Mapping of Black-tailed Prairie Dog (*Cynomys ludovicianus*) Colonies using National Agriculture Imagery Program (NAIP) 2015 Imagery

Prepared for:

Bureau of Land Management, Miles City Field Office

By:

Daniel A. Bachen, Bryce A. Maxell, Alexis L. McEwan, Boaz Crees

Montana Natural Heritage Program
Natural Resource Information System
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EXECUTIVE SUMMARY

Black-tailed Prairie Dogs (*Cynomys ludovicianus*) alter vegetation and dig extensive burrows, creating habitat for other species, and serve as prey for both mammalian and avian predators. Several animal species of conservation concern at the state and federal level, including the Mountain Plover (*Charadrius montanus*), Burrowing Owl (*Athene cunicularia*), and Black-footed Ferret (*Mustela nigripes*), are closely associated with prairie dog colonies and make use of burrows or the prairie dogs themselves. Recently, prairie dog populations have been impacted by sylvatic plague causing colony and population dynamics to change. The Montana Conservation Plan for Black-tailed and White-tailed Prairie Dogs identifies the need to monitor the distribution of these animals within the state to aid in the conservation of prairie dogs and dependent species.

We addressed the need for colony and complex monitoring by digitizing potential colony boundaries across Southcentral and Southeast Montana using 2015 National Agriculture Imagery Program (NAIP) imagery. In total, we mapped 4,154 potential colonies covering 556,136 acres. Of these colonies, 4 were over 5,000 acres in size, 55 were between 1,000 and 5,000 acres, and the remaining 3,199 were less than 1,000 acres. We aggregated colonies into complexes using the 1.5 km rule, and found that 15 complexes contained at least 5,000 acres of colonies and met the Category 1 criteria under the Montana Conservation Plan for Black-tailed and White-tailed Prairie Dogs.

To test the accuracy of our mapping, we ground truthed a subset of our colonies to determine if there was evidence of current or recent occupancy by Black-tailed Prairie Dogs. Our ground truthing efforts were based on 1 ha grid cells overlaid on each colony. We walked the perimeter of Category 1 complexes and recorded whether grid cells of the colony were active, inactive, or no evidence of occupancy. Of the 56 colonies we ground truthed, 95% had evidence of current or recent occupancy. At the grid cell level, we found that cells along mapped boundaries contained evidence of Black-tailed Prairie Dogs only 37% of the time while 76% of cells within the boundaries had evidence.

Our methods appear to have been effective at identifying colonies, but less precise at determining the exact boundaries of these colonies. Some inaccuracies may have resulted from the time delay between collection of the NAIP imagery and collection of ground truthing data. With future improvements in image quality and resolution our precision and accuracy will increase, thereby negating or minimizing the need to ground truth digitized colonies for future projects.

This project documented relatively large areas occupied by Black-tailed Prairie Dogs, including several complexes that may be suitable for targeted conservation efforts for species such as Black-footed Ferrets. With the development of an oral plague vaccine, identification and monitoring of colonies and complexes will be increasingly important. Mapping colonies from NAIP imagery may provide a cost effective way to prioritize areas for vaccine deployment and monitor the effects on colony size.

ACKNOWLEDGEMENTS

We extend considerable thanks and appreciation to all who conducted surveys for this project including: Boaz Crees, Alexis McEwan, and Ellen Whittle. Thanks to Braden Burkholder for assistance with the Prairie Dog database, Scott Blum for formatting the data and appending it to the Montana Natural Heritage Program's central animal observation database, and Bryce Maxell for providing valuable feedback throughout the project. We thank the Miles City Field Office of the Bureau of Land Management for providing funding and guidance for this project.

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INTRODUCTION

Black-tailed Prairie Dogs (*Cynomys ludovicianus*) alter vegetation and dig extensive burrows, creating habitat for associated species, and serve as prey for both mammalian and avian predators. Although this species is still widespread throughout much of its historic range in Montana, sylvatic plague and anthropogenic factors have reduced average colony size and changed colony dynamics (Augustine et al. 2008a), with concomitant impacts on dependent species such as Mountain Plover (*Charadrius montanus*), Burrowing Owl (*Athene cunicularia*), and the federally Endangered Black-footed Ferret (*Mustela nigripes*) (Augustine et al. 2008b, Desmond et al. 2000, Matchett et al. 2010). To address the conservation needs of prairie dogs within the state, the Montana Prairie Dog Working Group released a conservation plan in 2002 to identify objectives for conservation planning, including quantifying distribution and abundance (MPDWG 2002).

Since the 1980's several projects have sought to quantify the area occupied by both Black-tailed Prairie Dogs and White-tailed Prairie Dogs (*Cynomys leucurus*) within the state (MPDWG 2002). Over the last decade, the Montana Natural Heritage Program (MTNHP) has mapped colonies using the 2005 and 2009 National Agriculture Imagery Program (NAIP) imagery (Maxell et al. 2010). Mapping from aerial imagery can be a relatively cost efficient way to identify colonies, particularly on inaccessible public and private lands. However, two major shortcomings exist when these methods are used. First, colony boundaries are mapped on the presence of burrows; therefore, it is not possible to distinguish between active and inactive colonies or active and inactive areas within colonies. Second, features similar to burrows may confound colony boundaries or cause colonies to be mapped in areas without Black-tailed Prairie Dogs. The 2005 and 2009 NAIP projects were 69% accurate at identifying colonies and 80% accurate at identifying cells within these colonies in areas of the state where colonies are easily distinguished from the background vegetation, geological, and biological features (Maxell et al. 2010). However, the 2005 NAIP imagery delineated colonies in Custer, Phillips, and Rosebud counties, had ground truthed accuracies of 51%, 52%, and 35% respectively for the proportion of cells within a colony that had evidence of Black-tailed Prairie Dogs. The low accuracies in these counties may be caused by barren areas that can superficially resemble the structure of prairie dog colonies. Accuracy of mapping at the colony level was also relatively inaccurate for these same counties, with only 50%, 46%, and 32% of digitized colonies containing evidence of occupancy. These inaccuracies are problematic as these counties overlap core areas for this species within the state. Therefore, better information about colony coverage in these areas is necessary as conservation and management of Black-tailed Prairie Dog colonies is essential for the conservation of a number of Montana Species of Concern, and directly effects reintroduction efforts for the Endangered Black-footed Ferret.

Montana's Conservation Plan for Black-tailed and White-tailed Prairie Dogs (MPDWG 2002) identifies two objectives that can be address with mapping colonies from aerial imagery. Objective #2 is to "develop statewide and regional prairie dog distribution and abundance standards". To satisfy these objectives the plan calls for inventory and monitoring of distribution and abundance and identification of complexes of colonies. While abundance within colonies cannot be addressed with aerial mapping, this technique is well suited to quantifying distribution. Objective 3C: "identify

isolated prairie dog colonies in need of special consideration, assess their needs, and implement special management tasks, as appropriate" can be addressed.

The plan also identifies specific goals for the conservation of Black-tailed and White-tailed Prairie Dogs and associated species. Specifically, three categories are used to describe colony complexes (MPDWG 2002; pages 15-16):

> *Category 1: A minimum of two Black-tailed Prairie Dog complexes sufficient to maintain viable populations of Black-footed Ferrets. These should be at least 100 km apart, with each encompassing at least 5,000 acres of Black-tailed Prairie Dogs*
>
> *Category 2: A total of 36,000 acres occupied by Black-tailed Prairie Dogs, composed of at least 20 complexes of at least 1,000 acres*
>
> *Category 3: Complexes less than 1,000 acres in size… plus scattered isolated colonies of any acreage*

To address these needs we mapped colonies of Black-tailed Prairie Dogs using the 2015 NAIP imagery across some or all of Golden Valley, Stillwater, Musselshell, Bighorn, Yellowstone, Treasure, Rosebud, Prairie, Powder River, Carter, and Custer counties. To determine if the improved resolution of the 2015 NAIP imagery relative to earlier NAIP imagery impacted the accuracy of identifying colonies in previously problematic areas, we intensively ground truthed colonies on accessible public lands in central Custer County as well as confirming the presence of Black-tailed Prairie Dogs at other colonies across the rest of the mapped area.

PROJECT GOALS

Our primary goals for these efforts were to:

- Use NAIP imagery to map areas with recent evidence of Black-tailed Prairie Dog activity
- Evaluate accuracy of this methodology through ground truthing of 1-hectare grid cells
- Identify complexes for management and potential Black-footed Ferret reintroduction using a 1.5 km separation rule for defining a complex
- Confirm the presence of Black-tailed Prairie Dogs at colonies outside of the boundaries of historic colonies
- Provide data products to partners for management actions, planning, ground truthing, and environmental reviews

METHODS

Digitization of Colony Boundaries

Colony boundaries were delineated on the 2015 NAIP 20 kilometer × 20 kilometer tiles following methods used for the previous projects (see Maxell et al. 2010). However, we chose to delineate colony boundaries precisely instead of classifying 1-hectare grid cells as occupied. As the area of coverage was relatively small, and to reduce observer bias, a single technician conducted all of the mapping. All digitization was conducted using Arc Map 10.4 © ESRI Software. We examined the 2015 NAIP imagery at a scale of approximately 1:3,000 for features found within colonies such as mounding of dirt outside of burrow entrances, and clipped vegetation. When a potential colony was identified, we digitized the boundary as a polygon feature in a File Geodatabase (Figure 1). The colony boundary was then reviewed with previously mapped colonies and point observations overlaid, and any additional areas of occupancy detected on the 2015 NAIP imagery were mapped. Polygons were coded as having been detected blind, with the aid of previously mapped colonies, or reported observations.

Ground Truthing of Select Colonies

To determine the accuracy of colony boundaries delineated using the 2015 NAIP imagery, we ground truthed a subset of mapped colonies. All fieldwork was conducted over 30 person/days in September 2016. Our goals for this effort were to quantify the accuracy of mapped colonies on two levels:

- Colony: Did the mapped colony contain evidence of Black-tailed Prairie Dogs?
- Within colony: What was the proportion of area with evidence of prairie dog activity?

We prioritized ground truthing of colonies with high value for conservation of associated species, in particular Black-footed Ferrets. To sustain a ferret population, large aggregations of prairie dog colonies are required (Biggins et al. 1993). To ensure that our ground truthing results were most accurate within high priority areas we allocated the most effort to colonies within the largest identified complexes.

To create colony complexes (hereafter complexes), we buffered all colonies by 750 m. We then grouped colonies by overlap between these buffers to identify complexes of colonies within 1.5 km of each other. Finally, we calculated the total size in acres of mapped colonies within each complex. We focused our ground truthing efforts on complexes meeting the Category 1 criteria (i.e. > 5,000 acres of active colonies). To facilitate surveys, we overlaid a public lands layer on all colonies within the Category 1 complexes and prioritized publically accessible areas for survey.

Depending on the priority of each colony we used one of two methods. For high priority colonies in Category 1 complexes, we overlaid a 1-hectare × 1-hectare grid and identified cells in proximity to the mapped boundary. Field personal used GPS units with hectare centroids pre-loaded and hard copy maps with the hectare boundaries to identify each grid cell within and adjacent to colonies. They then walked the colony boundary and scored whether each hectare grid cell contained active burrows, inactive burrows, or no evidence of occupancy. For colonies that were either within these Category 1 complexes and visible, but not accessible or outside of complexes, we sought only to determine if there was evidence of prairie dog activity at the colony level. Personnel traveled as close as possible to these colonies and looked for evidence of Black-tailed

Prairie Dogs or their burrows. As any inference of absence using this survey method would be untrustworthy due to incomplete survey coverage, we only recorded if the colony was active or inactive.

Data Preservation and Dissemination

To archive and make project data available to land managers for use in conservation efforts and land use planning, we added the mapped colony boundaries and observation information to the Montana Natural Heritage Program's Prairie Dog and Point Observation databases. Spatial data containing both the mapped colony boundaries and ground truthing was appended to Montana's statewide Prairie Dog Database and information from this database is available upon request. The observations of active Black-tailed Prairie Dogs and other incidental species observed during surveys were appended to the MTNHP's point observation database, and are available upon request and through online tools in the Natural Heritage Map Viewer web application.

RESULTS

Mapping

Across the area of interest, we mapped the boundaries of 4,154 potential colonies totaling 556,136 acres (Figure 2). Of these colonies, 4 were over 5,000 acres in size, 55 were between 1,000 and 5,000 acres, and the remaining 3,199 were less than 1,000 acres. Mapped colonies averaged 134 acres with a minimum size of less than 1 acre and a maximum size of 9,210 acres. As in previous years, the majority of colonies were between 11 and 50 acres (Figure 3). When aggregated into complexes using the 1.5 km rule, we identified 942 discrete complexes. Of these complexes, 15 were greater than 5,000 acres in size and met the criteria for Category 1 designation (MPDWG 2002). An additional 53 complexes were between 1,000 and 5,000 acres in size, and the other 874 were less than 1,000 acres (Figures 4 & 5). The smallest complex was approximately 0.5 acres while the largest exceeded 100,131 acres and encompassed 472 mapped colonies. As expected, many mapped colonies were associated with previously documented colonies, but 2,577 mapped colonies were completely outside of those previously mapped. The total coverage of these new areas was 214,610 acres.

Ground Truthing

In total, we ground truthed 5,298 hectares in 56 prairie dog colonies within three Category 1 complexes (Figure 6). Of these colonies, 53 had evidence of prairie dog activity (95%). Across the ground truthed colonies, we surveyed 5 or more hectares within 48 of these colonies. Of these, 74% of the hectare grid cells that were interior to the grid cells along the colony boundary had evidence of prairie dog activity (active or inactive). However, for grid cells that overlapped the mapped colony boundary, only 37% had evidence of current or recent occupancy (Figure 6). The proportion of interior grid cells with evidence of activity varied across colonies (Figure 7). Of the 3 colonies where no prairie dog activity was recorded, all were within 5 km along the Powder River, and 1 had less than five cells surveyed. In addition to the intensive ground truthing of these primary colonies within Category 1 complexes, we also documented evidence of prairie dog occupancy at an additional 261 colonies (Figure 8). Of these colonies, 193 did not overlap previously mapped colonies.

Although we did not standardize the number of cells surveyed for each colony, surveying a greater proportion of cells within a colony did not affect the proportion of interior cells with evidence of activity (Figure 9). The apparent lack of relationship between cells surveyed and detections indicates that we did not bias our detection of Black-tailed Prairie Dogs or burrows through increased effort at some colonies.

DISCUSSION

Mapping prairie dog colonies using the 2015 NAIP imagery was successful both in the number of colonies delineated and the accuracy of mapping colonies. Total acres of active and inactive colonies exceeded those mapped in previous years within the same area. Although this could represent an increase in the area occupied by Black-tailed Prairie Dogs, this could also be due to more colony detections as a result of better imagery. Although we detected more colonies, using the 1.5 km separation rule we delineated many of the same complexes that were delineated using the 2005 and 2009 NAIP imagery (Maxell et al. 2010). As was the case with previous efforts, the complex in central and southern Custer County centered on the Pumpkin Creek area was one of the largest in the mapped area.

Compared to previous efforts in this part of the state, identification of colonies from the 2015 NAIP imagery appears to have been more accurate. However, methods used to ground truth colonies for this project differed from previous years, so the metrics are difficult to compare directly. Both this and previous efforts used 1-hectare grid cells as the sampling unit. However, in past years, cells were sampled randomly from within the colony and each cell was surveyed with greater intensity. For this effort, we sought to survey all cells along the boundary of the mapped colony, and any others within the colony should they be visible or the opportunity arise. While surveys of each grid cell were less intense, more cells were surveyed.

Our analyses of the data also differed from previous efforts. For this effort, we calculated the proportion of cells with evidence of occupancy on the boundary and in the interior of the colony. These proportions differed, with the interior cells being more accurate than those on the boundary. Whether due to clearer imagery or different survey methods, the proportion of mapped colonies that contained evidence of Black-tailed Prairie Dogs increased over previous efforts. Ground truthing showed that the mapping effort that used the 2005 imagery was correct at only 28 of the 56 colonies in Custer County. Our accuracy was much higher, with 53 of 56 colonies having observed evidence of occupancy by prairie dogs. Additionally, all three colonies that were mapped incorrectly are clustered within 5 km of each other, which may indicate challenging habitat or an isolated error in mapping.

Due to differences between efforts in techniques used to ground truth colonies, we cannot directly compare accuracy at the 1-hectare level. However, the increase in number of mapped colonies currently or previously occupied by Black-tailed Prairie Dogs provides evidence that this project was more successful at correctly identifying recent evidence of Black-tailed Prairie Dog activity. The 2005 NAIP imagery mapping effort reported that 51% of cells in Custer County were mapped incorrectly (Maxell et al. 2010). These protocols also included cells outside of colonies, which we did not test with our methods. We found that 74% of cells within the mapped interior of the colonies were observed to be active or inactive, which appears greater than the 2005 effort. However, the cells mapped at the boundary were only correctly identified 37% of the time. One reason our boundary accuracy may have been low was the temporal separation between the 2015 imagery and the ground truthing in 2016. The spatiotemporal movement of plague-affected colonies, like those in our study area, is more dynamic and accelerated than colonies not impacted by the disease (Augustine et al. 2008). Therefore, it is likely that the boundaries of colonies changed to some degree in the time

between when the imagery was taken and the ground truthing was performed. We would expect mounds and other evidence of previous occupancy under this scenario to be visible. However, if these indicators are less detectable than our expectations, this may contribute to the inaccuracy of the mapped boundaries.

Because we did not ground truth a subset of grid cells mapped outside of colony boundaries, we cannot assess the degree to which our mapping efforts missed colonies that may have existed within the area. We did observe Black-tailed Prairie Dogs outside of mapped boundaries during ground truth efforts, indicating that this error existed to some degree. Given this and the high accuracy with which we identified colonies, the number of mapped colonies should be considered an underestimate of the true number of colonies present.

We prioritized assessing the boundary and occupancy at the colony level over assessing occupancy at the burrow level. Consequently, using our methods makes it difficult to extract a total number of acres that have evidence of current or recent occupancy by Black-tailed Prairie Dogs within the mapped colonies. The area within colonies mapped using aerial imagery is positively biased if the circumscribed boundary is assumed to delineate an active colony (McDonald et al. 2011). With this assumption, the 556,136 acres of mapped colonies should not be interpreted as an estimate of active or inactive colonies. As we did not attempt to estimate the proportion of the colony that was occupied, we cannot infer the actual number of acres of Black-tailed Prairie Dogs present.

The increase in accuracy of detecting colonies between this project and previous efforts may be due to differences in imagery, personnel, survey techniques, or the intrinsic differences between years. Although the resolution of the NAIP imagery was 1 m for all projects, the 2015 images appeared to be much higher quality than the 2005 or 2009 NAIP imagery. We feel that this is the most likely cause of increased accuracy. As stated earlier, we also changed our ground truthing protocols and although unlikely, accuracy differences may have resulted due to these differences in protocols.

In 2018, the USDA is expected to release the 2017 NAIP imagery at 0.5-meter resolution (*https://catalog.data.gov/dataset/national-geospatial-data-asset-ngda-naip-imagery-2017-2018-planned-acquisition*). We anticipate that increased resolution will allow increased precision and accuracy of mapped colonies, potentially making ground truthing unnecessary. Future projects that use higher resolution imagery should seek to test the accuracy of detecting areas with and without evidence of prairie dog occupancy to help inform the need for future ground truthing.

The dynamic nature of colonies affected by plague has presented a challenge for this and other efforts that have used NAIP imagery to identify prairie dog colonies due to the time it takes for imagery to be processed and mapping to be conducted. Although it is unlikely that evidence of a colony would disappear between the time the area was flown and the colony was digitized, the likelihood of changes to the colony increase with time. This is especially problematic when trying to assess the accuracy of mapping boundaries. Although the time it takes for the USDA to release the NAIP imagery is beyond our control, we did demonstrate that it is possible to map colonies in a focal area relatively quickly. In total, it took us a little over a month to map our area of focus. For future work that requires geospatial status and distribution assessments of Black-tailed Prairie Dog colonies, mapping from recent NAIP imagery can provide this information relatively quickly.

This project documented relatively large areas occupied by Black-tailed Prairie Dogs, including several complexes that may be suitable for target conservation efforts for species such as Black-footed Ferrets. With the development of an oral plague vaccine (Rocke et al. 2010), identification and monitoring of colonies and complexes will be increasingly important. These mapping methods may provide an efficient way to identify complexes large enough to support ferrets and efficiently monitor the landscape level effects of a large-scale vaccination program.

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FIGURES

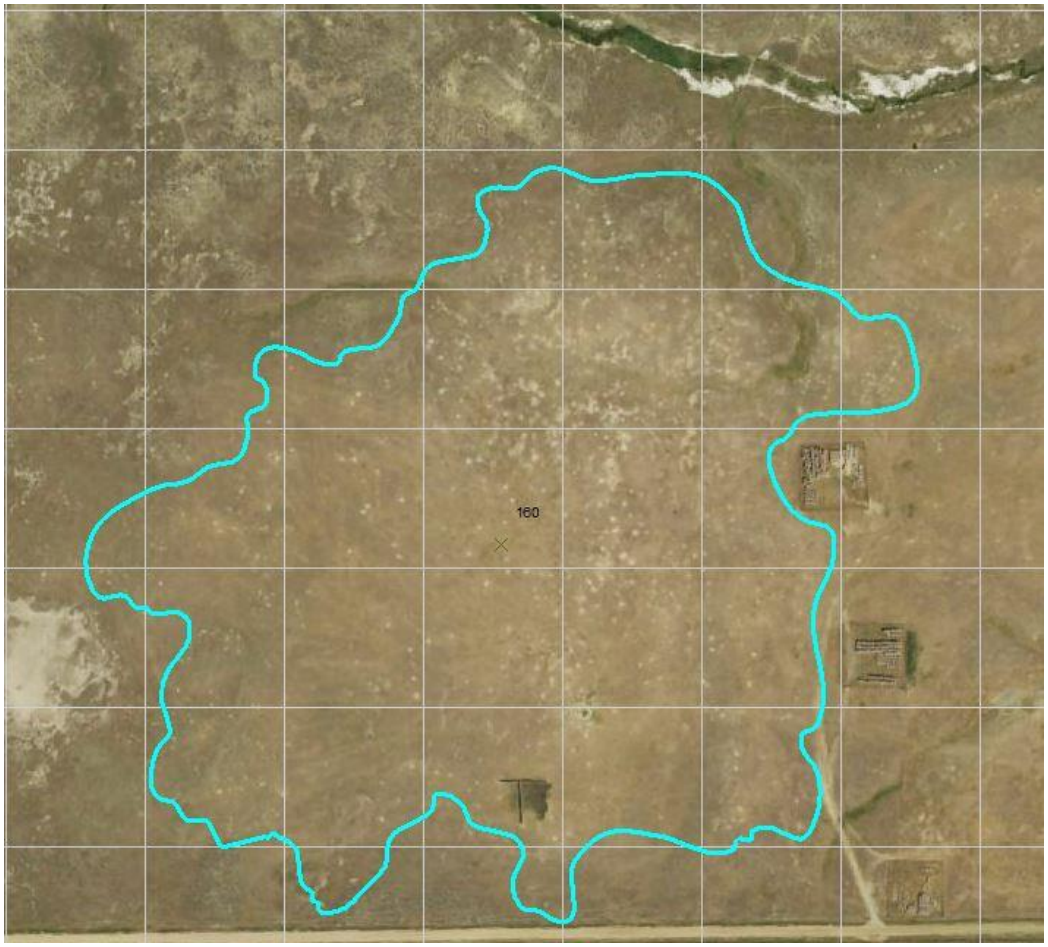

Figure 1. 2015 NAIP imagery with a potential colony boundary digitized and 1-hectare grid overlaid.

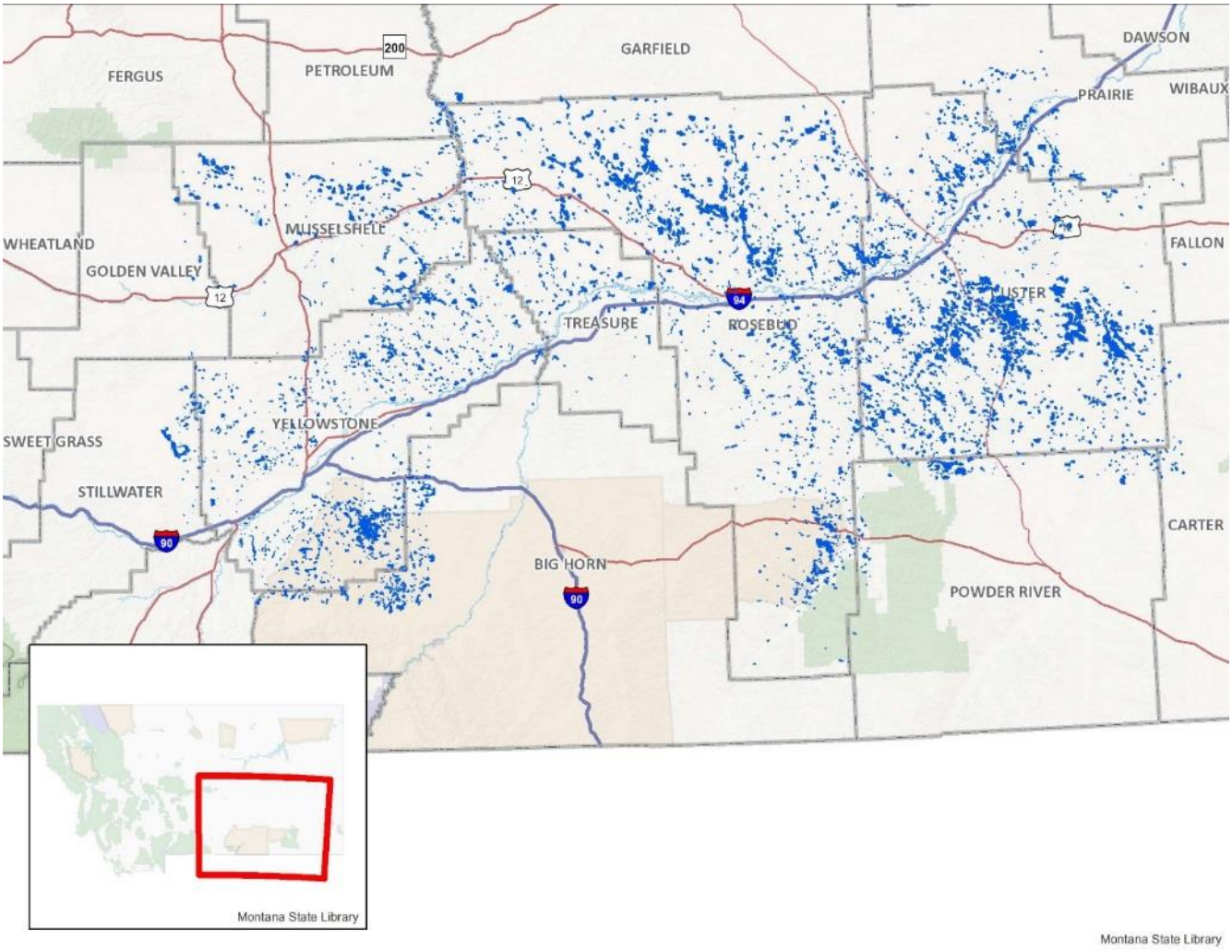

Figure 2. All colonies mapped from the 2015 NAIP imagery are shown in blue. Note that the highest density of colonies are in central and southern Custer County.

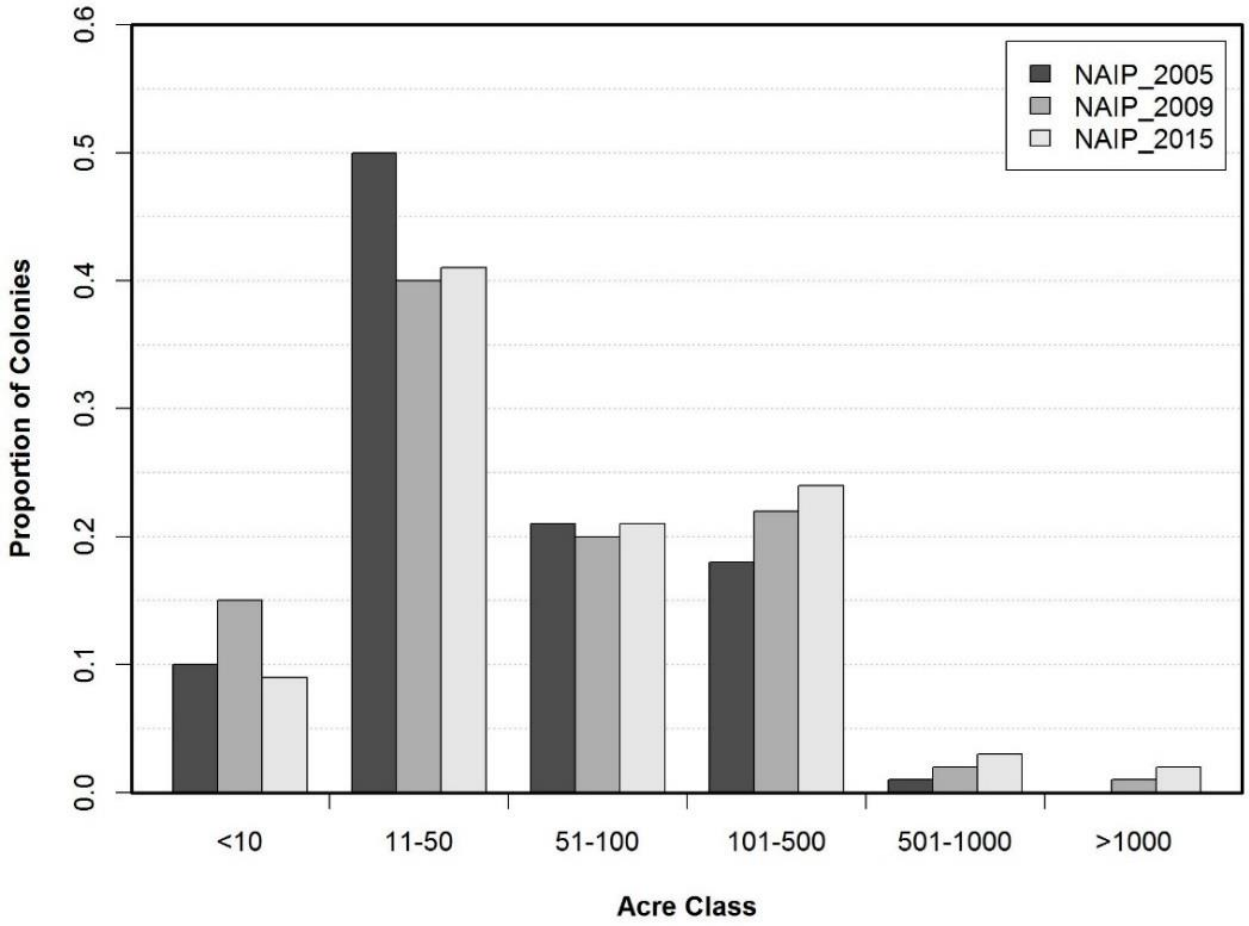

Figure 3. The proportion of colonies within 6 size classes for previous projects using the 2005 and 2009 NAIP imagery, and the current project which used the 2015 NAIP imagery. Proportions are used to compare previous efforts (range-wide) with the current effort (limited to 11 counties).

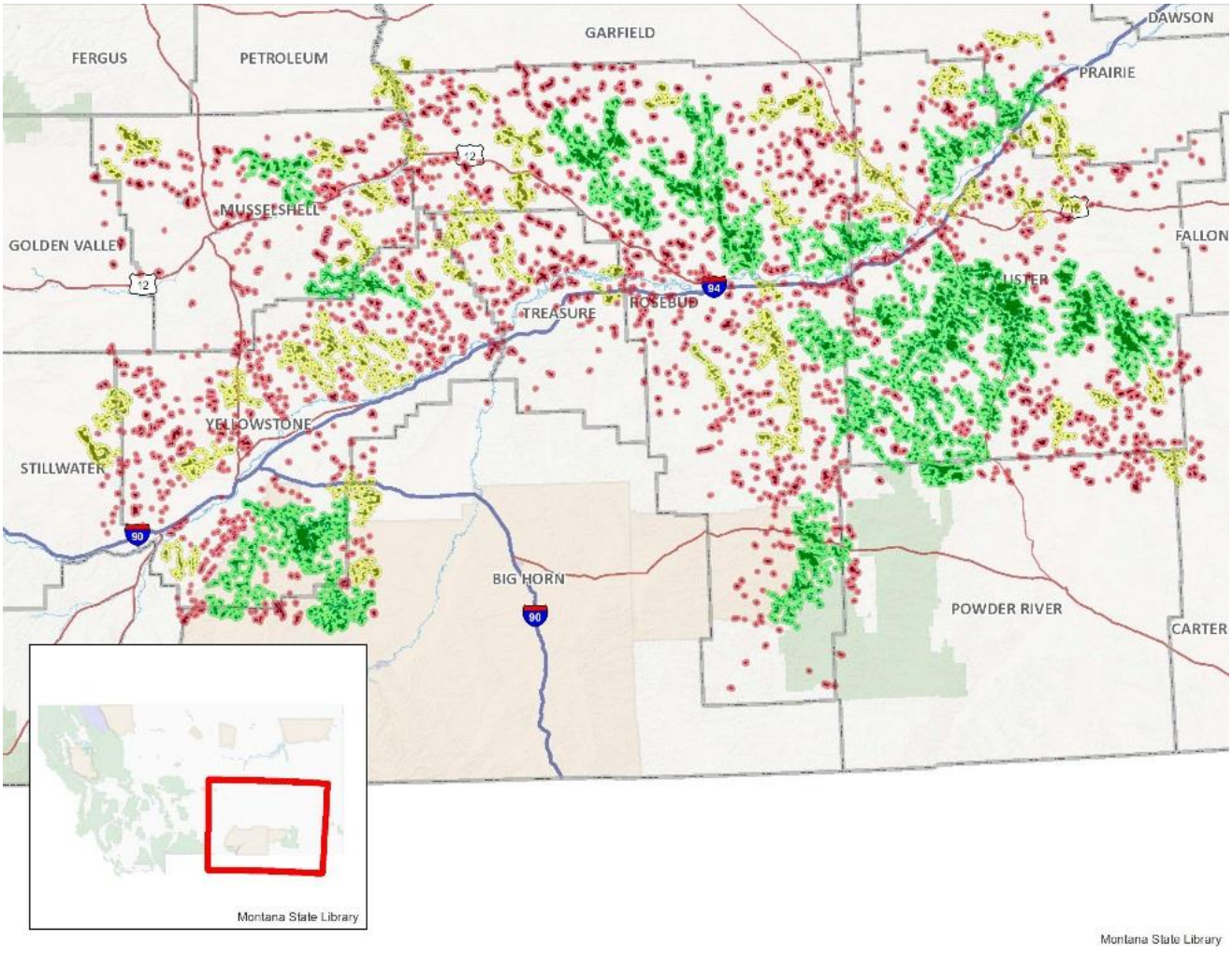

Figure 4. Complexes of mapped colonies using the 1.5 km separation rule that are greater than 5,000 acres (green), 1,000 to 5,000 acres (yellow) and less than 1,000 acres (red).

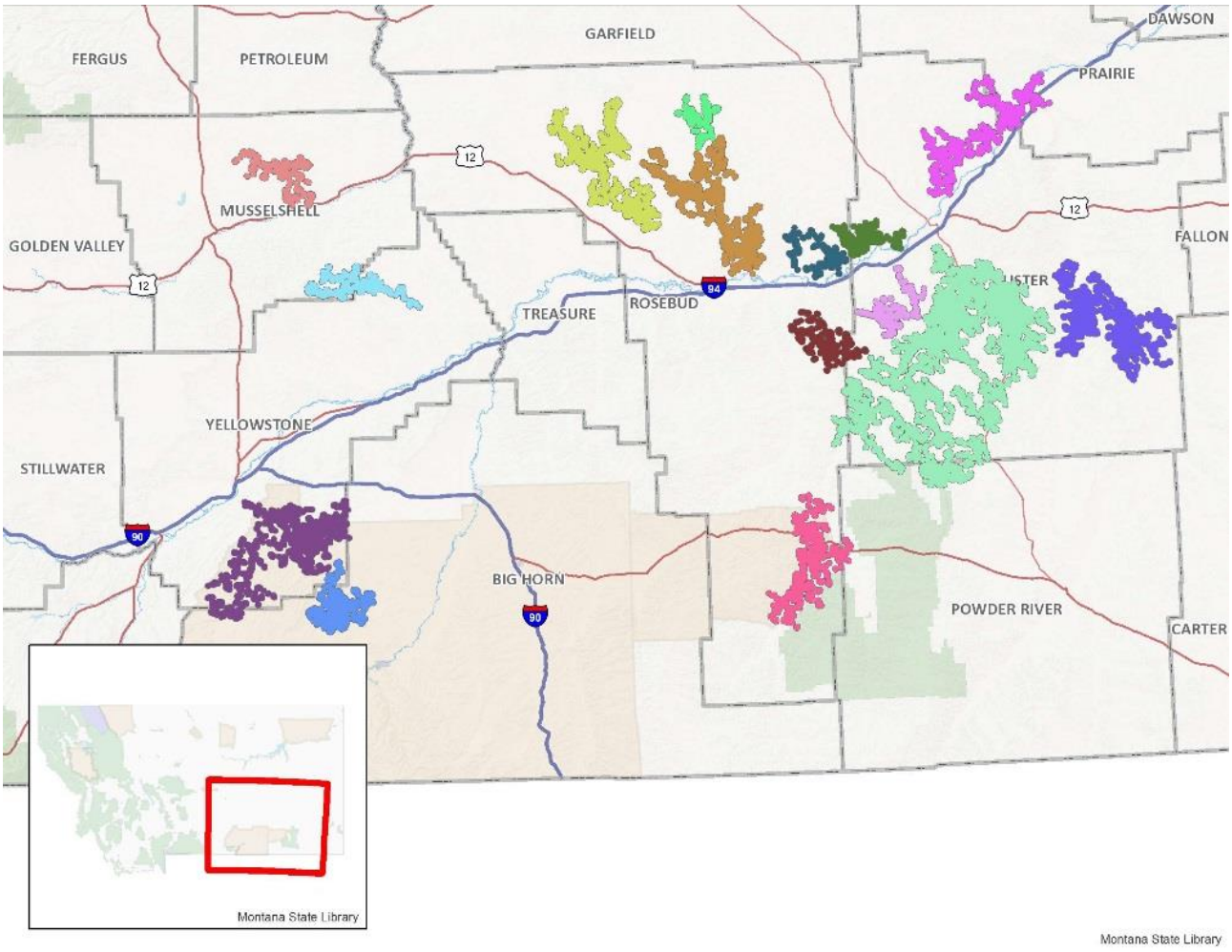

Figure 5. All Category 1 complexes (> 5,000 acres) identified using the 1.5 km separation rule. Note that the colonies themselves are not shown, only the 750-meter buffer around each.

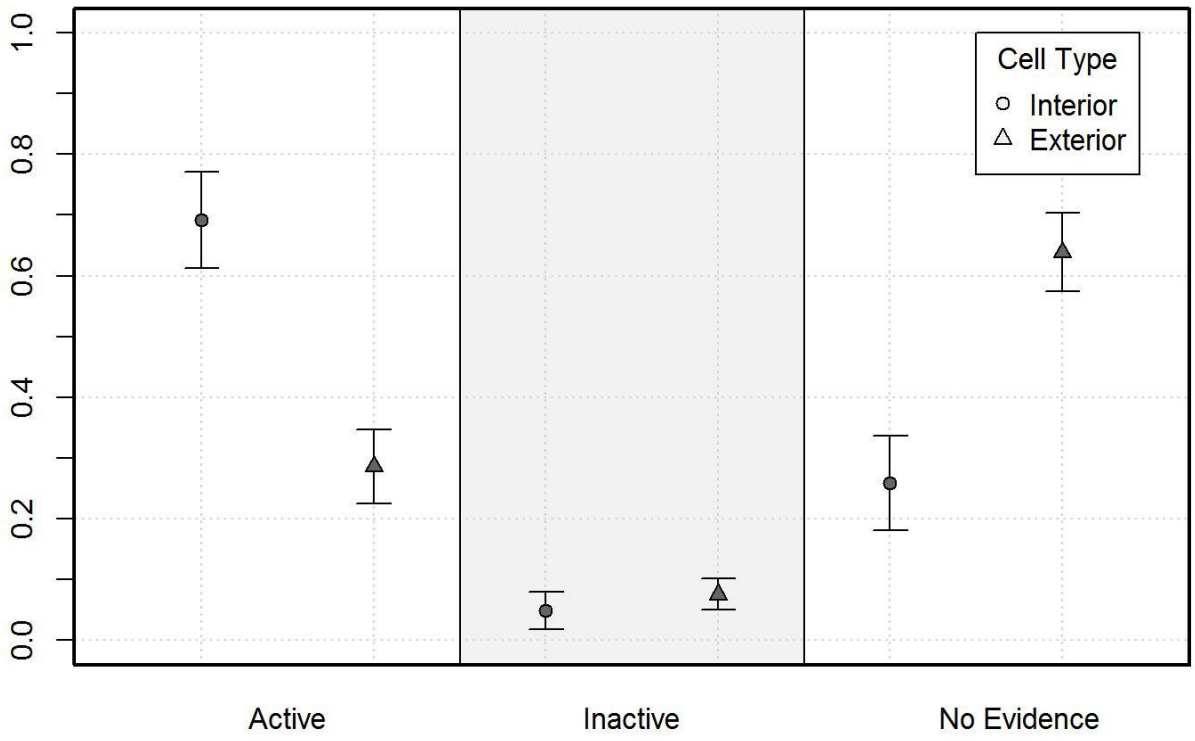

Figure 6. The proportion of 1-hectare grid cells with active prairie dogs observed, inactive burrows, or no evidence of current or historic prairie dog occupancy; 95% confidence intervals shown for each point. All colonies used in this analysis had at least 5 grid cells of each type surveyed. In total, 48 colonies were used to calculate statistics for interior cells and 53 for exterior.

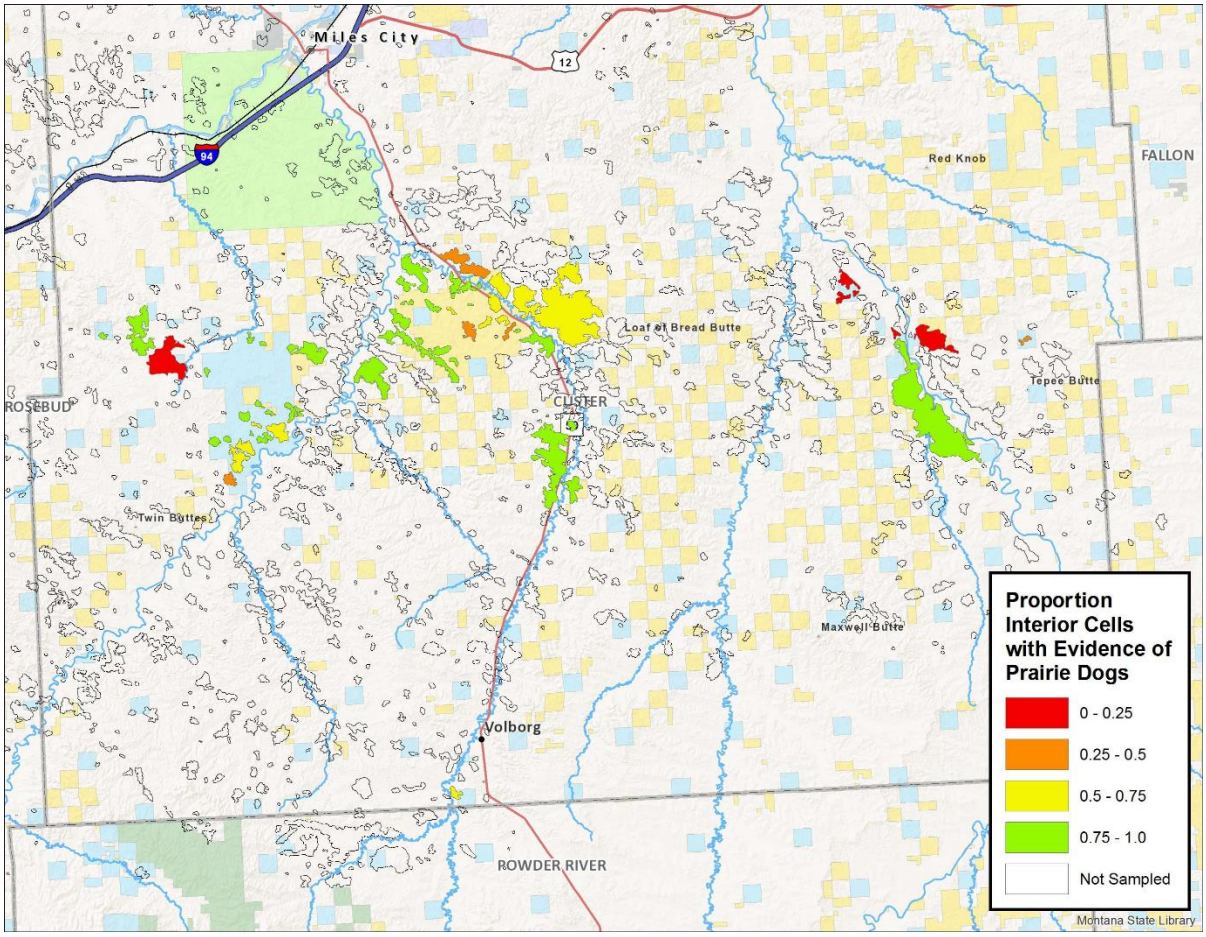

Figure 7. Ground truthed colonies within Category 1 complexes in central and southern Custer County. The proportion of interior grid cells that had evidence of active or inactive prairie dog colonies are indicated by the color of the colony. Note the three colonies shown in red and located south of Red Knob are the only colonies to have been delineated that did not contain evidence of current or recent prairie dog occupancy.

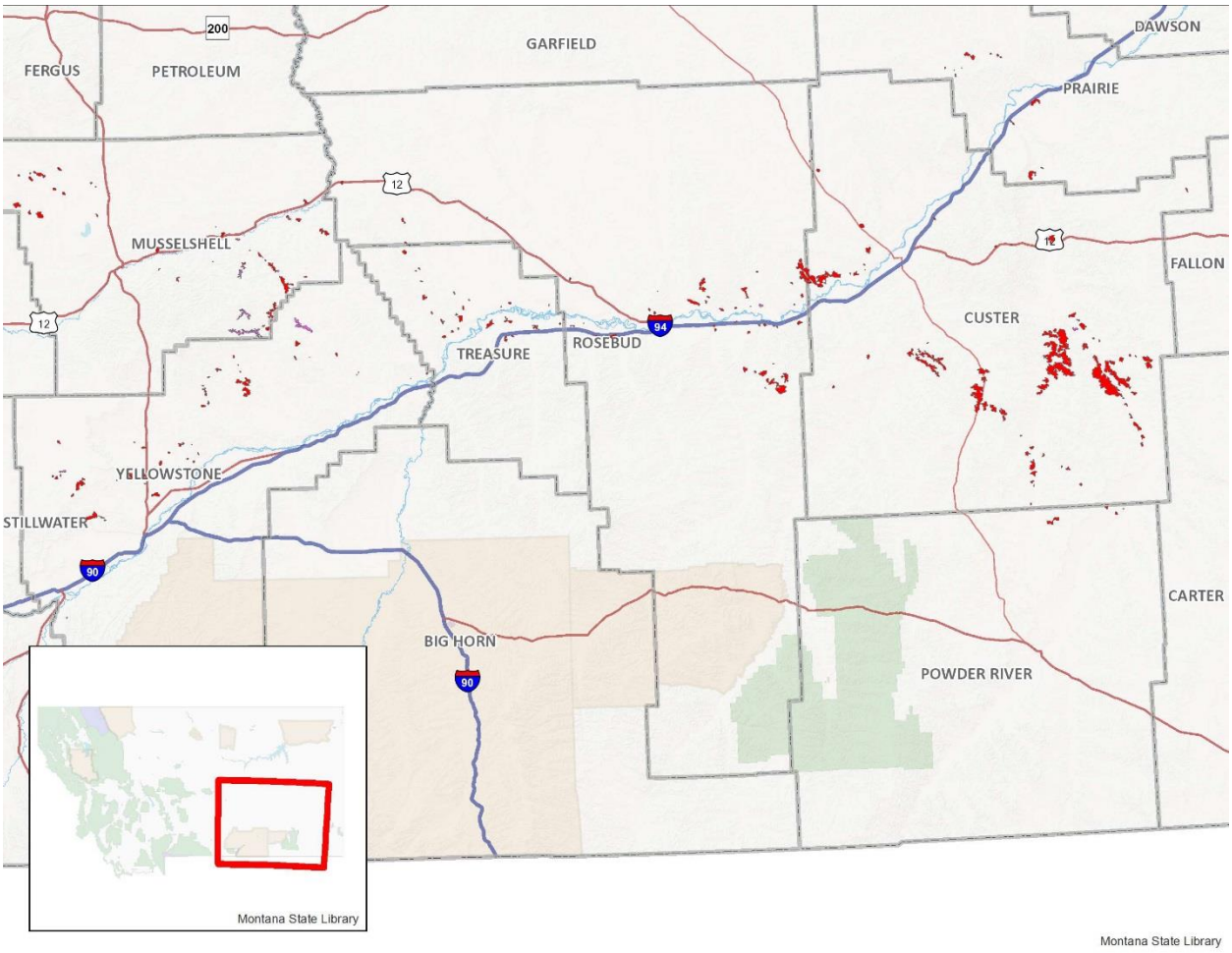

Figure 8. Colonies detected during ground truthing that did not overlap previously known colonies (red). These may represent new colonies created since the 2009 NAPI effort, or colonies that were overlooked during previous efforts.

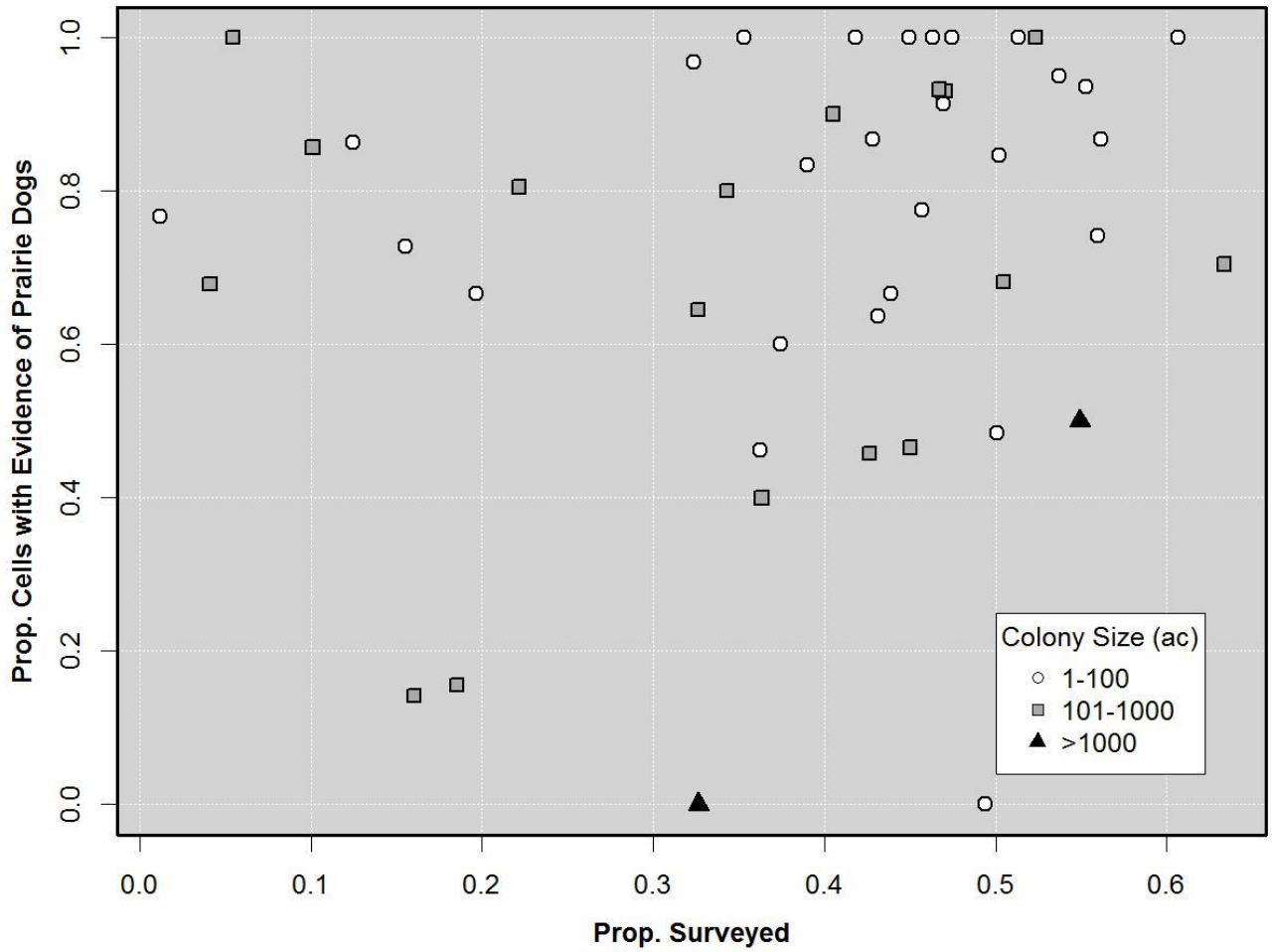

Figure 9. The proportion of cells surveyed plotted against the proportion of these cells with current or historic activity documented during ground truthing. Note that there is no pattern in each of these metrics for any of the colony size classes, indicating our results were likely not biased due to uneven survey effort.