17 counties.

Original estimates were classified by activity status (active, inactive or unknown) and whether or not the colony was identified by both NAIP and the initial aerial survey (matched or unmatched). This was done to increase the accuracy of the extrapolation of the reassessment data, under the assumption that colonies identified the same by both techniques were more likely to be correctly identified than those that were identified by only one technique. By calculating the percent of prairie dog colonies identified by one technique but not the other, and then multiplying the values for each of the two surveys together, a correction factor was developed to estimate the number and area of prairie dog colonies that both techniques failed to detect.

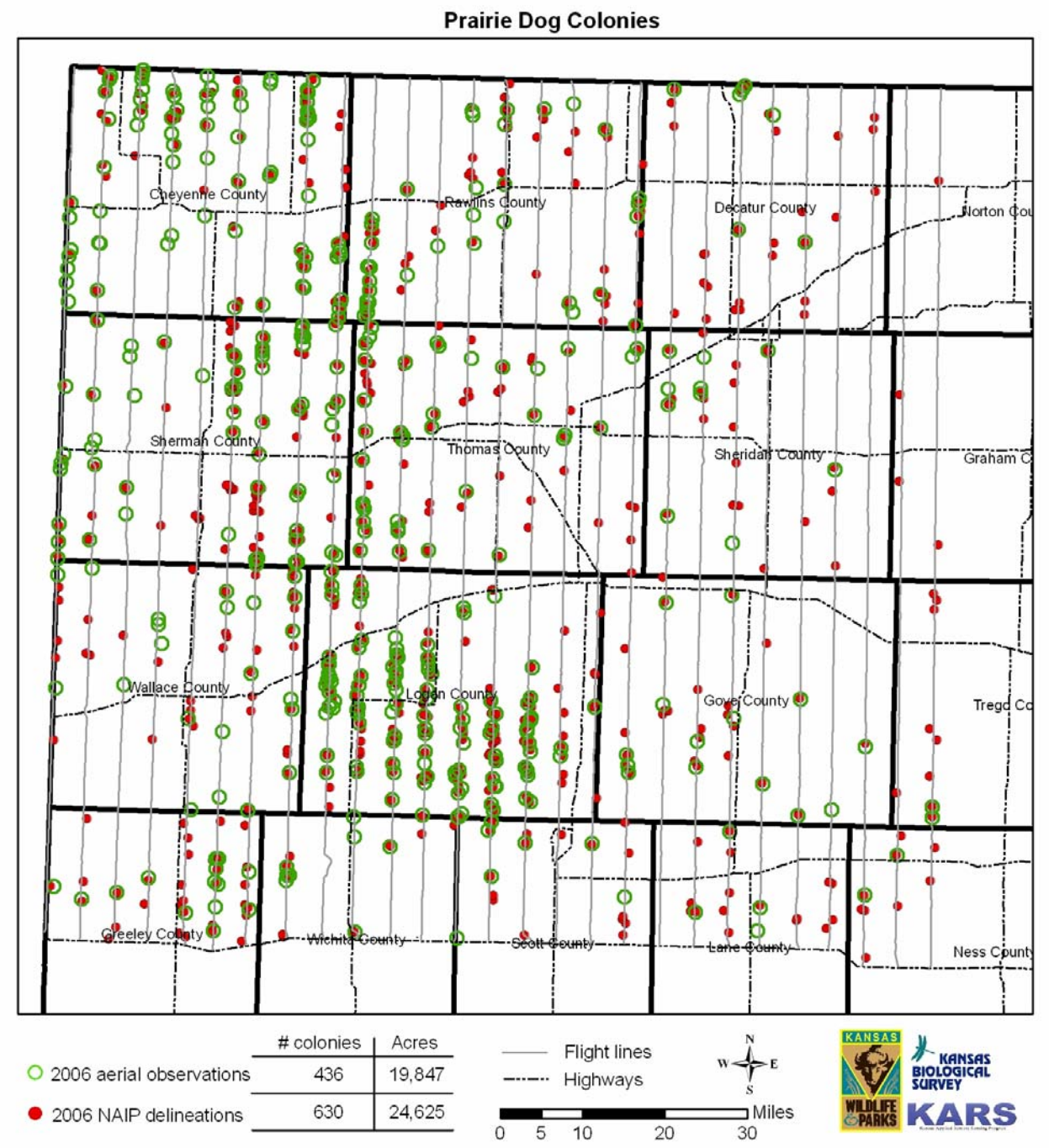
Results

The locations of active prairie dog colonies identified during the aerial surveys and from NAIP delineations are shown in Figure 2. A total of 436 active prairie dog colonies covering an estimated 19,847 acres were identified using the line transect survey. A total of 630 active prairie dog colonies were delineated using NAIP imagery, covering 24,625 acres. One hundred and thirty active colonies covering a transect distance of 73,523 m, which extrapolates into 28,736 acres, were included in the line intercept analysis. The estimated percent of the survey area occupied by active prairie dog colonies was 1.06, 1.36, and 1.60 %, respectively, for each of the three techniques. In addition to the colonies above, the following colonies detected by each technique were classified as "inactive:" Line transect - 43 colonies, 765 acres; NAIP imagery - 297 colonies, 4975 acres, line intercept - 7 colonies, 2770 meters (extrapolates into 1081 acres).

Total estimated area of prairie dog colonies within the Northwest quadrant of Kansas as per each of the three survey techniques is found in Table 1. Total estimated number of colonies within the Northwest quadrant of Kansas as per the aerial line transect and NAIP surveys is found in Table 2. The line intercept technique only accounts for colonies flown over so does not provide for an estimate of the total number of colonies within the survey area but the number of colonies associated with line intercept area estimate was 530.

Corrected Estimates: A total of 225 colonies estimated to account for 8623 acres initially identified during the aerial line transect survey (Table 3) and a total of 439 colonies estimated to account for 14,923 acres identified by the NAIP technique (Table 4) were flown and reclassified as prairie dogs, not prairie dogs, or unknown (no visible remnants of a prairie dog colony, gophers, ants, etc). When an active colony was identified by both techniques, the classification by each technique was considered from 92-96% accurate, depending on survey technique and whether number of colonies or area was being considered. The line transect survey was more accurate in terms of properly identifying colonies than the NAIP technique when evaluating

Figure 2. Location of prairie dog colonies identified in northwest Kansas during the 2006 aerial surveys and from NAIP delineations.



colonies identified by one technique but not the other. These "unmatched" colonies accounted for 7% and 35% of the active line transect and NAIP colonies, respectively. The line transect technique accurately identified 74% of the unmatched colonies and 87% of the unmatched acres, whereas the NAIP technique accurately identified 45% of the unmatched colonies and 37% of the unmatched acres. However, while the NAIP technique had more false positives than the line transect technique, the line transect technique failed to detect an estimated 166 colonies and 2591 acres that were detected by NAIP, whereas the NAIP technique failed to detect an estimated 86 colonies and 1005 acres. .

Because each survey technique failed to detect colonies that were detected by the other, it is reasonable to assume that some colonies went undetected by both techniques. An estimate of colonies that went totally undetected was calculated by multiplying the percent of active unmatched colonies (or acres) detected by each survey type to one another. This correction factor was applied after adding the respective undetected prairie dog colony values mentioned above to each survey technique. The estimated number and area of colonies for the survey is found in Table 5. These numbers yield very similar final estimates of 2452 colonies and 88,536 acres for the line transect survey and 2542 colonies and 85,933 acres for the NAIP analysis. Ultimately, 67% of the total estimated colony number and 91% of the total estimated colony area were detected by the original line transect survey, and 81% of the total estimated colony number and 94% of the total estimated colony area were detected by the original NAIP survey.

Expenses: The cost of conducting the NAIP delineations was approximately $100 per whole county surveyed (2 hours at $50/hr). Because some partial counties were surveyed, the total cost was approximately $1500. The cost to conduct line transect surveys was approximately $6400 (40 hours of flight time at $40/hr = $1600; $3500 labor by 3 employees; $1000 meals/lodging; and $300 vehicle depreciation). Conducting a flight check of the surveys required only one spotter and the pilot, and only about 1/3 of the survey area was reflown, so the cost of this follow up effort was approximately $2000.

Table 1. Estimated area of prairie dog colonies in Northwest Kansas as determined by three different survey techniques.

Survey Type	Estimated Area of Colonies (ac)	Estimated Proportion Affected	Standard Error	90% Confidence Limits
Line Transect	79,289	0.0112	17,942	(49,774; 108,804)
NAIP	97,011	0.0138	17,034	(68,990; 125,031)
Line Intercept	116,530		24,471	(76,275; 156,786)

Table 2. Estimated number of prairie dog colonies in Northwest Kansas as determined by two different survey techniques.

Survey Type	Estimated Number of Colonies	Standard Error	90% Confidence Limits
Line Transect	1,757	220.28	(1,395; 2,120)
NAIP	2,480	229.67	(2,102; 2,858)

Table 3. Aerial line transect estimates achieved by applying data obtained by re-flying aerial line transects (flight check) to data initially obtained.

Follow-Up Survey					Initial Survey									
Reclassification	Number		Percent						Subtotal		Unknowns Redistributed		Total	
Status	colonies	acres	colonies	acres	Activity	Match	colonies	acres	colonies	acres	colonies	acres	colonies	acres
dogs	39	428	74	87	active	no	101	1071	74	932	11	74	86	1005
not dogs	7	28	13	6	active	no	101	1071	13	61	2	5	15	66
unknown	7	36	13	7	active	no	101	1071	13	78	0	0	0	0
subtotal	53	492							101	1071	13	78	101	1071
dogs	146	7578	95	96	active	yes	321	18290	304	17596	10	346	315	17942
not dogs	3	147	2	2	active	yes	321	18290	6	341	0	7	6	348
unknown	5	152	3	2	active	yes	321	18290	10	353	0	0	0	0
subtotal	154	7877							321	18290	10	353	321	18290
dogs	0	0	0	0	inactive	no	7	34	7	34	0	0	7	34
not dogs	0	0	0	0	inactive	no	7	34	0	0	0	0	0	0
unknown	0	0	0	0	inactive	no	7	34	0	0	0	0	0	0
subtotal	0	0							7	34	0	0	7	34
dogs	11	205	61	81	inactive	yes	36	731	22	590	11	107	33	697
not dogs	1	10	6	4	inactive	yes	36	731	2	29	1	5	3	34
unknown	6	39	33	15	inactive	yes	36	731	12	112	0	0	0	0
subtotal	18	254							36	731	12	112	36	731
Total	**225**	**8623**					**465**	**20126**	**465**	**20126**			**465**	**20126**

Table 4. NAIP estimates achieved by applying data obtained by re-flying aerial line transects (flight check) to data initially obtained.

Follow-Up Survey					Initial Survey									
Reclassification	Number		Percent				Survey Values		Subtotal		Unknowns Redistributed		Total	
Status	colonies	acres	colonies	acres	Activity	Match	colonies	acres	colonies	acres	colonies	acres	colonies	acres
dogs	70	1569	48	37	active	no	283	6450	135	2405	32	186	166	2591
not dogs	49	2336	33	56	active	no	283	6450	94	3582	22	277	117	3859
unknown	28	302	19	7	active	no	283	6450	54	463	0	0	0	0
subtotal	147	4207							283	6450	54	463	283	6450
dogs	147	7878	92	93	active	yes	347	18174	319	16976	17	332	336	17309
not dogs	5	394	3	5	active	yes	347	18174	11	849	1	17	11	866
unknown	8	162	5	2	active	yes	347	18174	17	349	0	0	0	0
subtotal	160	8434							347	18174	17	349	347	18174
dogs	22	503	18	24	inactive	no	280	4427	50	1084	40	637	89	1721
not dogs	47	790	38	38	inactive	no	280	4427	106	1704	85	1001	191	2705
unknown	55	759	44	37	inactive	no	280	4427	124	1638	0	0	0	0
subtotal	124	2052							280	4427	124	1638	280	4427
dogs	5	164	63	71	inactive	yes	17	548	11	390	6	158	17	548
not dogs	0	0	0	0	inactive	yes	17	548	0	0	0	0	0	0
unknown	3	67	38	29	inactive	yes	17	548	6	158	0	0	0	0
subtotal	8	231							17	548	6	158	17	548
Total	**439**	**14923**					**927**	**29599**	**927**	**29599**			**927**	**29599**

Table 5. Final corrected estimates of the number and area of prairie dog colonies in Northwest Kansas as indicate by each survey technique.

Survey Type	Status of Active Colonies	Corrected Estimates unknowns redistributed		Detected only by other survey type		Subtotal		Correction factor for missed		FINAL ESTIMATE	
		colonies	acres	colonies	acres	colonies	acres	colonies[1]	acres[2]	colonies	acres
Aerial Line Transect	Correctly Classified as Pdogs	400	18947	166	2591	567	21538	0.0608	0.0074	601	21697
	Incorrectly Classified as Pdogs	22	414								
	Unknown	0	0								
	Total	422	19361								
NAIP	Correctly Classified as Pdogs	502	19900	86	1005	588	20905	0.0608	0.0074	623	21059
	Incorrectly Classified as Pdogs	128	4725								
	Unknown	0	0								
	Total	630	24625								

[1]Calculated by multiplying the percent of active unmatched colonies detected by each survey type to one another.
[2]Calculated by multiplying the percent of active unmatched acres detected by each survey type to one another.

Discussion

Initial estimates for the three survey techniques differed substantially. The second flight was conducted primarily to evaluate colonies that were unmatched between the line transect and NAIP techniques, particularly the more numerous colonies identified by NAIP but not during the aerial survey. Because the reassessment was conducted nearly two years after the initial surveys, results should be cautiously evaluated, but this appeared to be a reliable way to evaluate whether or not the colony in question was in fact a prairie dog colony, and lead to some interesting observations about each of the survey techniques.

The NAIP analysis was more effective at detecting colonies than the line transect survey. However, the NAIP analysis also falsely identified other things as prairie dog colonies more often than the line transect survey, which only incorrectly classified a few small colonies at the edge of the transect. For both surveys, colonies that the other technique failed to detect were smaller than colonies detected by both techniques (NAIP – 52 ac matched, 23 ac unmatched; line transect – 57 ac matched, 13 ac unmatched).

While the NAIP technique had a much higher level of colony misidentification, the aerial follow up flight indicated a high percent of the false positives were found in CRP. Further GIS analysis of the NAIP false positives indicates that 65% of the mistaken colonies and 74% of the mistaken area was in CRP. Because prairie dog colonies are rarely found primarily within CRP in Kansas, most of the NAIP misidentification errors can be avoided simply by identifying CRP in GIS and excluding "colonies" within this layer. It may also be possible that the NAIP CRP misidentifications (primarily pocket gophers) can be visually differentiated as the NAIP delineator gains experience in differentiating what is and is not prairie dogs.

One of the concerns associated with the line transect technique is the accuracy of the colony area estimates made by the observers. Consequently it is noteworthy that very similar estimates were achieved by the two survey types for active matched colonies (NAIP – 347 colonies, 18,174 ac; line transect – 321 colonies, 18290 ac (Tables 3 and 4)). In fact, the main error associated with the line transect technique was the failure to detect some colonies. A variety of factors likely contributed to this problem, including erroneously believing the colony was beyond the half mile transect edge, topography hiding the colony, missed colony while assessing area of another, and simply failure to detect by observer. It is believed that most of the error in identification with the line transect technique occurred near the transect edges. If the plane was flying high enough to get a good view of the transect edge a half mile out, it was too high to make a rapid assessment of activity status, or if low enough to rapidly assess activity status, the view at a half mile was less than desired.

Though line intercept data was opportunistically collected during the aerial survey, most of the emphasis for this comparison was placed on the other two techniques, and the line intercept technique was not adequately evaluated to explain the higher estimate of prairie dog colony area. One concern about this technique was that the delay in our GPS's ability to mark waypoints would erroneously produce longer than accurate flyover distances for smaller colonies. This assumption is supported by a comparison of the average flyover distance of colonies of 3 acres or less detected by this technique (n = 26) with the expected diameter of a colony of given acreage,

but the influence of these smaller colonies on total acreage was minimal, making this an unlikely source for the substantial difference in estimates. The follow-up evaluation of the other two techniques does indicate the line intercept technique did in fact overestimate prairie dog colony area.

Recommendations: An advantage of the NAIP technique remains the expected accuracy with which prairie dog colony area is assessed, while the area assessed by the line transect technique for each colony remains a guess. While the guess can be skilled, the issue of changing observers over time remains. False positives were an issue with the NAIP technique, but it appears this can be addressed by excluding possible prairie dog colonies identified primarily within CRP (since virtually none of these exist, it is reasonable to assume all such cases are false positives) and possibly with NAIP delineator experience. Accurately assessing activity status, including prairie dog densities within active colonies, remains an issue with all survey techniques, but is likely best addressed within survey constraints by aerial surveys. In light of the strengths and weaknesses of each technique, it appears the ideal survey strategy would incorporate the NAIP technique rangewide with the same sampling frame used in this (and the 2000) survey, and that a follow-up aerial flight should be conducted as soon as possible following NAIP delineations over a portion of the range to verify proper identification and activity status of colonies. This follow-up flight may eventually be eliminated, but at least initially, it should be conducted in case issues with the NAIP survey exist in other regions that were not apparent in the Northwest.

Conclusions

Initial estimates by each of the three survey types differed substantially. However, very similar results were achieved for the line transect and NAIP surveys after corrections were made based on an aerial review of the colonies detected by each technique. While each technique has advantages and disadvantages, the NAIP technique seems to offer the most consistency over time, and errors associated with it can be minimized by conducting an aerial assessment of a portion of the results. Such an effort should emphasize the strengths of each survey type, while minimizing flight time and expense associated with the survey.

Acknowledgements

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